HIGH AUTORITY
OF THE EUROPEAN COAL AND STEEL
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STEEL CONGRESS

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The High Authority
of the
European Coal and Steel Community

Steel Congress 1966

Steel in Agriculture

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in the presence of Their Royal Highnesses
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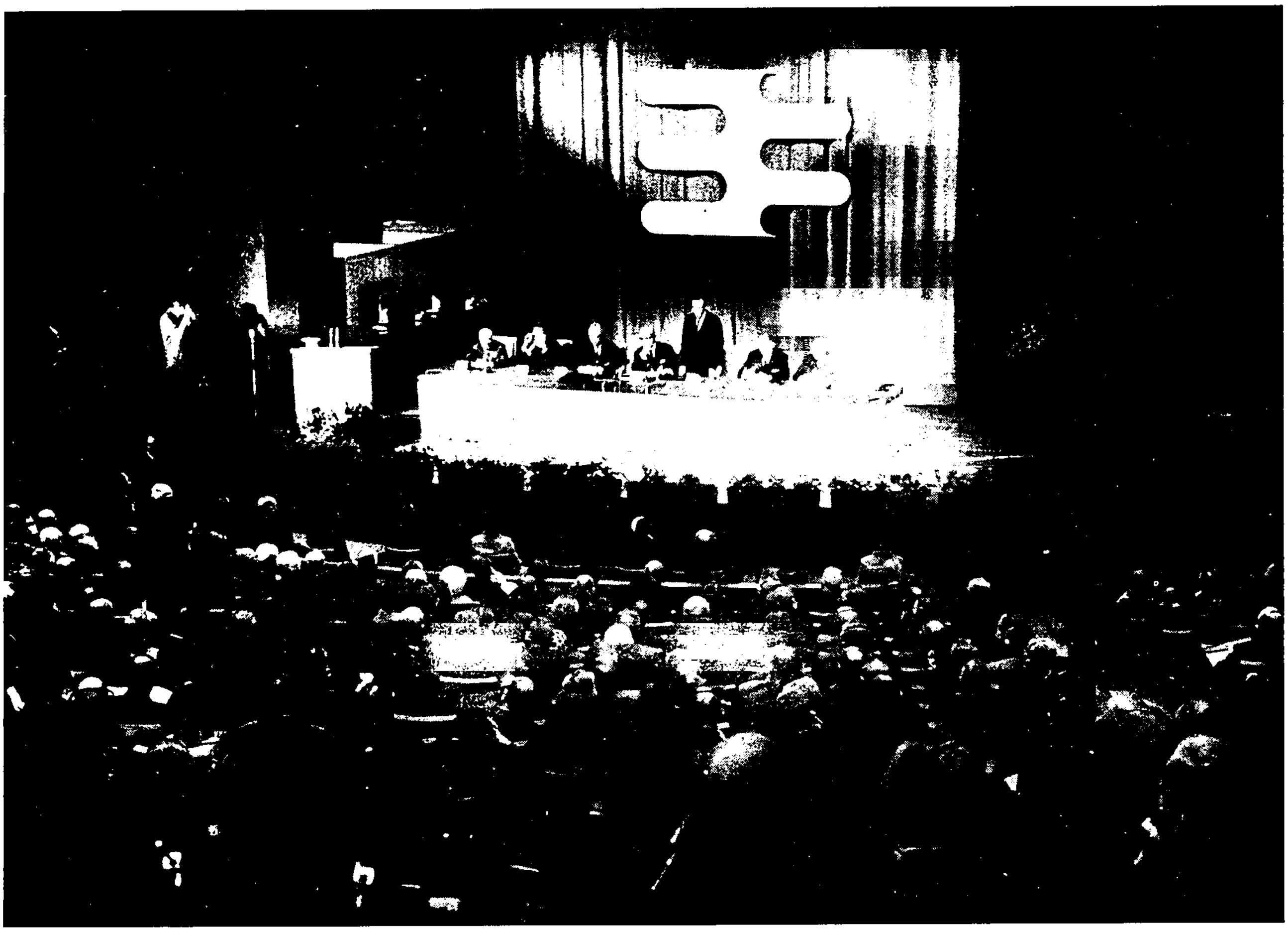


Dino Del Bo, President of the High Authority of the ECSC,
at the Official Opening Session of the 1966 Steel Congress

Dino DEL BO

President of the High Authority

Address of Welcome

Your Royal Highnesses, from the fact that you have once again graciously consented to be present at our Steel Utilization Congress, we may take it that the High Authority's action in launching the series two years ago has won your approval.

May I say how sincerely my colleagues and I and the whole Congress appreciate this fact.

We have here with us today delegates from thirty countries, in Europe, in Asia, in Africa, in North and South America. This is evidence that international public opinion has grasped the importance of these occasions. Some of those present are here for the first time; others now rank as veterans, having regularly attended throughout the series. All kinds of groups are represented—steelmakers and manufacturers, national civil servants responsible for their countries economic policies in general and steel policies in particular, college lecturers and researchers. This complex and significant pattern of attendance is symptomatic of the importance of the Congresses. The High Authority's aim in convening them—an aim absolutely in line with the ECSC. Treaty's requirements—has been to organize a thorough study of the trend in the steel sector in the light of economic developments in general, and to underscore the growing realization that increased steel utilization will be achieved in proportion as the potential uses of steel are extensively explored in as many sectors of industry as possible.

Each of the Congresses has been held in Luxembourg, and the High Authority hopes to hold more here in the future. On each occasion all possible co-operation, understanding and assistance has been forthcoming from the Grand Ducal Government and the authorities of the city of Luxembourg, to whom I likewise take this opportunity to convey our warmest thanks.

The first Congress examined ways and means of increasing steel utilization in building by encouraging a switch to industrialized production methods in the building trade. At last year's Congress, devoted to steel processing, emphasis was laid on the more and more vital importance of ensuring that steel could be used for all the purposes, some of them entirely new, involved in technological progress.

We are now embarking on the third Congress, under the distinguished chairmanship of Count Moens de Fernig.With Count Moens presiding we can be sure that the proceedings will be a model of their kind. He has the unrivalled qualification of having been Commissioner at the great Brussels World Fair some years ago; in addition, he was formerly Belgian Minister of Foreign Trade, a post requiring its holder to be specially alive to the interdependence of the different sectors of the economy, and, nowadays, of the different nations of the world. And lastly, he is particularly competent to judge in the matters with which we shall be dealing, since he is President of one of the biggest steelconsuming companies in the Community.

The subject of this year's Congress is Steel in Agriculture. That subject in itself is sufficiently indicative of the scope of the debates. The Congress is to discuss the increasingly extensive use of steel in a field, agriculture, which would appear at first glance only very remotely connected with it. More than that, it is to bear witness once again, in this particular sphere with which we are concerned, to the willingness of the developed countries to provide large-scale assistance in order to help meet the growing needs of the world's population, which by the end of the century will have reached the gargantuan figure of six thousand million.

At this Congress as in the past, discussion must be frank and objective. There are a number of points calling for particular attention.

In the first place, it will be necessary to discuss how to achieve a sufficient degree of rationalization of agricultural equipment, with particular reference to job specialization. Also, the Congress must try to establish how best to step up mechanization in those branches of agriculture where at any rate a start has been made, and to introduce it where it is still unknown. And it must consider ways of modernizing storage and preservation facilities for agricultural produce.

We have thus before us a considerable range of problems, some of which have never really come up before. So delegates will be able to enjoy the intellectual stimulus of venturing into territory partly if not wholly unexplored.

The ultimate objective of the Congress is to bring home to all the importance of genuinely industrializing agricultural production, and the help we can give to agriculture in facing up to the great challenge of our time—to see that men, women and children the world over have at least enough to live on.

Accordingly, as was done last year, one part of the proceedings is to be devoted to the developing countries —not merely because some, indeed most of them, are situated in tropical latitudes and their agriculture therefore faces special geographical and climatic problems requiring to be tackled in special ways, nor because it is primarily there that crop diversification is so urgently needed, but, as I say, because common human decency demands that there should be solidarity between the already industrialized countries and those that still have a long haul ahead of them.

Such, your Royal Highnesses, and Ladies and Gentlemen, is the background to the Congress now opening. I should like to recall in conclusion that at the end of both the first and the second Congress the respective Chairmen, M. Jeanneney and Herr Etzel, not merely asked but urged that the High Authority make still more intensive efforts to help steel—still the great basic industry today—to live up to its mighty past, to do more and yet more for understanding, co-operation and peace, to move forward to a truly good and prosperous future. And they said the High Authority might best do so by having the Steel Utilization Congresses become a regular, established feature of the European Community.

We feel we have duly responded. And to see so many and such distinguished delegates here today is confirmation to us yet again that, despite present difficuities, our work has not been for nothing and may well still achieve further major successes.

Pierre WERNER

Prime Minister of Luxembourg

Address

To all those attending this Third Steel Congress, I would extend a warm welcome on behalf of the Grand Ducal Government and the people of Luxembourg.

The success of the first two Congresses has encouraged the High Authority to hold a third of these notable encounters on the many and varied openings for using one of the basic industrial products on which the whole majestic technological civilization of our times has been built up. The President and Members of the High Authority are to be most warmly congratulated on their action. In this country, where we are especially alive to the problems of the steel sector, delegates may be sure that the friendliest interest is being taken both by the authorities and by industry—indeed by the whole population—in the Congress' proceedings.

The theme of the Congress carries quite a number of associations. At first glance it appears a somewhat surprising choice, since the economic history of the last century and the early part of this produced a sense of conflict between the aspirations of heavy industry and of agriculture. The cost of living is too dependent on the state of agriculture for the industrialist to view that state without regard to its incidence, direct or indirect, on his production costs, and in an economy wholly given over to selfseeking, in which *laissez-faire* results in hardship for the weaker sectors, such antagonism is liable to develop. Fortunately, present-day insights into the facts of economics are bringing it home to us that economic progress on all fronts is interdependent and indivisible. In consequence, a process of levelling-up is going on among the major sectors with respect to mechanization and the introduction of new methods and techniques.

So, in an advanced society, we are reaching a stage where technical progress and rational work organization are being pursued simultaneously at several different levels and in many sectors. Agriculture is making up the leeway lost.

The point I have been trying to make is especially important in the case of countries which have always been and will long remain primarily agricultural. This is apparent in many of the developing countries. Their anxiety to equip themselves with manufacturing industries, while understandable and praiseworthy in itself, is often accompanied by an unduly conservative and casual attitude as regards working up agriculture towards the higher yields and bigger acreages and herds needed to feed a rapidly-expanding population. Here again, economic growth and individual welfare are dependent on the aid of improved technology, on the further aid of what human ingenuity has devised and developed in other fields, and—to turn to the more immediate concerns of the present Congress—on the use of the processes and equipment evolved by the steel manufacturers.

Here then is one link between steel and agriculture that is not so surprising after all. And there are others. Thus we are fond of instancing what has been done by basic Bessemer slag, a byproduct of steelmaking, to fertilize the immemorially barren lands of the Luxembourg Ardennes. All credit to those long-headed persons in authority at the end of the last century, who made it a condition in granting mining concessions here that the slag should be made available at cut rates to farmers—surely a good example of really intelligent Government intervention!

Then there has been the history of the two sectors with regard to European integration. Here again, the Common Market for agriculture was laboriously negotiated and established years after the introduction of the Common Market for steel. Actually, everything started with coal and steel, as I emphasized yesterday at the unveiling of the monument to Robert Schuman.

Now if you will forgive me I should like to say just a word concerning certain problems now facing the European steel industry in general and the Luxembourg steel industry in particular. Surely, for the sake of continuing European co-operation, we must trust to be spared such a painful inconsistency as the final installation of a complicated and intricate European market machinery for agricultural produce which coincided with a falling-off in market interpenetration in the heavy-industry sector, the first of them all to be integrated.

I hope I need only put this possibility before you to ensure that we shall all of us do our utmost to work out co-operative and equitable solutions to our difficulties.

I wish this third Steel Congress under Count Moens de Fernig the fullest measure of success. May it serve to underscore the interlinking in progress of the different sectors and so foster and further the well-being of our peoples.

Dr. Habil. Fritz HELLWIG

Member of the High Authority

Steel in Agriculture—Tradition and Progress

The theme "Steel in Agriculture" is one which involves aspects ranging far beyond the technical and commercial side of present and future co-operation between two sectors of the economy. Some indication of this is offered by my sub-title, which is intended to suggest that steel in agriculture stands between two determining forces in the march of civilization—tradition, the outward and visible reflection of a certain *vis inertiae* inherent in human nature, and technological progress, the most striking product in our own time of the forward-thrusting mind of man.

To trace in full the interdependence of ironmaking and agriculture we have to go back to the dawn of prehistory. Today we tend largely to forget the millennia of interaction between the two. This is the effect of the specialized division of labour that is part and parcel of the modern industrial economy. The more the elaborate series of processing stages, subject to technological and economic laws of their own, has come between the ironworks and the farm, the more we have ceased to consider the close bond between them that formerly moulded the development both of ironmaking and of agricultural methods. Who today, when the subject of steel in agriculture is mentioned, remembers that for centuries the itinerant ironfounder and the itinerant smith used actually to set up their workshops on the farm or in the village? From recent research into the early history of ironmaking in different parts of the world, we know how closely the work of smelting the metal in tiny, primitive furnaces and then hammering it into usable shape was bound up with the methods of tillage then employed. The "forest smiths" of Central Europe would move into the peasant communities, bringing with them the small quantities of iron they had managed to produce in the neighbourhood of ore deposits and of charcoal, and there start to forge whatever ploughshares, scythes, sickles, hoes and so on the inhabitants might require. In the Far East, where forging and the making of forgeable iron came later, casting, already well known and highly developed, was used instead. It is one of the surprising facts of metallurgical history that the iron plough was devised independently, yet more or less simultaneously, in several different parts of the world.

In consequence of this breakthrough, it became possible for the first time to employ iron not merely, as heretofore, mainly for making weapons and personal ornaments, but for a wide variety of purposes which opened up completely new vistas for humanity. The invention of the iron plough may not have been the biggest technological advance ever achieved by the questing human brain, but it was the one with the biggest implications for the future of mankind, for it marked the beginning of the end of the nomadic way of life, of the tribes that moved from place to place hunting, driving their flocks, and appropriating whatever they found by the way. With the coming of the iron plough they were able to cease from roving, to begin systematic tillage and to settle where they tilled. But the most lasting result of the economic and social revolution thus brought about by iron was in human relations, in the basic order of things which these now stabilized communities evolved for themselves. In place of the jungle law that had made existence a succession of pursuit and plunder, of battle, murder and sudden death, there came rules to regulate the behaviour of man to man. And even as the invention of the plough occurred independently in different places, so in the various emergent societies there grew up those great bodies of legislation which form the bedrock of civilization and whose fundamental principles are still with us today. Alongside the Ten Commandments of the Old Testament stand parallel enactments instituted by other peoples and other societies.

Of the technological advances that have decisively affected human history, there is, viewed in this wider context, scarcely one that has made such a difference as the first harnessing of iron to the service of agriculture. It may be that future generations will say something the same of what has been happening and is happening in our own day—and I do not mean this or that spectacular achievement in science or technology, I mean the results of that co-ordination of endeavour among a host of specialized disciplines without which we should not now be witnessing an unprecedented expansion in world population. The by now familiar references to the "population explosion" imply recognition, not only that the process has burst upon us with elemental force, but also that into its making have gone all kinds of individual contributions from the scientific, industrial, agricultural-engineering and organizational sides. Perhaps posterity will judge this age of ours by whether mankind has succeeded, by appropriate rules, in establishing that basic order of things that is so vitally necessary if unprecedented numbers of human beings are to live crammed together into an inhabitable area which cannot, after all, be stretched to accomodate them beyond a certain point. The same problem confronts our generation with respect to the gigantic forces put into men's hands by the probing and control of atomic energy. If we further include the start made on the exploration of interplanetary space, it looks very much as if humanity were now entering upon a stage of accelerated technological and scientific development such as has not been experienced for hundreds if not thousands of years, a stage comparable in the demands it makes upon the men of our time to the invention of the plough. And the relevance of all this to our subject today? We all know that it is most of all the country-dwellers who are the repositories and custodians of tradition in the best sense of the word. We know too by now into what contradictions and discords traditionalist peoples and communities can fall when faced with a situation in which their position and their heritage can only be maintained by adopting the results of a scientific, technological and economic trend which has already brought increasing affluence and increasing power to others. Between the rational organization that stems from scientific, technological and economic knowledge and the irrational forces that influence the patterns of society there cannot, now or ever, be anything more than a kind of armed truce, for so long as man is endowed with a will of his own and able to react not only rationally but emotionally.

These are points that have to be borne in mind in considering the mechanization and rationalization of agriculture and steel's contribution thereto. Now while agriculture does make use of steel in a great many different ways and forms, economically it does not constitute one of the major consumer sectors like vehicle manufacture or bridge-building. But in the present state of the steel market, both in the Community and in many other parts of the world, it is evident that the time has come for the industry to concern itself with the requirements of sectors consuming smaller tonnages of steel. The days of soaring steel production, breaking one record after another, are over, for the time being anyhow. ECSC's production in 1965 was 86,000,000 tons: in 1970 it is expected to be only about 10 % above that figure, because economic expansion during these years will be largely confined to sectors with a low steel consumption. This Congress has been organized to help the steel industry move away from its traditional approach to production and break new ground.

In the industrialized world of today steel in agriculture means tractors, cultivators, harvesters of all kinds: that is to say, the mechanization of outdoor farm operations. It also means the rationalization of indoor operations, with the aid of modern livestock housing, milking and dairy equipment, grain-drying apparatus, silos and so on. And again, it means the preservation, packaging and transport of processed agricultural produce in steel containers. The experts will be quoting you startling figures in the course of the Congress, such as that the amount of steel on a big farm—machinery, implements, buildings, fences—can come to as much as 45 tons; that the capital outlay per worker, not counting that sunk in the land itself, can in extreme cases total anything up to $ 100,000 and that from the world's annual production of tinplate (which is used principally for the canning of foodstuffs) there are manufactured no less than a hundred thousand million cans, or 25 per head of the world's population. These are sidelights on the tremendous changes going on in agriculture, where the whole focus is now on pushing up productivity as hard as it will go, thus releasing a number of the extra workers without whom the all-round expansion of the Community economy during the last few years could not possibly have been achieved.

This trend, with fewer and fewer farmers feeding more and more people, will doubtless continue. In agriculture, in contrast to other sectors of production, there is still plenty of scope for increases in productivity and in value added but not, paradoxically, in the number of persons employed in it full-time. In fact, agriculture has its hands full enough dealing with unfortunate legacies from the past. There is the old, old tension between town and country, with its primitive prejudices on both sides; there are the sins of commission and omission that have been made in development policy; there are the economically ruinous inheritance practices that have resulted in pointless fragmentation of cultivable acreages, a process which can now only be reversed by an uphill struggle against strong resistance to achieve a more rational distribution of ownership. Nor is ownership the only matter over which suspicion and hostility tend to be shown: they are encountered too, though less frequently than they used to be, with respect to technological progress and the improvements thereby made possible in farming methods. Of course, it can happen that farmers are chary of laying out substantial amounts of capital owing to sheer bewilderment in face of the vast range of production aids offered them. The manufacturers could, for instance, well do something to standardize and concentrate their production, offer better aftersales service, and, as some of them are already doing, provide technical assistance and instruction, in order gradually to get their public more attuned to the idea of using the new methods and arrangements.

It is natural to wonder whether further technological developments in the field of steel and of steel manufacture for agriculture can be expected to yield major fresh advances developing new methods of cultivation, the winning of new markets, possibly even the farming of land hitherto rated as unfarmable. There is certainly still room for improvement in present mechanical, transport and processing techniques, whether as regards better utilization of manpower or of agricultural produce, but such improvements would appear likely to come about by degrees rather than by a radical upheaval. The same is true as regards energy availability and utilization. Nevertheless, I should like to cite you the example of a process recently evolved by modern science which well illustrates how technological progress in steelmaking can have revolutionary repercussions, forthwith or quite some while later, for agriculture. I refer to the synthetic ammonia process that has now become one of the most important methods of manufacturing the indispensable artificial fertilizers—a process whose existence we owe to the fact that some time earlier the steel industry's researchers had succeeded in solving the problem of producing weldless hollow ware from forgeable steel. It is thanks entirely to progress in tubemaking technological potentialities, that high-pressure synthesis and working with pressures, high temperatures and corroding materials have become possible.We see the results of the steel industry's research and development work in this field alone on every hand as the opening-up of the earth's resources goes forward—above all in the energy economy of today.

Among the fundamental innovations in steelmaking that have had important side-effects for agriculture we must undoubtedly include the process devised by two Englishmen, Thomas and Gilchrist, whereby Henry Bessemer's converter process was adapted to enable steel to be produced from phosphorus pig-iron. On the European Continent, and here in our six Community countries, whose indigenous ores could not formerly be used to any great extent owing to their phosphorus content, the introduction of the Thomas or "basic Bessemer" process was the starting-point for a tremendous expansion: I do not think it is an exaggeration to say that the modern iron and steel industry which is the outstanding feature of this land of Luxembourg, and of the neighbouring regions of Lorraine, Belgium and the Saar, owes its being to basic Bessemer. Now one of the great factors that helped to make basic Bessemer steelmaking such an eminently paying proposition was that the phosphorus slag could be turned over to agriculture as phosphate fertilizer without expensive further treatment. And who can say whether, had it not been for basic Bessemer, our steel industries here would ever have developed to the point of being able, ultimately, themselves to provide an important part of the initial impetus to the economic and political integration of their countries?

And so, in conclusion, I should like to express the hope that the present renewed encounter between steel and agriculture will once again be productive of the same kind of cross-fertilization as has so often occurred between them in the past.

Comte MOENS de FERNIG

Former Minister, Chairman of the Congress

Co-operation Between Agriculture and Industry and its Contribution to Economic Progress

The organizers of the Third Steel Congress, and all those taking part, are most honoured by your Royal Highnesses' presence at this Opening Session.

That you have graciously consented to be with us this morning is evidence of your interest in the subject with which we shall be dealing in the next three days. May we be permitted to express our appreciation of your most valued encouragement.

My warmest thanks first of all to the High Authority of the European Coal and Steel Community for the honour they have done me in inviting me to take the Chair at this Congress.

The subject of the Congress is "Steel in Agriculture," and by way of introduction to our discussions I would suggest that we give a few moments' thought to the interrelation of agriculture and industry in contemporary civilization.

It is usual to date that civilization from the Industrial Revolution which originated in England about 1750 and spread across the Continent, taking root at different dates in different countries and climes, between 1810 and 1880.

But we tend to forget the all-important fact that the Industrial Revolution had been preceded by an Agricultural Revolution. What is more, it was that Agricultural Revolution, a development far too little studied by those seeking to understand how we came to be what we are today, which actually enabled the Industrial Revolution to take place.

It has often been questioned why the seventeenth century, with its succession of scientific discoveries, brought no industrial revolution.

For a very simple reason: because agriculture remained immobile. When Louis XV mounted the French and the Hanoverians the English throne, agriculture was still as it had been at the end of the Middle Ages. Everything, everywhere, was done by hand, with feeble and primitive implements: the swing-plough scratched the soil, the beasts were thin and scrawny, not much more than half the weight of ours today, and practically nothing could be done in the way of manuring, for poor dung will not make rich earth.

And among the people who lived thus precariously by their heart-breakingly unproductive tillage, the death-rate was fantastic: it has been shown, for example, that around Beauvais in the early eighteenth century the average expectation of life at birth was 22!

Men were old at forty. Epidemics and famines carried them off like flies, in what French writings of the time call "mortalités." Ninety-five per cent of the population of Europe were country-dwellers, and whether gentry or peasantry they lived in the same universal penury. In Beauce—today some of the most opulent farmland in France—it was said of the local squires that when they were having their breeches patched they had to go to bed. The peasant's lot was harder still. When a natural disaster struck, those who survived at all became wanderers on the face of the earth: the pauper vagrant was a reproach to the age that not all the panorama of brilliant courts and intellectual glories can obscure.

But by the end of the eighteenth century the picture had entirely changed. The countryside no longer had the depressed, neglected look of less than a hundred years before. In England there had been the massive land redistribution known as the Enclosure Movement, from the absorption into larger units of the ancient "open fields." Everywhere new crops were being introduced, including more especially potatoes, maize and tobacco, brought in from America. And other most far-reaching experiments were in progress too: in the Austrian Netherlands, the present Belgium, for instance, conifers were being planted in the barren Campine and Northern Flanders and in the sandy soil of Brabant.

Improvements were being made in farming equipment: the plough proper was coming into general use. Improvements were being made in the livestock: new breeds had been introduced and were beginning to flourish. Big irrigation projects were being undertaken. The results were noticeable, indeed striking. By the end of the eighteenth century, the average length of life in the Beauvais region, to which I referred just now, was up to 32, and among the middle classes in Beauvais itself to nearly 40; in England it was about the same. Poor enough by our standards, no doubt, but an astounding advance in the course of a few decades! In Belgium, the population actually increased by 40 % between 1755 and 1785. Famines and shortages became less and less frequent, and agricultural surpluses began to occur here and there. And those surpluses were unquestionably to have much to do with the swift progress of the Industrial Revolution.

It is true to say that an Agricultural Revolution preceded the Industrial Revolution—in fact, made the Industrial Revolution possible. And more than that: the two revolutions sprang from the same source. I should like to dwell on this point for a moment, because I consider it of supreme importance. The Agricultural Revolution and the Industrial Revolution came to Europe as a result of one and the same movement in the mind of man. I refer, of course, to that changed pattern of human thought that we call the Enlightenment. Modern industry and modern agriculture originated in the thinking of the same philosophers. The Bible of them all was the *Encyclopaedia* of Diderot and d'Alembert and Helvétius. Its wonderful engravings quite as often depict projected industrial techniques as they do the latest innovations in agriculture, and more especially English agriculture.

The *Encyclopaedia*'s article "*La Culture des Terres*" written by Diderot himself, is entirely based on the successful experiment with crop rotation which had turned the sandy wastes of Norfolk into first-class farmland. Industry was all the rage in the world of art and letters. Painters painted subjects such as "*La Visite aux Forges*". But agriculture was studied just as keenly. Rousseau went botanizing at Hermenonville, Arthur Young toured all over Europe lecturing everybody he could get to listen to him on the new methods of tillage and stockbreeding. Louis XVI played at being a locksmith in the attics of Versailles, Marie-Antoinette amused herself posing as a farmer's wife at the Trianon. And Goethe, relating how Faust passes his time after the Gretchen tragedy is over, shows him reclaiming vast expanses from the sea and covering them with "pastures, gardens and villages."

And this brings us to another most significant point. Not only did the change whereby agriculture left behind its former perennial uncertainty and periodic dearth for relative plenty make industry possible at all, but—a fact we tend to forget—the "manufactory" was to begin with a village institution. From 1780 onwards in England, from 1810 to 1860 on the Continent, factories were far more the new village than the new city landmarks. Industrial entreprise was in its origins a country affair.

Here again the old prints are most illuminating. Take for instance the stream of lithographs that started to come out about 1850 in France and Belgium and England to acquaint the public with the new advances in technology. They make it abundantly clear that industrial plants of all kinds—ironworks, paper mills, breweries, vinegar and sugar factories, even collieries—were located primarily in rural areas: in fact, it was to be many years before they acquired their urban character.

This is borne out by what we know of the social trends of the time. Over a very long period the "manufactory" sucked in the extra agricultural labour rendered redundant by population growth and improved farming methods—women, children, temporary hands, and not a few of the footloose wanderers who were a regular feature of the social scene almost up to the beginning of the twentieth century, despite largely unavailing efforts by the vagrancy laws to catch up with them. Readers of Mrs. de Ségur will remember her charming character Diloy the tramp.

But for all the initial intertwining of agriculture and industry, of the village and the factory, we must nevertheless remember that it is industry which has been responsible for the growth of the great urban agglomerations, and remember, too, the sociological antithesis that has developed between the town and the country-dweller.

An entirely modern phenomenon, this antithesis, for it cannot be too strongly emphasized that the towns were utterly unimportant units, politically and socially, before the rise of industry.

Industry made the towns, industry sent their size and their population soaring. Industry gave them the administrative influence they now possess—the result, in effect, of the concentrated power of analysis, planning and control they represent.

Industry made the towns places where the interaction of individual thoughts and ideas proceeds at tremendous speed. Industry created the city mentality; industry gave the city its appeal, and its dangers.

Down to the early nineteenth century unrest manifested itself from time to time in the countryside, in such outbreaks as the "Jacqueries" and the Peasants' Wars. After 1789, it tended more and more to be confined to the cities. And it was all too easy for the novelists and essayists of our grand-fathers' day, and for quite a few sociologists as well, to contrast this city mentality, this twin pull and thrust that the city exerted, with the gentleness, the conservatism, the virtues of the countryside.

Quite obviously, the cities of the Industrial Revolution were the product—in human terms—of the country. Since their own inherent growth potential was comparatively low, their population explosion was due in the main to immigration.

The conclusion seemed clear: the city had killed the country, and in particular industry had stifled and enslaved agriculture. And to that conclusion any number of observers jumped headlong.

All the same, this cut-and-dried presentation of the position is false. The towns did indeed drain away the population from the countryside, and especially from those parts of it that had always been poor and backward. But it was not, for the most part, the farmers and farm labourers themselves who migrated. The people who did, and still do, had not left the plough or the cowshed to make their move. A series of penetrating sociological surveys have shown that "those involved in the flight from the land have been chiefly small craftsmen and tradesmen and persons of standing in village society," and that "the countryman proper has difficulty in adjusting to city life." Moreover, it is evident that incomers from the country do not as a rule gravitate to industry, but much more commonly to the services sector, to retail trade (usually in foodstuffs), or to Government or other office jobs.

Yet at the same time industry has all along played its full part in aiding the steady improvement of agricultural efficiency. For the fact that this gigantic movement to the towns has taken place at all, and the teeming millions of town-dwellers nonetheless being regularly supplied with more and more and better and better food by fewer and fewer country-dwellers, is due to the continuous improvement over the years in tillage and stockbreeding methods, in fertilizers and in farm machinery and equipment.

In fact, then, there has never been a clean break between industry and agriculture. Progress in agriculture was the proximate cause of progress in certain major sectors of industry. And it has been thanks to agriculture—a more and more streamlined and modernized agriculture increasingly aware of what it can achieve and increasingly bent on achieving it—that industrialization has been accompanied by an astounding leap in the number of human beings alive in the world, and an equally astounding leap in the number of years they can expect to live.

The average life span in Northern France in the early eighteenth century was 22: today it is round about 70. Agriculture and industry between them have brought this about, operating throughout in harness notwithstanding some inevitable, and in the end often creative, tensions. Their interdependence has been far more important and more basic than all the cleavages between them.

And in any case the cleavages too are losing their sharpness. Everywhere nowadays life on the land is becoming more akin to life in the city.

What is more, agriculture no longer dances to industry's piping: it has regained its freedom of action and organization. All over Europe an élite of young farmers is developing, all of them marked by the same lively, forward-looking, clear-headed approach. They have shown that they have no intention of being at industry's beck and call: they want to think out agriculture's particular problems along specifically agricultural lines and deal with them in specifically agricultural ways. I am firmly convinced that European integration will help them to stick to their guns.

We sometimes hear it said that "agriculture has stopped being an also ran." On the contrary, I am pretty sure that in many respects it is leading the field. In its concentration on research, in its determination to modernize its equipment from A to Z, in its productivity drive—the productivity increases on the top-class farms have been startling—in its sales promotion activity, even in its push to boost its exports, it most certainly is.

There is much debate in industrial circles today on the problems facing small and medium-sized business concerns. I feel certain that the heads of those concerns would find it most illuminating to study the problems, initiatives and successes of a top-class farm. They would find there a modernness of outlook, a preoccupation with efficiency and progress that can stand as a model for us all.

That is as it should be. Division of labour is right and proper, but the mind of man is indivisible. Whether he is feeding iron into a steel furnace, sitting at the dispatching board of a power station, reaping a field of corn or staring into an electron microscope, man has always with him those mysterious age-old faculties that from the beginning of time have been his bane and his blessing, the source of his vulnerability and of his power, that in a word have made him what he is—consciousness and creative imagination.

I wish you every success in the deliberations before you, the results of which I shall be summing up at the close of the Congress.

With the gracious permission of their Royal Highnesses the Grand Duke and Grand Duchess of Luxembourg, I now declare the 1966 Steel Congress open.

D. K. BRITTON, M.A. PCF (Econ.)

Professor at the University of Nottingham
Loughborough — United Kingdom

Life on the Land in Europe

The observer of rural life in Europe in the 1960's is likely to be impressed by two facts: the decline in the number of people engaged in agriculture; and the rapid disappearance of many of the old distinctions between rural and urban modes of living. These two features are, of course, connected with one another. Many people who have given up agricultural work and taken jobs in the towns or cities continue to live in their rural homes, or frequently visit their families in rural areas, and bring back to the countryside the standards, values and customs of the urban community.

In 1950, one third of all the people in civilian employment in Western Europe were engaged in agriculture. At the present time this figure has diminished to one fifth, and in Belgium, the Netherlands, Sweden, Switzerland and the United Kingdom it is already less than one tenth. The trend is strong and steady, and it seems very unlikely that it will be reversed, though the decline may begin to slow down in some countries.
It is true that in Greece, Turkey and many parts of Eastern Europe this decline in agricultural employment has hardly begun, but in these countries the process of mechanization is gathering momentum and it may be predicted with confidence that millions of parents now living on the land in these countries will see their children take up other occupations.

It is not my purpose today to analyse the economic causes and consequences of this transfer of people out of agriculture, but it is clear that the causes have not yet spent their force and that the consequences already observed will be rapidly intensified. The causes have been frequently described as consisting of "push" and "pull" factors. Sometimes men and women are pushed out of agriculture by the pressures of mechanization and modernization which make it possible for farming tasks to be performed in less time and with smaller groups of workers; sometimes they are attracted by the higher wages, shorter working hours and better living conditions which are offered in industrial or other employment.

The process of mechanization is now going ahead very rapidly in European agriculture. Generally speaking, the further south one travels the more radical is the transformation which is taking place before our eyes. In Scandinavia and in the United Kingdom the replacement of horses by tractors is almost complete except in some of the more remote areas; but France still has about one million horses on her farms; Italy, Spain, Portugal, Turkey and Greece have about 7 million horses and mules; and many farmers in Southern and Eastern Europe are still using oxen or cows for draught power. The number of tractors on farms in European member-countries of the Organization for Co-operation and Development (OECD) is increasing at the rate of one million every four years. They replace rather more than that number of horses and other draught animals, and the disappearance of one million horses releases about one million hectares of land for food production, which was previously used for grazing or for growing fodder crops.

A similar story could be told for many other kinds of farm machinery, for sowing, weed control and harvesting of crops, and for milking and other work in the farm buildings. This development, coupled with the decline in the number of workers, has meant that the amount and the value of the capital equipment operated by each man has increased enormously. In one country after another the typical equipment of the farm worker is no longer a set of hand tools and horse-drawn implements, but a range of power-driven machines, often of great complexity and requiring much skill and experience in their operation and maintenance. This has raised the esteem of the farm worker's job in his own eyes and to some extent, in the eyes of the townsman. Slowly the whole community is beginning to realize that training and education is just as necessary for farm work as for other more highly-paid occupations.

The discrepancy in wages and incomes, however, still remains. In most countries the wages of men and women employed in agriculture are at least 20 per cent lower than in industry, and often the difference is as much as 40 or 50 per cent. The incomes of independent farmers show great variations from one farm to another, mainly because of differences in the amount of land available, its quality and the standard of management achieved; but on the whole farm incomes are chronically low in relation to those earned in the rest of the community. This is often expressed in terms of statistics which show that the share of agriculture in the national income is much less than its share in the total working population.

It is not only the attraction of higher wages that draws people off the land and into the towns. The provision of housing, schools, medical services and other amenities is usually inferior in rural districts; and the more agriculture predominates in the structure of employment, the poorer these social provisions appear to be. It has often been remarked that even if the young men working on farms are willing to put up with these inferior conditions, the young women will not. They move into the towns, where they have a brighter prospect for finding well-paid, regular work in congenial conditions and modern types of housing in which they can bring up the next generation in acceptable surroundings of comfort and convenience.

The transfer of people out of agriculture into other occupations does not necessarily mean that they must move their homes and live henceforth in an urban environment. Many farm people take up non-agricultural work within travelling distance of their rural homes and continue to live there. This is one reason why it is a mistake to identify the rural population with the agricultural population. A more important reason is that, as cities become more congested, more urban dwellers spill over into the country districts in near proximity to urban centres, and villages begin to have a population structure which is entirely different from that which prevailed when agriculture engaged the majority of the population. In the extreme case, villages have become little more than dormitory accomodation for people who work in towns or cities and whose whole existence is orientated towards urban values and modes of life. But apart from these extreme cases, there are thousands of villages in Europe today in which, though they are situated in genuinely rural areas where almost all the surrounding land is put to agricultural use, the agricultural population is a minority, outnumbered by industrial workers who are engaged in local industries recently established in rural areas; by "commuters" who travel daily to work away from the village where they live; or by retired people who have left the cities in order to pass their remaining years in what they hope will be quiet and peaceful surroundings.

These villages, where farm people are finding themselves increasingly outnumbered, are generally increasing in size and flourishing economically, adding to their amenities and imitating in many ways the facilities and other attractions of the towns. However, there are many other villages and hamlets which are undergoing no such renaissance. Either because of their remoteness from urban centres, or because there are no local alternative occupations for displaced agricultural workers, or because of some accident of chance which has encouraged the growth of some villages in an area at the expense of others, there are villages which have suffered a sharp decline in population. For example, it has been stated that in the northern part of the Netherlands, the number of villages with fewer than 500 inhabitants constitutes about 70 per cent of the total number of residential nuclei. This makes it even more difficult than before for them to provide the social and cultural facilities which are needed. They become "non-viable" communities, and enter upon a spiral of decline from which there is usually no escape except by way of a rescue operation planned and supported by public authority. It is well known that the cost of providing basic public services becomes prohibitive when population falls below a certain minimum. To provide equality of treatment to all small and dispersed communities would be a very wasteful use of public funds. Either the process of "spontaneous concentration" of villages must continue or the inhabitants of the smaller villages must be prepared to travel to obtain what they need.

We can see, then, that two of the main features of traditional village life are disappearing: its self-sufficiency and its isolation. The ideas, the fashions, the ambitions which find expression among rural people have more and more come to resemble those which hold sway in the cities. The mass means of communication—radio, television, newspapers, gramophone records—have an immediacy of impact in the farm household which has effectively destroyed the feeling of separateness which for so long was the common experience of rural people.

This process has not, of course, reached out to all areas or to all individuals. In places where the road system is poor, where motor-buses and motor-cars are few and where the distances between habitations are to be measured in hours rather than minutes, there is still rural isolation. Radio and television may span the distances, but there is still lacking the frequent personal contact with people outside the narrow circle of family and neighbours which is so essential to the active acceptance and adoption of ideas which are powerful enough to transform a way of life.

Yet the motor-car is now to be seen in virtually every inhabited part of Europe. This is perhaps the most significant fact about life on the land today. Whether they are driven by local professional men, business representatives and traders, or by tourists who come from far away to taste the flavour of solitude and serenity before they are totally submerged by the flood of population and distracting noise, motor-cars convey to every village and hamlet a way of life which is "modern" in every good and bad sense of that word. If you pause to think what the phrase "life on the land" means to you, as opposed to "life in the town", can you deny that once the motor-car is universally present, the distinction rapidly breaks down? It is not only that the villages fairly near to towns have become suburban in character, with the majority of their population being nocturnal and week-end "visitors"; the remoter villages too are brought into the zone of influence of the towns. Their shops sell the same standard products and their fashions in dress and even in speech begin to change in rhythm with the towns.

I have mentioned the impact of tourism on those who live in Europe's countryside, and the importance of this factor should certainly not be under-estimated. It is true that some areas have been much more exposed to this influence than others, because of their scenic beauty or because the local way of life holds a fascination for the townsman as it stands in such strong contrast with his normal experience. Unfortunately, the invasion of tourists of these specially attractive areas leads to their rapid transformation. In catering for the needs of the tourists by providing hotels, camping sites, petrol stations, airports, car parks and traffic controls, the local communities surrender their character and charm and begin to resemble more and more the appearance of suburbia. This compels the discerning tourist to transfer his attention to other "undiscovered" localities which have not yet been tainted by the all-too-familiar urban influences, so that we are not far from the paradoxical situation that the more isolated an area is from the economic and social pressures of the town, the more likely it is to be attractive to tourists simply because it has the rare quality of being different, vestigial, eccentric. Thus the process of obliteration of the differences between urban and rural ways of life is accelerated. Petrol is the basic necessity of the twentieth century traveller and the petrol pump is the symbol of the surrender of rural archaism.

There are many signs that the exodus of people from Europe's towns and cities, such as occurs from Paris every year at the beginning of August, will in future take place not just once a year but much more frequently. As the five-day working week becomes general, more families find that they have time to "get away" more often; they possess the means of transport; and in time they will devote part of their increasing family income to the purchase of a small house in the country, usually quite modestly equipped and even deliberately frugal in its provisions, where they can escape from all the noisy intrusions and social pressures of their urban neighbourhood and adopt a simple way of life. Whether any real integration of these two-house families into rural society will take place remains to be seen, but it seems unlikely, for in general they do not wish it. Seeking to escape from the stresses and strains of their urban responsibilities, they will not be inclined to accept new obligations in a community to which they are total strangers and on whose members they do not need to rely for any of their means of subsistence.

In contrast, the contribution to rural communities of the genuine "commuters"—those who travel daily from a rural home to an urban place of work—is often very substantial. Athough such people usually did not originate in the village, they are absorbed by it, and frequently the men, women and children of such families take on roles of leadership and are fully accepted and respected by those who were born and brought up in the locality. The same can often be said of retired people who move from the town or city to the village rather late in life but are neither too old nor too restricted in their outlook to be able to take an active part in the life of the community.

All this inter-penetration of urban and rural life, caused by the increasing engagement in non-farm work (including military service) by members of farm families, by the settlement in rural areas of commuters, retired people and others whose origins are essentially urban, and by the visits of tourists (in residence or in transit), has led to a weakening of the power of tradition and conservatism in rural areas. Of this generation more than of those which came before it can be said that what was good enough for their fathers is not good enough for the sons. The remark applies with equal force to the daughters and their mothers. New ways of performing old tasks are constantly being sought and adopted. In building, experiments are made with new designs and new materials. New methods of farm management are readily taken up, based on a more scientific attitude.

Measurement, precision and planning are gradually taking the place of custom and the irrational enslavement to inherited routine. Farmers are more conscious of the requirements of the market and are changing their systems of production accordingly. Production for sale now takes first place on farms which, one or two generations ago, were producing mainly for family subsistence or for exchange in the immediate neighbourhood. In consequence, more cash passes through the hands of farm families and they now buy a wide range of factory-produced consumer goods which previously had either been made by rural craftsmen—for example, textiles and footwear—or had not been seen at all in farm households.

Even in the shaping of the farms themselves—their boundaries and their layout in relation to buildings and roads — there is evidence of a new willingness to reconsider the old, irrational patterns with their meaningless fragmentation and separation of individual plots and their gross inconvenience of operation. In many countries, but especially in Germany, a great movement is in progress towards consolidation of fragmented farms, resettlement of farm houses and buildings in relation to the land and amalgamation into larger units of thousands of small farms which cannot provide a livelihood for a family.

Many of the changes in life on the land which I have mentioned have proceeded more or less spontaneously, or at least without deliberate government intervention. This is not the case, however, with land consolidation. Vast sums of public money have been devoted to schemes for redistributing farm land, and this expenditure is likely to continue on an increasing scale for many years, for the problem is enormous in its extent. Not only is there the accumulation of many generations of misguided subdivision based on legal rights and customs, but also there is the need for a dynamic and flexible approach to the question of farm size, rather than the static approach which attempts to prescribe a certain number of hectares which constitutes the optimum size, without regard to changing techniques of production and organization.

Farmers are particularly sensitive about any proposals from other persons or bodies concerning the re-allocation of land, and governments have usually had to proceed very slowly in the early stages of any campaign for reorganization. The exchange of parcels of land between owners in order to reach a more rational arrangement of boundaries is an extremely delicate operation involving long processes of demarcation, valuation and arbitration for which great patience and tact and much professional skill are needed. Land consolidation schemes have frequently run into difficulty because of the stubbornness and mutal suspicion of the farmers concerned. A technique which has proved its worth is that of the "pilot" scheme, by which a small area is selected for special attention and to which many professional and financial resources are devoted so as to ensure success on a limited, local scale, always on the basis of the voluntary co-operation of farmers in the area. The pilot area then serves as an example to which people in other areas, not yet convinced of the advantages, can be referred. Once the fundamental attitude of farmers to proposals has been changed and their indifference or hostility has been turned into acceptance or positive enthusiam, the whole process can rapidly gather momentum. Legislation can then be put into effect which enables the state, in certain circumstances, to buy and redistribute land and to prevent its future subdivision into uneconomic units. Incentives can be given to encourage local schemes of consolidation, such as by the provision of grants to meet legal and other costs.

There are many other ways in which governments have undertaken increasing responsibilities for the welfare of rural people and especially of those engaged in agriculture. Nearly all European governments now have a specific policy for farm incomes which finds expression in legislation governing the prices of farm products and affording to farmers some measure of guarantee that their incomes—in total if not individually—will not be permitted to fall too far out of line with incomes being received by people in other sectors of the economy. Such measures have given an economic stability to farming which was quite unknown thirty or forty years ago. This stability has been beneficial in stimulating investment and the expansion of production, leading to greater efficiency in the use of labour and other resources. Agriculture is now rightly described as a capital-intensive industry, and it can confidently be expected that those countries which at present stand very low in their degree of capitalization relative to labour will before long enter upon a phase of massive farm investment and improvement, which will have tremendous repercussions on the whole economic and social situation of rural areas.

Besides having a declared policy for prices and incomes, most European governments have what is called a structural policy. This is concerned with the number, size and location of farms as well as with those aspects of layout and arrangement of boundaries which I have already mentioned. In many regions of Europe there are too many farmers; if agriculture is to prosper and receive its fair share of the benefits of economic growth and technical progress, production will have to be concentrated into fewer units. This is not to say that the farms will cease to be controlled by individual families; it seems likely that the family farm will be characteristic of agriculture in Western Europe for many years to come. However, the scale of operations which one family will be able to achieve must and will be greatly enlarged. Some governments have decided that the two-man farm is the minimum economic size which they should help to establish. This means that the scale of the enterprise should be such as to keep two men fully occupied throughout the year. There are millions of small farms in Europe which do not measure up to this criterion, and governments have accepted responsibility for helping to bring about a better adjustment between the agricultural population and the land on which it depends.

Assistance to structural adjustment is taking many forms, but the most important are the steps taken to provide alternative employment for farm people in rural areas, and the arrangements for training rural youth to take up non-farm jobs when they leave school or for re-training young farm workers who intend to transfer to other employment. The process of transition from a mainly peasant economy to one in which agriculture plays a diminishing role has never been achieved in any country without hardship to many of the people affected by the transition; but the significant feature in the present situation is that governments realize that much can be done to ease the transition—which is quite inevitable in any case—and to avoid unnecessary hardship. The pains of growth should be shared by all members of the community—this is the philosophy which has gained wide acceptance in the past twenty years and which is beginning to be translated into practice. One manifestation of it is the identification of "problem areas" or "depressed regions" whose rehabilitation is declared to be the responsibility not only of those who inhabit them but also of the wider community, in some cases transcending national boundaries as in the European Economic Community which has recognized that certain agricultural areas call for special measures of assistance.

In these and many other ways, a new environment surrounds life on the land in Europe. It is no longer seen as a separate, isolated mode of existence, simple, picturesque and self-sufficient. The economy of town and of countryside, of industry and agriculture, is seen as an integrated economy, and the keynote is interdependence, not independence.

A modern system of agriculture requires the purchase of many essential resources—fertilizers, machinery, fuel, processed feedingstuffs, chemical pesticides—from industry; and modern industry depends on agriculture for the supply of many of its raw materials.

Economic development is therefore a closely integrated process, and it is impossible to draw up sound plans for agriculture without reference to plans for other sectors. It is one thing to recognize that there is an excess supply of labour in agriculture which depresses the level of agricultural incomes; it is quite another thing to arrange for the smooth transfer of the surplus active population to other kinds of employment. Yet these are the two sides of the same problem. We are witnessing the acceptance by parliaments of obligations which are too great for small rural communities to carry unaided.

Rural planning is still in its infancy in most countries. The division of responsibility between central government and local government, between one central government department and another, between the State and the individual, has not been fully worked out, and the result is that planning—or interference, as some would call it—is often unco-ordinated, with exasperating results. The farmer finds his life invaded at many points by officials who ask for statistical information, require him to observe regulations to prevent disease and infestation, survey his land and offer him compensation for the compulsory sale of part of his property for the construction of new highways or housing developments, control the quality of his products and his selection of channels of marketing, and so on. This erosion of individual freedom of action has been going on for a number of years and many farmers resent it; but the majority, especially among the younger generation, seem to acknowledge this new discipline as the price which has to be paid for the acceptance by the whole community of the burdens which have to be carried as agriculture is cemented more and more securely into the framework of the national economy and into the fraternity of common citizenship.

And as the farmer awakens to the realization of his new dependence, so the townsman perceives that his "neighbourhood" extends as least as far as his car will take him.

L. G. RABOT

Director-General of the General Directorate Agriculture
European Economic Community

Working Conditions in European Agriculture

Business problems are the order of the day. Economists, while not neglecting general economic problems, are taking a growing interest in the physiology of firms, problems regarding their optimum size, their growth and their role in economic growth, their ramifications, associations and the resultant subsidiary relationships. The heads of firms are showing a growing awareness, particularly in the Common Market, of the need for rearrangement in each sector and as a result there is a vast movement towards concentration. Governments, too, are following any developments in this field with close attention and intervene where necessary. Even countries with socialist economies are showing a renewed interest in the concept of enterprise and its profit-earning capacity.

However, I am not merely referring to current fashion in taking the problems of the agricultural undertaking as the main topic of my talk on working conditions in agriculture. I think it is justified because few economic activities are conditioned to the same extent as agriculture by the type of undertaking in which they are carried on, a type of undertaking which in the case of agriculture is particularly stable, as we shall see.

The main feature of the agricultural undertaking in Western Europe is its extremely small size. In 1960 the average area of farms, excluding those covering less than one hectare, was 8.2 hectares in Belgium, 9 in Italy, 9.3 in Germany, 9.9 in the Netherlands, 13.4 in Luxembourg and 15.2 in France. Another important point is that this average area is increasing very slowly (for example by only 1.3 hectares in Germany in 13 years, 1.4 in Belgium and 1.2 in the Netherlands in 9 years). Even if this growth were more rapid, for example if the average area were to increase by half in a few years, the new farms would still be very small undertakings from the economic point of view. They would still only employ one or two full-time workers.

This basic aspect of farming in Western Europe is the result of its family nature. The head of the family is generally the head of the farm, he and his family provide most of the labour (three-quarters in the EEC), he puts up most of the capital and he or his close relatives (parents, wife, brothers or sisters) generally own the land he farms.

Although incomes were generally low and living conditions hard, until about twenty years ago a high proportion of farm workers had no desire to work outside agriculture and even if they had wished to, they had no real opportunity to do anything else since they were untrained for industrial work and there were no jobs nearby. Consequently, in most families there was at least one child in each generation who stayed on the land, and if he was to remain in agriculture, he preferred to have the social status of an independent farmer rather than to work for a wage. This is why many of the farms in existence before the Industrial Revolution have been handed down from generation to generation and still survive today. Some, of course, have disappeared and been split up amongst their neighbours, but generally speaking none of them has grown sufficiently to employ hired labour. And farms which before the industrial revolution were not family farms in the true sense of the word (*latifundia*, estates farmed on the *métayage* system) have tended to disappear, giving way to much smaller farms of the family type.

Curiously—and contrary to the predictions of famous 19th century economists such as Karl Marx—technical progress has not brought about any great changes in the size of the internal organization of farms; what is more, farms, with few exceptions, have not adopted the form of a capitalist company. A few words of explanation for these two facts will not be out of place.

Towards the end of the 19th century technical progress led to the emergence of the first generation of machines (mowing machines, bunchers, combined reapers and binders) but their prices were reasonable and their running costs insignificant; they were drawn by animals and they were very durable. If necessary farmers made use of the new machines by helping each other or calling in outside contractors (for threshers). These machines fitted into the farm without any need for appreciable modifications in size or internal organization. The same was true of other forms of progress (in genetics, cultivating methods, disease prevention in livestock, fertilizers, etc.) adopted on the farm at the same time.

The second generation of agricultural machinery, consisting of the tractor and a number of harvesting machines, the best known of which was the combine-harvester, had a more marked effect on farms; by using them, agriculture became more dependent on the trade economy and as a result a number of farms unable to balance their accounts were forced to sell up; if they were to use the new machines efficiently, farms had to grow, but to a lesser extent than one might have supposed. In fact the machinery was scaled down to make it suitable for the farms then in existence.

The types of capitalist business organization which could have made farms grow in size did not extend to agriculture. The first reason for this was that in the course of the 19th century, as a result of surplus production and competition from overseas countries, the profits to be made in agriculture had become lower than those in other economic activities where there were opportunities for go-ahead businessmen to introduce profitable technical innovations which had no equivalent in agriculture. In any case, they would have had to buy land, only available at high prices because of the excessive valuations of small farmers for whom the ownership of land represented the right to work. Unless it enjoyed special circumstances, the large agricultural undertaking employing hired labour and forced to pay relatively high and steady wages in order to keep them would have been ill-equipped to withstand competition from family farms. Since the family is prepared to suffer hardships, these farms are far better able to withstand the risks inherent in farming: the risks to production from weather and biological factors and economic risks resulting from price fluctuatons.

One factor which accounts for the refusal, until recently, of farms to adjust under the pressure of general trends is that since the start of the 19th century there has been a constant drain on their dynamic forces: in the economic growth process the other sectors of the economy have drawn upon agriculture for their development and not vice versa. Agriculture has been expected to supply them with the labour and capital they need. Frequently it was just those individuals who would have been most capable of contributing to agricultural progress who left it first. And frequently the farmers remaining on the land had to use their savings to compensate their co-inheritors who had migrated to the town, or else they themselves yielded to the temptation of jobs outside farming, often with greater financial rewards.

The predominantly family nature of the farm has many far-reaching and varied consequences.

1. First a few words on the type of farm which predominates in Europe: it has until now been fairly well adapted to the nature of agricultural production and the level of education of the peasant class. In farming many decisions must be based on the consideration of factors which can only be appreciated on the spot, in the field (literally and figuratively). Examples are decisions regarding soil cultivation or stock management. This is quite different from industry, where practical methods for many production processes can be determined in advance and entrusted to subordinates who in the case of difficulties or hitches can easily refer to their foreman or chief engineer, particularly as such difficulties or hitches can be expressed in a conventional language. Even if the problem cannot be sufficiently clearly expressed in such language, distances are short enough to enable the boss to come and see for himself.

This is not so in agriculture. Yet agriculture on the basis of very large farms is not inconceivable. However, it would require numerous well trained employees at management level for the planning, organization and supervision of work, preparation of budgets, accounting, etc. The more modern and complex the techniques used, the better trained these men would have to be. Until recently the peasant class in Europe was not sufficiently educated to perform these duties. Countries which have tried to develop very large farms without having sufficient competent personnel (USSR, Algeria, etc) have encountered and are still encountering serious difficulties. Therefore it must be stressed that the type of farm predominant in Western Europe was in keeping with the situation prevailing up to now.

This does not mean that things are not changing in this field. A growing number of farming operations can now be effected under conditions similar to those prevailing in industry, for example in stock farming. Also,

farm workers are now better equipped than in the past to take on jobs involving some degree of responsibility on large farms. Therefore conditions are ripe for the establishment of a certain number of large farms.
In doing this, the agricultural world will have to face up to a social problem it has so far generally managed to avoid: that of the wage-earner. Because of the small size of farms and their correspondingly large number, agriculture is the sector of the economy in which economic power is most widely distributed amongst those working in it. Most people engaged in farming have a reasonable hope of becoming the head of the farm and consequently of freely accepting full responsibility. The ability to work hard, intellectual curiosity, a liking for innovation and the desire to save and invest are spontaneously stimulated and encouraged in agriculture.
2. The characteristics of farms are at the root of a number of difficulties experienced by agriculture in adapting to economic growth.
a) First of all one fact should be mentioned regarding adaption of production to the market: the characteristics of farms and particularly their small size have a marked influence on the type of products and the overall volume of agricultural production. As agricultural producers are unable to increase their income by enlarging the area they cultivate (since this would mean that some farms would have to disappear to the benefit of their neighbours), they tend to concentrate on products which make more intensive use of the area available and provide the highest income. This accounts for the extent of speculation in livestock and in particular the high dairy production in Western Europe. It is also the reason for the recent expansion in poultry farming. Conversely, on the larger farms, animal production per hectare is generally lower.
The situation regarding the volume of production is as follows: a long time ago farmers could have used certain technical advances to good effect and did not do so, or did so only to a minor extent. But the outlook of farmers in many parts of Europe underwent a radical change after the second World War. They desperately wanted to enjoy the same income and working conditions as other classes and also possibly to acquire a similar status to industrial workers by using modern machinery and techniques; they started to act on the basis of economic calculations which were often unformulated. The result was an appreciable increase in the volume of farm production which was not based on market or price trends in the same period. By a fortunate coincidence demand increased during the same period because of increased consumption as a result of the higher standard of living, but this was merely a coincidence and not cause and effect. As for prices, since these are guaranteed by the government in industrial countries they have for social or political reasons always shown sufficient profit to make it worth while for farmers to produce more even if their production costs increased.
The main characteristics and in particular the size of farms in Western Europe make it difficult for governments to limit the total volume of agricultural production by price measures; the most it can do is to influence farmers towards certain products rather than others. But there are limits even to this channelling of production. As long as the prices of farm produce are not clearly lower than production costs, many farmers decide what they will produce on the basis of factors other than price: natural conditions, skills acquired, size of farm, available capital, labour to be used, risks run and security factors. Price fluctuations are of course taken into account, but only if they are big enough and appear likely to be lasting. In practice many farmers have little choice open to them except as regards the expansion of some special types of production such as horticulture or poultry farming.
Consequently, a rise in the price of grain is only likely to result in appreciable extra supplies on the market if there are farms large enough to produce grain for immediate sale without the necessity of converting it into animal products to make use of existing labour. There has been some increase in grain production in some countries, but this is a consequence of new opportunities for mechanizing crop production rather than of favourable price trends. Total milk production appears to depend largely on the number of small farms and the labour force for whom they have to find work.
These examples confirm that governments will bring about a better adjustment of agricultural supply to demand just as, if not more, effectively by changing the characteristics of farms and encouraging them to combine within organizations responsible for influencing and disciplining production as by price measures.
b) It is generally agreed that the working agricultural population can be allowed to decline since the same volume of agricultural production can be achieved with less labour provided capital outlay is increased. This reduction is also essential both to increase the income of those remaining on the land and to satisfy the demand for labour in other expanding sectors of the economy.
The working agricultural population of Western Europe has in fact declined considerably in the past century. But the manner of this decline makes one wonder whether in the future it will not be closely dependent on

the size and number of farms. In fact, hired farm labourers who had fewer ties, were the first to leave; working members of the family followed them so that now a growing number of farms are one-man enterprises. In the future the movement away from agriculture can only be of any significance if it is the heads of farms themselves, or those who would otherwise replace them, who move away. Therefore any additional decline in the working agricultural population is dependent on a reduction in the number of farms.

In areas of the Community where the land of abandoned farms does not revert to waste land any reduction in the number of farms results in expansion of those which remain. This expansion will be limited, since it is most probable that the first farms to disappear will be the smallest ones, only a small area of land will be released in comparison to the land held by other farms. Nevertheless it appears advisable to encourage the disappearance of a large number of farms so that production factors can be efficiently combined on fewer but larger farms.

c) There is one problem which does not affect farming in socialist countries but which is acute in our countryside. That is the distribution of agricultural land amongst the various farms. In Eastern bloc countries there is in a given region generally a single production unit, such as the sovkhoz or kolkhoz in the USSR, whereas in the West, apart from some villages where there is only one large agricultural holding, there are several farms in each village which have to divide the land between them.

In some regions the farms, whether owner or tenant-farmed, are estates with fixed boundaries and the problem of developments in their size does not arise. However, in most regions the land is divided into parcels which are not definitely tied to a particular farm and are sold or leased at irregular intervals, which provides an opportunity for farms to expand. But generally all farms want to do this. The law of supply and demand comes into effect, making the selling prices or rents very high, generally as a reflection of local population pressures rather than of the farming value of the land; even if in principle it is the richest farmers who buy, these costly purchases often leave them short of capital for really productive expenditure. Some consider that the allocation of scarce property to the highest bidder is the fairest way of apportioning it. But land is not "reproducible", its production cannot be increased when its price rises and price increases do not have the salutary effect they may have in other fields.

There is a growing trend in Europe for the authorities to intervene. Their first objective is generally to prevent the existence or even the profitability of the agricultural undertaking from being endangered when the farmer dies (right of the farming son to take possession) or when the land is put up for sale (tenant's right of preemption). In other cases the authorities intervene more directly in assigning available land to a given farm, by making the operation subject to their supervision, by giving financial compensation to those giving up their land or by temporary purchase of land to apportion it more suitably than would be done voluntarily. It can make a big difference whether 5 hectares from a farm which has been given up is attached to a farm of15 hectares or one of 45 hectares. By means of succesive additions of land, the farmer may hope to attain a size suitable for the efficient combination of production factors, while the latter may have already exceeded this size.

d) The possibilities of *using and combining production factors* are closely dependent on the size of the farm. Firstly, as regards the quantities available, the family-type farm is often limited to its own resources; it finds it difficult to pay hired labour and the capital it uses is money which has been saved (but with difficulty, in view of the small size of the farm and its low income), or at a pinch borrowed from loan funds. Its small size and legal status make it difficult for outsiders to participate directly in financing it under the same conditions as on the capital market, as is customary in the case of companies.

The small size of the farm also makes it difficult to use certain types of machinery or equipment; it is then necessary to turn to machinery or equipment which is smaller but often more expensive to use; for the same reason the number of buildings (particularly cattle sheds) is increased because there is one small one on each farm.

A proportion of the labour force of each farm is always unwilling to consider changing its job; the strength of this proportion can generally only vary by half, one third or one quarter (one worker fewer out of two, three or four).

All these reasons militate in favour of enlarging the economic size of farms, as this would facilitate their financing and also permit more efficient use of capital and more flexible and above all more economic use of labour. One possible solution is for farmers to call on the services of contractors using machinery which cannot be kept by a single farm; this method is being used more and more (grain, sugar beet, potatoes, flax).

Another is for farmers to help each other, but this raises serious problems. A third is the association of several farms for group farming or to pool together in a production "workshop."

e) The small size of farms accounts for the problems which arise in their relations with the industrial or commercial enterprises to which they sell or from which they buy and which are in general economically much more powerful. In fact, these problems appeared until recently to have become less acute: farms had overcome the drawbacks of their small size by grouping together within co-operatives and the authorities had organized and supported the markets for the main agricultural products so that industrial and commercial firms had little influence on the marketing and price of farm produce such as grain, wine, butter and most cheeses.

This situation is now changing and for a growing number of products such as eggs, poultry, pork, fruit and vegetables the type of relations between agricultural and non-agricultural undertakings is of vital importance for the survival and growth of the former.

The present trend with such produce is towards what is known as a contractual system or vertical integration. The farms and the industrial or commercial firms enter into an agreement not when the quantity produced is ready for the market but before anything has been produced at all. A contract is signed which amongst other provisions specifies the quantities to be produced by the one and bought by the other party, and states the price of the transaction or at least the method of calculating it.

This system gives the farmer increased security; he enjoys a guaranteed market and is protected against price fluctuations. The firm with which he deals enables him to benefit from useful technological innovations, helps him to organize his farm, gives him technical assistance, encourages him to invest more capital, lends him money or enables him to obtain capital.

As a result integrated farms of this type gain new opportunities of achieving economic growth; in return they give up part of their freedom. In its own interests, the company with which they deal will increasingly decide on the type of activities, capital outlay and eventually the future of the integrated farm. Consequently, by deciding to conclude contracts with a certain type of farm in a specific region, industrial or commercial firms practising vertical integration of this nature will play a decisive role in the development of large sections of agriculture.

In conclusion, I should like to stress in particular the effort agriculture must make to improve its capital equipment in order to increase productivity, adapt its production to trends in demand and make up for the necessary reduction in labour.

These efforts will largely relate to machinery such as tractors, tilling, treatment and harvesting machinery or transport equipment. It is essential to purchase such equipment, above all for the efficient utilization of the manpower remaining in agriculture. But there is another form of capital equipment less frequently mentioned which is nevertheless badly needed and on which there is less information then on machinery. I refer to farm buildings. This part of the farmer's fixed assets is often very old and consequently in poor condition and above all ill-suited to the increased activities on many farms and to modern working methods. For example the widespread use of the combine for harvesting grain poses completely new storage problems. The barn of yesterday is useless; bins are now required to hold the grain. Similarly the increase in the number of livestock on the farm and the reduction in available labour make it necessary to redesign many livestock buildings.

Farmers hesitate to embark on such capital investment; the cost is high, it is difficult to pay off, and the future of some products is still uncertain, at least at farm level. Their hesitation is partly because they do not yet know enough about the simple, functional, multipurpose buildings at reasonable prices which modern industry is or would be able to provide.

The trend in working conditions on the farm make these efforts to obtain new machinery and buildings essential; in addition the choice and size of machinery and buildings and their financing depend on the expansion of the farm themselves, on their size and their grouping together for production purposes. Generally speaking, the income of those working on the land can only improve as a result of three developments which must be pursued simultaneously so that their effects are combined: reduction in the labour-force, an increase in the size of farms and, finally, capital equipment for agriculture, a field in which the steel industry can play an important part.

2 *Proceedings of the Congress*

Working Party I

Steel

in Farm Buildings and Installations

Chairman	*Prof. ing. A. Ramadoro*
Rapporteur	*Dr.-Ing. H. Odenhausen*
Introductory Papers by	*Prof. Ir. W. F. Coolman*
	Dott. ing. I. Potenza

Prof. Ir. W. F. COOLMAN

Hoofd van het Instituut voor Landbouwtechniek en Rationalisatie
Wageningen

How Buildings and Installations Can Help to Rationalize Farm Work

(Translated from Dutch)

Agricultural work has undergone great changes in the present century. Countless inventions, often by technically-minded farmers, have led to greater mechanization. Industry has, moreover, taken over many ideas and developed them, producing implements and installations that are not merely efficient but ergonomically justified. Then the places in which the work is to be done—the farm buildings—are now in the process of evolution, or even of revolution in some areas.

The relation of agricultural workers to their work has likewise completely changed. The long working day is becoming rare and now occurs only from time to time, usually because weather conditions demand it. In more developed agricultural areas, the heavy physical effort of earlier days has to a great extent been replaced by the intelligent use of usually expensive technical aids making more mental than physical demands on the operator. All this has pushed traditional methods into the background. Certainly, the farmer does not forget that he is dependent on the weather, the soil and the market, and consequently he invariably reacts in accordance with often unwritten natural laws; at the same time there is a feeling of wanting to know more and be able to achieve more, which has helped to give rise to new working methods. The work can still be satisfying, and the farmer has not been robbed of his pride in producing a fine crop; the pride we see expressed with gratitude in the gay display of the harvest festival.

It is remarkable what large differences still remain in the degree of development. The more modern European farms stand comparison with those in the United States, where wage and price relations led much earlier to technical development, or in New Zealand, where it is primarily the climate that gives farmers their lead. Even in advanced European countries, however, and even in the United States, there are still many small family farms that cannot raise the necessary capital for modernization, and for which some other solution must be found. Nevertheless, there is evidence of a definite development based on increased labour productivity, which is the only way to help increase workers' earnings. On the one side we see a reduction in the number of family workers, and on the other, in some areas, a switch to the more intensive use of land, to horticulture, for example, or to pigs or poultry, which need hardly any land at all if their feed is bought. In spite of these changes, big differences in farm sizes will remain, and with them differences in production techniques; solutions must still be sought for the smaller farms. This is why it can be so misleading to work from averages in agriculture. The differences between hill farming and farming on level land are too great, and so are the differences between one type of soil and another. Today's farm types are based on the experience of years, and cannot be changed just like that.

Technical development demands investment. In the mind of the ordinary farmer, borrowing money is an admission of failure, something he has to do when the harvest has let him down. Farmers do not like borrowing. They prefer to pay cash for their supplies and for farm improvements too.

This is why financially good years always see an increase in new buildings and the purchase of new equipment. Modern farms, however, are already being financed more "industrially" than they used to be.

Whenever profits remain steady, the modern farmer will be ready to borrow, apart from the times when circumstances force him to do so. High wages, the loss of labour to other branches of the economy, and the knowledge that not to modernize will put him behind, make borrowing, e.g. for labour-saving equipment, a necessity. He does it then as cautiously as possible. Only very few farmers really aim at the correct proportion of the three factors of production—labour, capital and land—in their system of farm management.
A final point to wind up my introduction. Farmers are businessmen too, wanting the best possible income compatible with maintaining or extending their production equipment. To this extent they in no way differ from their usually much bigger counterparts in industry. On the income side, however, the situation is very different. With crops varying according to the weather, and often only limited scope for expansion, farmers are nearly always confronted by relatively inflexible demand for their produce.
Only in exceptional cases are returns substantially higher than the cost of production. Margins are often small, whether artificially or not. Economically, the farmers are in a weak position nowadays, and the sad thing about modernization is that while it often helps the consumer it does not help the farmer, at least not in the sense that he is much better off as a result. He just manages to hold his ground. But he still ploughs on, because it is not only his trade but his vocation.
The preceding general survey is followed by a more technical and statistical evaluation of developments in the field of labour rationalization, with particular reference to conditions in the Netherlands.

Development of labour productivity

Because it is largely in the years following World War II that the use of technical aids has increased, an attempt will be made to indicate the trend from 1950 to 1965 with the aid of a few relevant figures.
The following *table*, compiled from data supplied by the Central Statistical Bureau and the Agricultural Research Institute, both in The Hague, first gives some labour figures (lines 1 and 2). The number of full-time workers shows a steep drop. Since 1960, the annual loss has amounted to about 20,000, which works out at nearly 4% per annum. It is expected that numbers will fall to about 300,000 regular workers, or roughly 6% of the total Dutch labour force, towards 1975.
Technical development is illustrated by the figures for machinery in lines 3 and 5. Tractor capacity per full-time worker increased during the 1960-1965 period, but the fact that in 1965 there was still only one tractor for every three workers shows that, from the technical point of view, there is still room for more: there are parts of the United States where the ratio is 1.5 tractors per worker. The drop in the number of draught horses is obvious (line 4). Incidentally, the figure for 1965 is equally typical of what has happened on many small farms.
On farms with a fair amount of livestock, a great deal of time has to be devoted to their care, usually amounting to over 50% of the total working time. Milking machines, which start to pay their way at six or seven dairy cows, are now in fairly general use (line 5).
If the minimum could be reduced to five cows per farm (line 6), it seems that the 76,000 milking installations in use in 1965 might be extended; in that year there were about 73,000 farms with more than 10 cows. Theoretically, each of these should be milking mechanically, and it seems that in fact they are. We can also see a distinct growth in the number of cows per farm, particularly in the ranges 10 to 20 and 20 to 30 cows (lines 8 to 10). This is partly because many small farms have disappeared, and partly because, with fewer farms, the total dairy herd has become larger (line 7). For reasonably complete mechanization, however, a herd of 50 to 70 cows seems desirable (about 25 cows per worker); in the United States they talk of 80 to 120 head as the right number for a family farm, while in New Zealand, with its favourable climate, there may be 160 to 200 head on a family farm with perhaps no more than two able-bodied workers. But in the Netherlands over half the dairy farms have less than 11 cows (line 11), which reduces the chances of rationalizing labour. Clearly the scale needs to be enlarged. This is true of many West European countries. Buildings also have a part to play, which will be considered later.
In the Netherlands, intensified livestock husbandry usually means pigs (line 12). The practice of buying feed has nearly doubled the number of pigs being kept for fattening. This has called for big investment, especially in buildings. However, rational working is still by no means possible everywhere. Even in 1964 only 3% of the farms keeping pigs had more than 50 of them and only 9% had between 30 and 50. Rationally managed pig

farms in America keep up to 500,but theese are farms where pig fattening is the main activity, instead of being the more or less specialized side line that it usually is in Western Europe.
Modern Dutch pig farms are, however, already based on a minimum of 150 to 200 head. There would be room for further development in this field, if it were not for the fact that the pig market is as easily overstocked as the dairy produce market; moreover, small farmers who keep a pig or two can supply a big share of the market without much extra investment, and with only a little extra work each morning and evening—not enough to be reckoned in the cost. On the other hand, the big slaughterhouses are going to demand a larger quantity of uniform product, which will favour the large production units.

Development of Labour Productivity in Dutch Agriculture and Horticulture

	1950	1955	1960	1965
1. Full-time workers, in thousands	700	567	502	403
2. Full-time workers as percentage of total working population	19.9	14.0	12.1	9.4
3. Wheeled tractors in thousands	24	45	82	130
4. Draught horses, in thousands	208	184	138	84
5. Milking installations, in thousands	3.8	9.2	38.6	76.0
6. Farms with over 6 dairy cows, in thousands	115	114	121	117
7. Dairy cows, in thousands	1,520	1,510	1,628	1,723
8. Percentage of farms with 10-20 dairy cows	16	18	23	32
9. Percentage of farms with 20-30 dairy cows	5	6	7	9
10. Percentage of farms with 30-50 dairy cows	2	2	3	4
11. Percentage of farms with under 10 dairy cows	76	74	67	55
12. Pigs for fattening, in thousands	900	1,016	1,205	1,698
13. Egg producing poultry farms, in thousands	230	237	173	133
14. Broilers, in millions	—	—	5	13
15. Gross value of total output, in million Fl.	3,481	4,682	6,198	7,827(1)
16. Net added value, in million Fl.	2,149	2,740	3,652	4,556(1)
of which wages paid, in million Fl.	443	568	663	750(1)
of which rent, in million Fl.	107	154	176	192(1)
17. Farmers' income, in million Fl.	1,599	2,018	2,813	3,614(1)
18. Gross output at constant prices, in million Fl.	3,973	5,260(2)	6,204	6,646(1)
19. Man year units, in thousands	522	445(2)	418	357(1)
20. Labour productivity/man year unit	7,611	11,820(2)	14,842	18,616(1)
21. Do. as percentage, 1958 = 100	64	100(2)	125.6	157.5(1)
22. Cost of living index, 1938/39 = 100	240	319(2)	330	368(1)

(1) 1964: figure for 1965 not known.
(2) 1958: figure for 1955 not known.

The same reasoning applies to the egg and poultry industry. In the laying hen sector recent years have seen a marked recession in the Netherlands. Widely fluctuating egg prices have had a big effect on the size of the flock. Since labour costs contribute less to the cost of egg production, the urge to increase the scale of operation is not so great as it is with milk production. In 1964, the number of farms with over 400 laying hens was only 17% of the total number of farms delivering eggs. This is about as many birds as are needed to justify the use of simple mechanical aids. Egg production on a big scale, with automatic feeding and egg collection, requires a flock of at least 2,500 birds. In 1964 only 504 farms, out of a total of nearly 133,000 were operating on this scale. This is a sensitive market, in which the big, specialized farms run more risk than the farmer who keeps hens as a side-line and can easily retrench or expand. The broiler sector has grown rapidly since 1960. The number of birds per farm has risen too, from not quite 1,000 to over 3,000 in a batch. This branch of farming needs little labour, but does require special buildings and installations; thanks to the high level of export prices, it has been quite profitable.

After these examples of development in the direction of increased size and specialization, a few items on the general state of Dutch agricultural production.

Total labour productivity of agriculture (field crops, livestock and horticultural produce) are shown in lines 15 — 21. The gross value of production, including internal supplies, has risen considerably. This was due, among other things, to (*a*) increased output, and (*b*) higher prices. The net added value, or farm income, is what is left after allowing for the purchase of raw materials, depreciation, taxes and subsidies. This farm income is further subdivided into wages, rent, and the remainder, which is the farmers' personal income; these too, have risen. To eliminate distortion caused by rising prices, gross production is shown at constant (1958) prices in line 18, immediately before the number of man year units (line 19). Lines 20 and 21 show what progress has been made. With better working methods, and with technical aids being used to increase efficiency, the number of farm workers has dropped by a good 40% since 1950, while their productivity has more than doubled, in net as well as gross value. Moreover, this has been accompanied by a big reduction in the number of women working on the land, and by a marked general improvement in working conditions, both material and social. With the higher cost of living, however, the purchasing power of this increased labour productivity has fallen, which brings us back to the farmer's economic weakness as a food supplier.

The examples in the foregoing outline of the trend in labour productivity are taken from livestock husbandry, because this is where the most labour is needed, and where buildings and installations play so large a part. To complete the picture, it should be noted that arable farming and horticulture make quite a substantial contribution to the national agricultural income in the Netherlands (16 and 18% of gross production respectively), and that in the latter sector especially a big part is played by glasshouses and the equipment that goes with them.

Technical aspects of developments in labour rationalization

Agriculture has fallen behind many other branches of the economy in the application of technology, both from the technical and the work-organization point of view. The difference between agriculture and industry is particularly wide. Many farm implements have hardly changed since the days when they were produced by the village blacksmith. Most of them are used for only a few hundred hours each year, because they can only carry out one partciular operation. Even the more versatile, such as farm tractors, seldom work as much as 1,000 hours a year. Therefore people try to economize by spending as little as possible on maintenance. Nevertheless, a machine capital of between 30,000 and 40,000 Fl. per worker is not uncommon.

With fixed indoor installations the situation is different. These are mainly concerned with livestock husbandry and are therefore in daily use. A milking machine, for example, operates 1.5 to 2 hours twice daily, or about 1,000 to 1,400 hours a year; an automatic feeder in a broiler house works for 20 minutes every other hour, or nearly 225 hours in each fattening period of 56 days and about 1,300 hours a year.

These hours are still decidedly less than those worked by most industrial machinery. Still, these installations tend to be more sophisticated than much farm equipment, particularly in their automatic, or semi-automatic, operation (independent starting and stopping, regulation of quantities, transport). Much research has already been done on materials handling with particular attention to feeding equipment. The installations used by the Rothenberger brothers in Illinois to store and supply feed for their beef cattle may serve as an example (*Figs. 1, 2 and 3*) they feed 350 head twice a day, taking only 14 minutes each time to do the job. Four feed augers put the correct proportions of two kinds of maize, chopped green maize silage, and mineral concentrates into the mixing hopper; the big auger delivers the mixture evenly along the feed trough. Feeding entails no more than pressing a button. It is hardly necessary to describe every such installation here; the point is that transport on the farm, which formerly involved wheelbarrows and sacks and bales, can now be carried out automatically, in an unbroken stream. This calls for machinery that is not only modern in its conception and operation but, also capable of working in all weathers, unaffected by the dust and dirt inherent in agricultural production. That potatoes, grain, pig feed and milk, for example, call for different treatment is obvious enough, not to speak of disposal of manure.

Obviously, buildings play an important part in all this. Here Europe has its special difficulties. If there is anything that expresses the link between farming and tradition, it is the farm building, often representing the achievement of several centuries. How different is the situation of the American farmer in the productive mid-

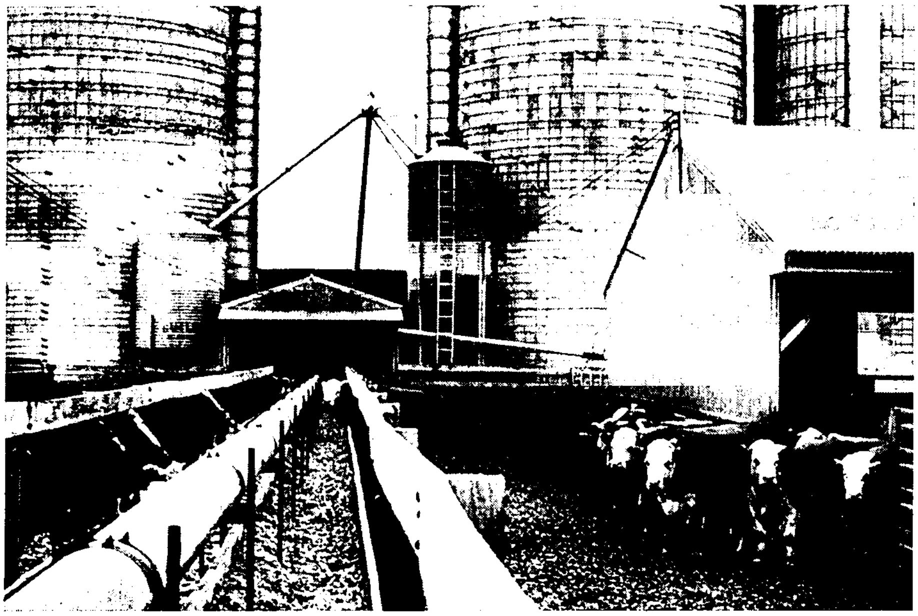


Fig. 1—Central mixing area for rough fodder, with feed trough dividing the yard in two.

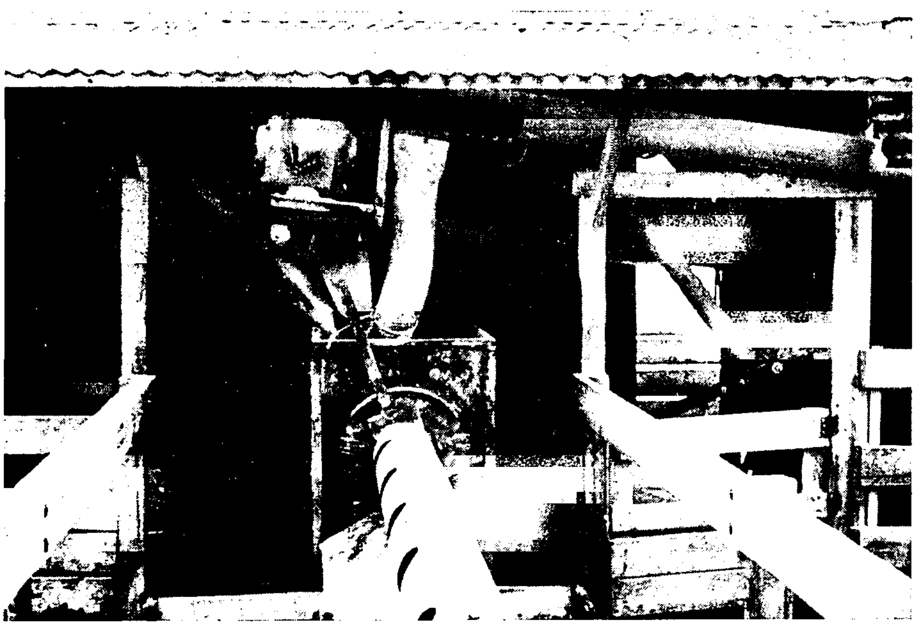


Fig. 2—Central mixing hopper with auger to take off the feed. The auger unloads to the left or the right at the turn of a handle.

western states, who regards building as part of his work programme; some universities, in Illinois, Iowa, Ohio and Indiana, for example, will design complete farmyards, groups and different types of building, and suppliers of sectional buildings specialize in this kind of production, so that the farmer with a few helpers can put up inexpensive buildings which can be written off after 15 or 20 years. A few decades ago, when labour was less scarce, the European farmer could afford an indulgent smile for this way of doing things.

We compare these extreme points of view for a purpose. In planning new buildings, the modern European farmer certainly does not neglect rational working, larger units, complete or semi-automation with or without gravity feed. Western Europe too is familiar with sectional buildings and modular structure and standardized units, but in our climate we prefer to build rather more solidly and for longer life, because the principles of any particular occupation are often embodied in the building, and we do not regard such an occupation as merely semi-permanent. But we shall need to do a lot more work on buildings for the care of livestock, where it is possible to achieve a more rational use of labour.

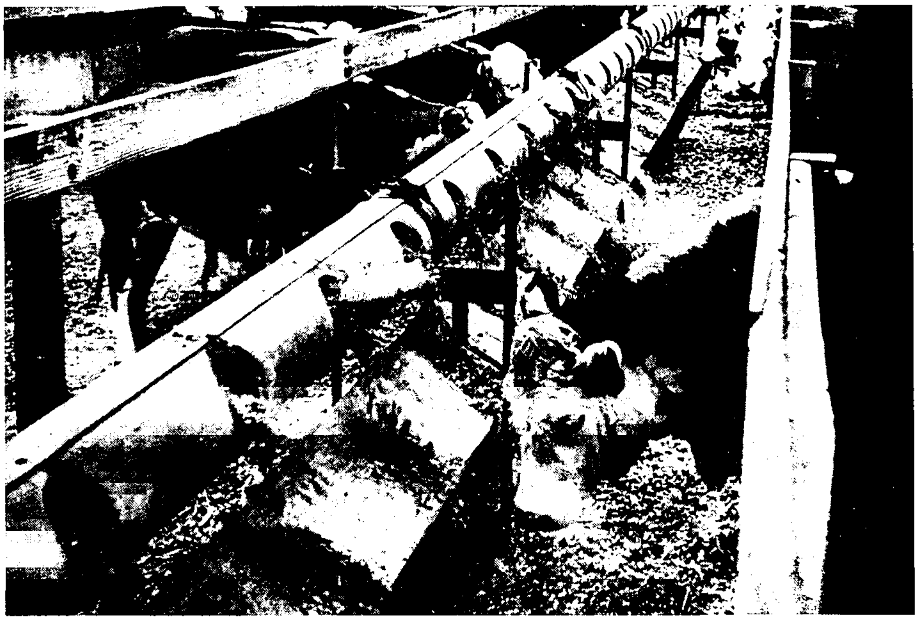


Fig. 3—The auger in action, filling one side of the trough.

This means that there must be adequate access to the place where the feed is stored, to the place where the stock is kept, and from one to the other, and that provision must be made for the removal of the end-product, including manure, with a minimum of labour. Care must be taken that the bigger units thus achieved do not result in less individual attention to the stock, as this can quickly lead to a fall in the feed conversion rate, which is a very bad thing.

Next in importance to the housing of livestock in the range of farm buildings comes covered accommodation for machinery, with space provided for maintenance work. This last activity is becoming increasingly important on the modern farm, as the cost per hour of skilled labour is rising steadily. Here, too, the United States points the way.

To conclude, it is noticeable that metal is being used more and more for building components. In Europe, we are already used to all-steel grain and green-fodder silos, tractor sheds and barns, in which the advantage of easy assembly offsets the higher cost of the material and its maintenance. The price competition offered in different localities by other materials, such as brick, concrete, and wood, make it impossible to give any averages for this but at least there is no doubt that every type of farm can use an easily constructed large clear area with a level floor.

Conclusion

The foregoing can be summarized, from both the technical and the economic point of view, by saying that agriculture is modernizing itself on the basis of increased labour productivity. Rising wages (index figures for the Netherlands are 85 in 1952 and 250 in 1965), and the much slower increase in the use of technical aids (index figures 120 in 1957, 140 in 1965) show clearly that more effort must be made to replace labour by machinery. On the other hand, as the price of farm produce has not risen very much (index figures 98 in 1950, 118 in 1964), it is evident that a much higher output per worker is needed for a farm to carry on at all.

To achieve this, good planning is essential. Small wonder that in management studies and labour theory such concepts as linear programming and labour budgets have become the rule. To translate these into a form that the progressive farmer can not only absorb but put into practice is a matter to which the information and advisory services are already devoting and must continue to devote close attention.

To sum up:

(1) the livestock or arable farmer of today works with a capital of between 200,000 and 300,000 Fl. per worker (in horticulture the figure is considerably higher), 20 to 25% of it invested in buildings and installations and 7 to 15% in machinery;

(2) about half the cost of exploitation is taken up by operating costs (machinery and labour);

(3) these are usually the only cost factors that can be modified to any worthwhile degree, other costs being usually pretty well fixed or at any rate hardly to be influenced by the farmer;

(4) although natural costs have a considerable effect in the determination of yields, production costs per unit of production are often decided by the degree to which the work is rationalized;

(5) the manufacturers of machinery, equipment and building components can therefore play an extremely useful part in lowering the cost of food production on various kinds of farms;

(6) a proper co-operation between agriculture and these industries is the key to a healthy development of the function of agriculture in society and a concern not only of the farmers but of everyone. Technical development is a necessary and important aid to this end, but not an end in itself.

Dott. ing. Ivo POTENZA

Direttore generale della Costruzioni metalliche Finsider
Milano

Industrialized Manufacture of Farm Buildings and Components

(Translated from Italian)

I often hear talk of "industrialization" in the building trade, in agriculture and so on. In my experience, people tend to use this term far too loosely, meaning that they want to transform the building trade into an industry or, in other words, to apply to building concepts of construction usually associated with industrial processes. This is only one side of the problem. The most important aspect of industrialization is, I think, that of enabling industry to take part in building, using low cost systems. This must involve establishing standardization and the use of modules in building and in farming, since these are the basic pre-conditions making possible the mass production, according to fixed and accurate construction standards, of the components required for assembling buildings. By these means industry can produce the required units at low cost, employing repeatable standards and ensuring the highest degree of quality control. This does not mean to say that all the buildings will be the same, but that, while they may differ in appearance, all will be assembled from mass produced components readily obtainable from a number of manufacturers and distributors.

To get the idea we need only think of the finest example of a standardized building component, brick. Bricks today come in standard sizes and can be obtained from many producers, but vary in quality and design according to the use for which they are intended. Standardization has resulted in the establishment of better and better equipped works producing brick of the highest quality for the most specialized purposes. And it is thanks to this very fact that brick stands up so well to competition from new materials. It will only be superseded—and then not completely, I think,—when new materials are produced in accordance with well defined standards and when more manufacturers can produce them without having to devise them specially every single time.

I hope my praise of brick has not upset my hearers who, like me, only really know and love steel!

Until a few years ago it was quite unheard-of in most farming circles to talk of practical applications in agriculture that involved essentially industrial practices and processes. In those days the idea of agricultural industrialization went just about the length of machines as such—threshers, mowers, tractors and so on—but no further. Fixed equipment was installed as and when required, using all sorts of different systems and designs, which frequently depended on the resourcefulness of the individual and were certainly not the best and most economic ways of going about it.

But as time goes on it is becoming more and more apparent that on farms of all sizes traditional methods are being almost entirely abandoned. The planning and construction of buildings on an industrial basis is becoming more and more the rule, because it is the only way to build really economically.

Nowadays we do not just muddle through any more: it is quite common to find special courses being run for architects on the designing of various types of farm buildings. This process of industrialization in the broad sense has developed steadily with the increasing production, by manufacturers specializing in steel buildings, of mass-produced structures at increasingly competitive prices. And so, as the industrial product with its indisputable economic advantages has established itself on the market, agriculture has grown steadily more aware of the vast potentialities open to it and has made the most of them in every one of its sectors.

Today these mass produced structures have become an indispensable and exceptionally economic item of guaranteed quality, offering unquestionable advantages of all kinds at every stage of operations, as regards transport, erection, extensions, recovery value, and so on. The components are invariably of highly accurate manufacture, light in weight and compact in their dimensions, and so economic to transport from the production line to the building site. The simplest plans are used in every case, so as to achieve uncommonly light, versatile and workable structures.

No more hit-or-miss approach—the project is carried out in a series of carefully-planned stages, thus ensuring complete adherence to working programmes and, above all, keeping costs down.

Steel is highly suited for industrialized uses in all farming infrastructures, owing both to its intrinsic advantages and to its competitive cost. It is worth noting in this connection that to judge by developments, in countries more advanced than Italy and by the tenfold increase in Italian consumption between the pre-war period and today, the use of steel in Italian agriculture may be expected to go up very considerably. In this paper, I shall deal in particular with one of the factors contributing to the industrialization of farming in Italy: I refer, of course, to the role of mass produced farm buildings.

The basic reasons behind the increase in the use of steel in buildings are

- its strength and lightness;
- its convenience to transport;
- the quick and easy erection it allows;
- the fact that, thanks to modular construction of components and a variety of methods of assembly, it is possible to alter the size and use of the building;
- the ease with which the building can be taken down and put up again elsewhere;
- its space-saving properties;
- the very wide spans it makes possible;
- the small amount of maintenance it needs thanks to galvanization or special protective coatings;
- the fact that it is fireproof and will last more or less indefinitely;
- its relative cheapness.

But the main characteristic of a prefabricated steel structure is its versatility. Thus it can be used for:

- barns, sheds and so on for housing farm implements and machinery;
- storehouses for crops, seed, fertilizers, etc.;
- hay and straw barns;
- livestock housing, including cowsheds, henhouses, piggeries, stables and sheepfolds;
- cold stores;
- repair workshops, etc.;
- glasshouses;
- silos.

To give a fuller picture of what is going on, I now propose to describe two types of standard structure produced in Italy.

The first type is based on the use of unwelded tubing with a high yield point, and is assembled from just a few components held in place by means of bolts of standard size and design. These basic components are

(1) *purlins*, consisting of tubes merely cut to size with fixing holes at both ends;
(2) *wind-braces*, rods with straining bolts;
(3) *roof trusses*, consisting of two joint-type welded lattice girders placed according to the pitch of the roof, fixed together at the ridge with a flanged joint and at the base with a tie-rod;
(4) *stanchions*, consisting of tubing cut to size equipped with welded plates at both ends to support the trusses and fix to the foundations.

These are, as you can see, easily manufactured structures, made on ordinary mass production lines for cutting and drilling with the additional use of Müller-type moulding rigs to ensure perfect cutting of the tube's extremities at the points selected for joints. They are not however, the very last word in economy, since a certain amount of costly labour is still required for the necessary hand welding, though this is made easier by clamping and aligning equipment.

But the second type, consisting of cold- and hot-formed sections, represents a fresh advance in a field where brilliant results have already been achieved. This type of structure is manufactured by a process which can fairly be said to be unique: a series of sections is cut to size with varying characteristics and measurements depending on the structural components to be produced, and these are then passed along a production line for automatic drilling. By this method it is possible to process several hundred kg. of material per man-hour. The joints are secured by a standard type of bolt *(Figs. 1a and 1b)*. In the simplicity of the whole chain of operations right up to the completion of the building these structures are perhaps even more advantageous than the others. They undoubtedly provide the customer with a highly finished job at a thoroughly reasonable price.

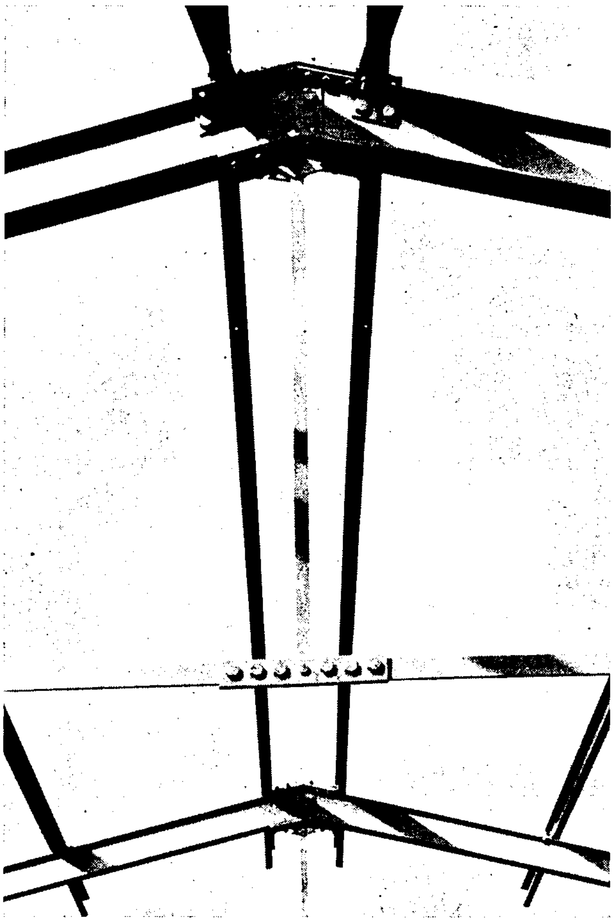


Fig. 1a

Fig. 1b

Farm buildings of every size, type and degree of importance have been built using the first type of structure, covering a total area of over 1,000,000 sq.m.

Structures of the second type are more recent in origin, but many have already been put into use for a variety of purposes.

While we are dealing with this type of all-bolted structure, it is, in my opinion, worth mentioning the bins and containers which are being used more and more in agriculture for all storage purposes; they have opened up new and greatly improved methods for the ensiling of crops, which has in itself become a fully industrialized operation.

The methods adopted in Italy for the factory production of this type of structure are likewise highly streamlined. The bins consist essentially of a framework made from steel sections; the uprights are manufactured on automatic cutting and drilling lines (like the structures used in those buildings we looked at earlier), while the straps are calendered in addition,. This framework is then clad with corrugated sheet, drilled in bundles, which makes it quick and economic to assemble afterwards. To this group of basic components are then added the usual accessories such as loading and discharge outlets, access and inspection covers, and so on. Finally, special attention has been paid to making the bins airtight: all bolts are equipped with suitable washers, and where steel surfaces overlap special jointing is inserted.

These measures of industrialization at the planning and production stages are appropriately followed up in all the ensuing operations.

1. The items leave the production line and are warehoused ready for despatch. Delivery dates are, as a result, extremely short.
2. The components, thanks to their small bulk and low weight, are easily packed, suitably marked. On arrival at the building site their identification and subsequent assembly are thus greatly facilitated.
3. The simplicity and lightness make them exceptionally easy to assemble. The assembly joints, which are never welded, are of a simple design; the bolts used are of one type only, the spanners are standardized accordingly, and only very ordinary lifting equipment is required. The structures are rapidly and cheaply assembled, and it is by no means always necessary to employ gangs of skilled workers. Indeed, with the help of detailed assembly drawings and plans drawn up for the purpose, they can be put up even by persons without special knowledge in the matter, which is a very considerable advantage in agriculture.

In a word, the implications are as follows: thanks to these advances, specialized producers are now able to supply accurately manufactured steel structures, suitable for all purposes, more and more cheaply, to the great benefit of the farmers, who can thus plan each project on a really economic basis, using modern building and management methods.

To give an idea of the versatility of steel, I should like to make a quick review of some of its most important uses in agriculture.

Barns, sheds, etc., for housing farm implements and machinery

The steadily increasing use of expensive mechanized equipment in agriculture makes it essential to have proper accommodation for this. Steel structures lend themselves admirably to this purpose, since they consist of modular components designed for assembly. They can be put up in all sorts of shapes and sizes. This makes them suitable for use on any farm. They can be built lengthwise or crosswise, as preferred, to suit the sites available and the equipment to be housed in them.

Besides being functional and practical, they are more economical than traditional buildings or the makeshift structures farmers sometimes run up themselves; the latter are only apparently more economical since, in reality, they are neither durable nor particularly efficient *(Fig. 2)*.

Storehouses for crops, seeds, fertilizers, etc.

Here too, steel is proving most useful, since it is to the farmer's advantage to provide proper protection for his produce, which is very much more important to him than the cost of acquiring suitable accommodation for it.

In this particular case moreover, where space-saving is a specially important consideration, it is a further advantage that steel trusses and columns take up far less room than their traditional counterparts, and thus make for more efficient utilization of storage capacity and in the long run greater economy. Another very considerable advantage, which applies in every field of application, is that steel structures lend themselves admirably to the use of both transparent infilling and steel or fibrocement sheets in the roof and sidewall cladding, which permits a rational and economic distribution of window-openings.

Again the speed and ease with which steel structures can be erected and the small quantity of foundation rubble needed enable them to be put up wherever they may be required, thus avoiding deterioration and wastage of produce.

Hay and straw barns

All the points I have just made also apply here, and in additon the fact that it is possible to build to considerable heights with comparatively slender stanchions.

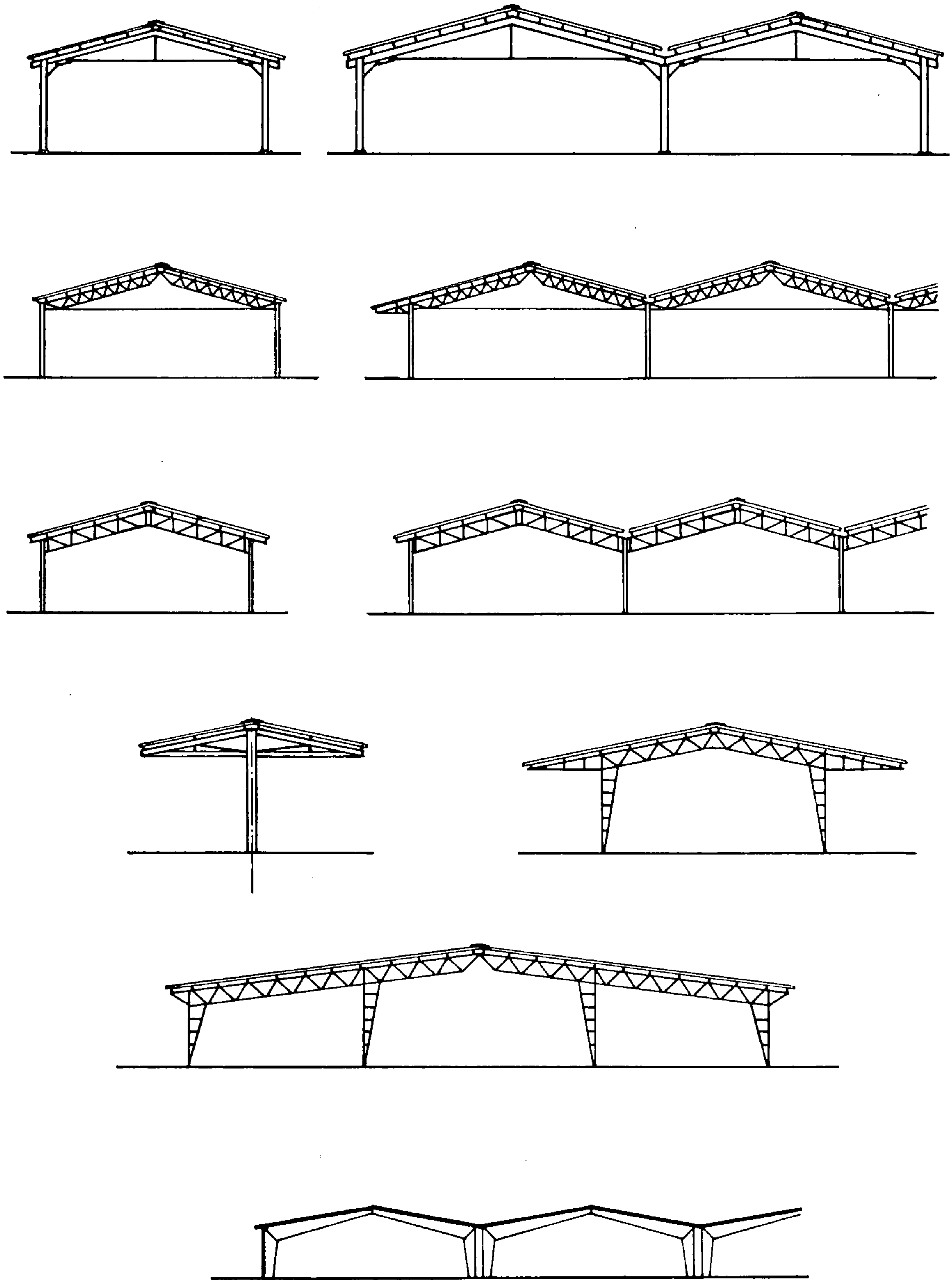


Fig. 2

Livestock housing

The present major manpower shortage is bearing more and more heavily on farming, whittling away the already tiny number of farm labourers that remain and thus increasing the cost of their services. This necessitates choosing very carefully among the new ways and means available for making stockbreeding pay. The initial and maintenance costs of capital equipment for animal housing per head of livestock are factors of crucial importance to the success of the enterprise. Obviously, therefore, the closest attention must be devoted to finding the correct and, at the same time, the most economical answer. One good answer is prefabricated, industrially-erected steel structures, which being light and easily transported can well be put up even at great distances from the plant where they were manufactured, unlike the heavier type of prefabricated building. The shallow foundation required is also a help in areas with few roads, as in consequence highly efficient modern buildings can be erected in places very remote from any industrial centre.

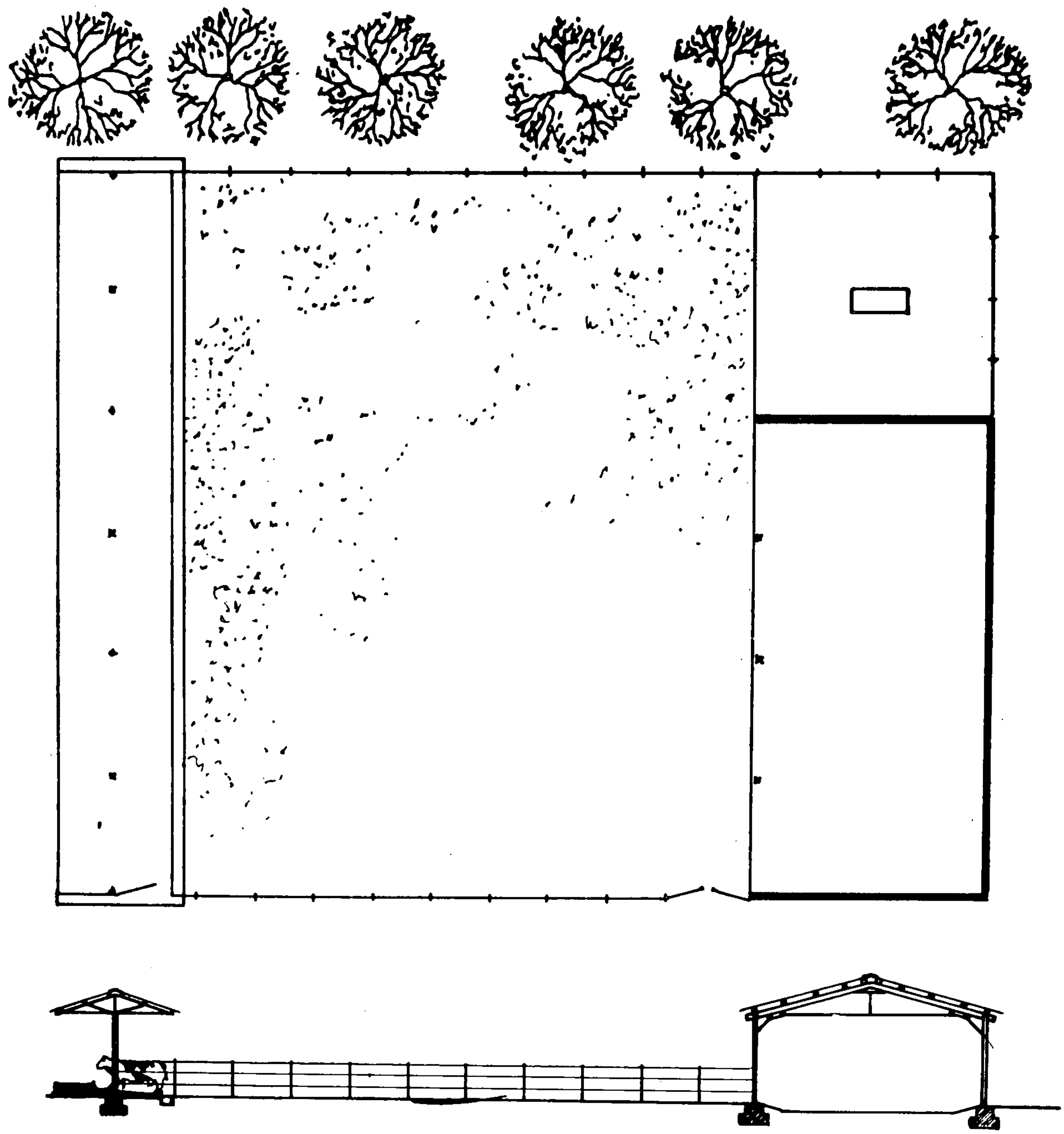


Fig. 3

The types of structure used for animal housing with internal feeding arrangements are usually sheds with couple-close roofing and with or without a lean-to on either side. In the case of loose housing with outdoor feeding arrangements, where the feeding area is separate from the resting area, a different layout has to be used with three different parts, the loose stable, the feeding shed and the fencing. An example of this type of plan is appended *(Fig. 3)*.

As can be seen, steel was put to good use in all three. Considerable advances have been made in this field since, as is recognized, loose housing is now regarded as being a quite valid system for raising well-developed, disease-free, high-yield livestock.

An example of a very large and well-equipped farm is the 4,000 hectare Maccarese enterprise at the seaside near Rome, where two of the biggest stockbreeding research centres in Europe have been set up for 2,000 dairy cows.

The area covered by the centres is 67,000 sq.m. of which 35,400 are built over and 31,000 left for grazing paddocks *(Figs. 4 and 5)*.

As can be seen, to achieve the best layout several buildings were built side by side: areas used for different purposes in the part under cover are often demarcated simply by lines of stanchions, which also serve to support the necessary mechanized equipment. From the point of view of standardization it is interesting to note how the same fencing component has also been used to divide up space in the open, thereby preventing the animals from clustering together in disportionately large groups.

The capital cost of the two centres (Lire 135,000 per head including milking machines) was most reasonable considering the quality of the structures and the complete ultra-modern apparatus with which they are equipped. In addition to the lower initial cost, considerable savings have been made in the running of the farm itself: with the new equipment and stock system a saving of about 50% has been realized on labour costs by comparison with the previous traditional cowsheds (one man now looks after 40 head of cattle). There has, furthermore, been a marked decrease in forage wastage and the consumption of straw.

The same advantages gained from using steel structures are also obtained with housing installations for other animals, such as piggeries, poultry houses, stables, sheep housing, etc. *(Fig. 6)*. Suitable adaptations and variations in the structures themselves are, of course, studied for each type of stock-raising enterprise, bearing in mind the characteristics and the physcial and physiological requirements of each species of animal.

Slatted floors

Special mention should be made of another of steel's applications, not, this time, as a structure, but in a form specially designed to supplement the structures proper used in farming. I refer to slatted flooring, which consists of a grid made up of small rolled sections over which animals can move freely while dung falls through the slots and accumulates in the area lying beneath until its subsequent disposal.

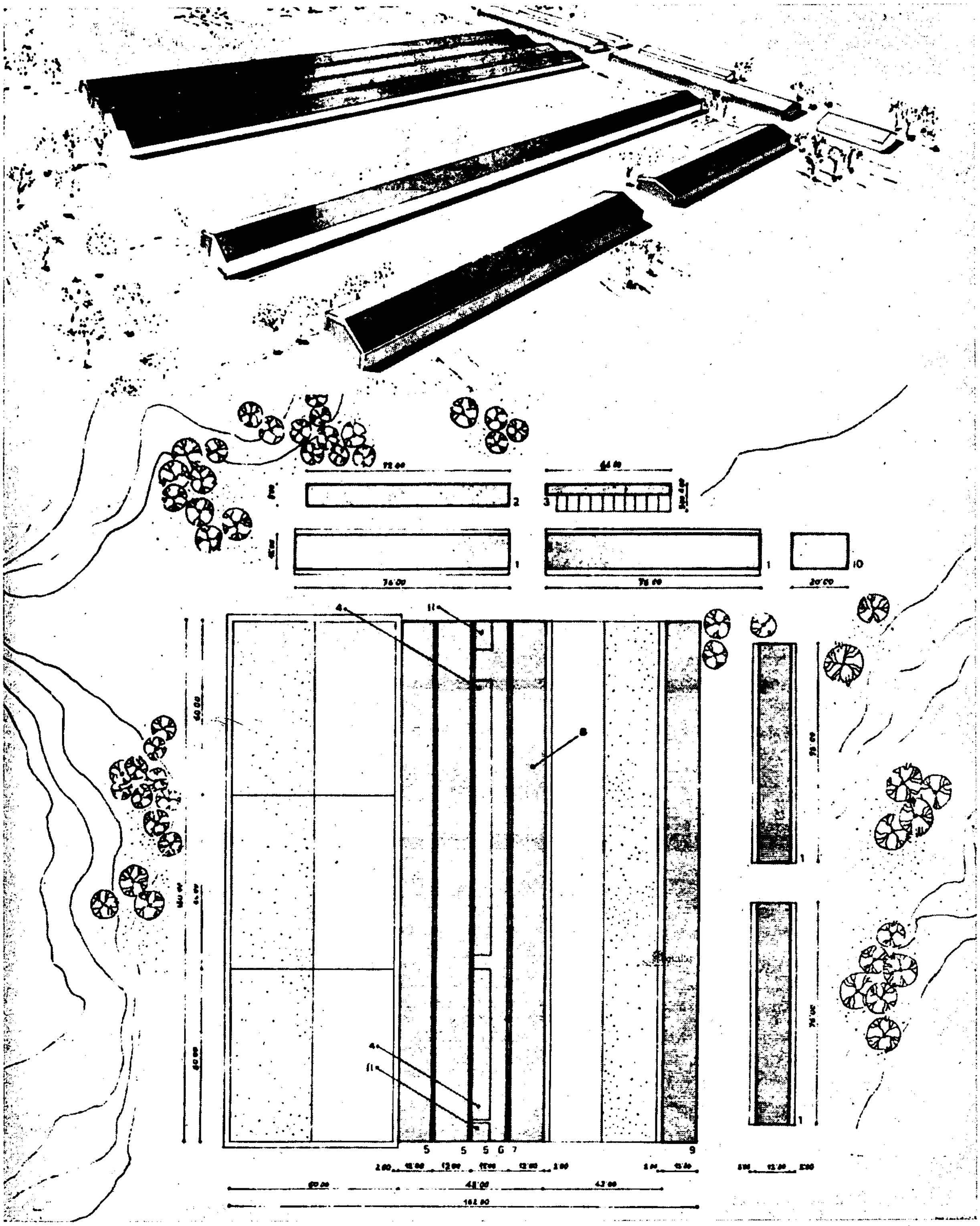
Slatted floors have two advantages: they allow of mechanized cleaning and save bedding straw (which is becoming more and more scarce owing to consumption by the paper industry).

Glasshouses

Glasshouses are today instrumental in raising yields both of forced early fruit and vegetable crops and of flowers.

Various notable design problems have been solved by the use of steel sections in these buildings, in as much as the whole structure is thereby rendered exceptionally light and it is possible to use sections which enable the most suitable form of cladding to be added without trouble, ensuring thoroughly hermetic sealing. Incidentally, besides the traditional glass, a cheaper form of protective covering using plastic sheeting has lately been doing well in Italy.

The great advantage of steel-framed glasshouses is that, common to all such structures, they are easy to move. This overcomes the problem of soil exhaustion.



1. Fodder storage barns
2. Maternity unit
3. Bull pens
4. Collecting area
5. Cows' resting area
6. Milking parlour
7. Cows' feeding area
8. Steers' feeding area
9. Steers' resting area
10. Infirmary
11. Dairy

Fig. 4

and lessens the danger of an accumulation of toxic matter in the soil after a long succession of pesticide dressings. The other feature of steel structures, namely wide spans and few supports, makes it possible to use mechanical equipment for cultivation under glass.

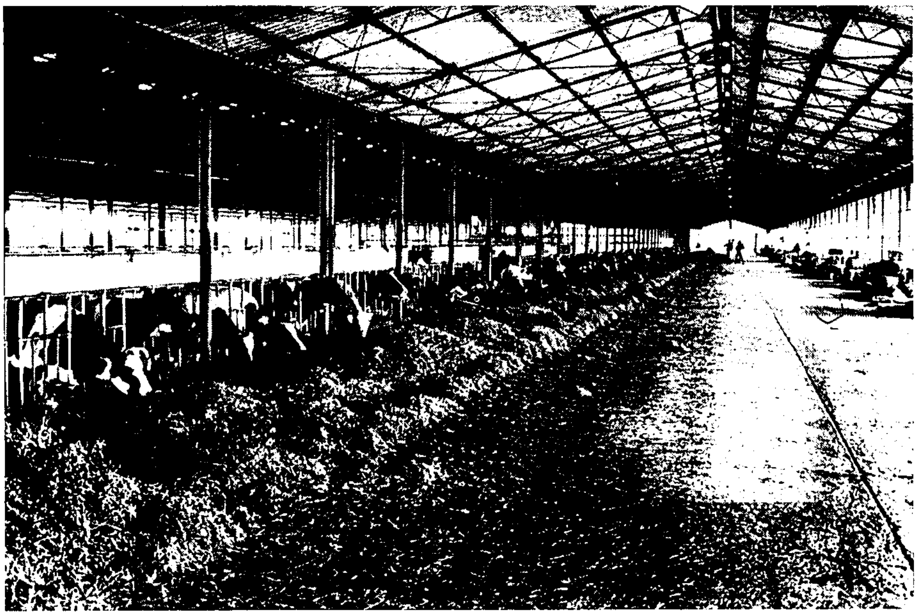


Fig. 5

Fig. 6

Silos

To avoid the disadvantages attaching to the old type of storage container, especially as regards pest infestation and problems of loading and discharging, increasing use is being made of steel silos for grain, cereals, vegetables, fodder, etc. Wheat and other cereals keep perfectly in these, as do also animal feedstuffs.
Here again, the most important advantages of steel silos are those common to all steel structures, namely that they are easy to transport, can be assembled quickly and allow of adjustments in capacity, and in additon are damp-proof.

Delegates' Papers and Comments

Dipl.-Ing. Ernst Peter SCHMITTER

Regierungsbaudirektor
Düsseldorf

The Rationalization of Farm Building (¹)

(Translated from German)

The farming industry in Europe is at present in the throes of a process of basic re-adjustment to more rational economic methods and is being obliged to meet market requirements which are the result of changed habits of eating and new trading methods. The farming industry has to limit itself to the production of certain types of crops and to improving the quality of output.

These changes in production and marketing already have not been without effect on farm building and the future will see an increase in the need for extensive building projects.

Large-scale building programmes are under way in all European countries and in West Germany alone the amount of farm building work undertaken in 1965 was assessed at approximately 6,000 mill. DM.

Without venturing any forecasts as regards the future extent of farm building in Europe it is nonetheless safe to say that it will be impossible to cope with the considerable amount of work involved using traditional building methods. The European market will in future only be able to function satisfactorily if it succeeds both in substantially improving the rationalizing conventional building methods and—and this is most important—in encouraging the widescale production and use of industrialized building components within the farming industry and enabling such methods to achieve a breakthrough. It is particularly important that builders working in rural districts be given clearly to understand that the preliminary work carried out at the factory enables them to achieve both a qualitative and quantitative improvement in efficiency in farm building construction and thus to fulfil their future building programme.

The building industry has now entered upon the phase of industrialization. The change-over from hand craftsmanship to industrialized building began when the working process was divided up into the two stages of production and assembly. There were various reasons for this, among which were the progress made by engineers in the field of statics, the discovery of the possibilities afforded by the use of reinforced concrete in building construction, the necessity for rationalization within modern enterprises and the general changes in the structure of modern society, particularly as regards our social progress.

(¹) This paper has been abridged. The complete text may be obtained from the High Authority.

The principles and rules governing rational building which have been developed over the past few years are basically valid for all branches of the building industry and thus also for farm building. However, the problems to be solved within this specialized field are so manifold that rules and research results need to be adapted and complemented on the basis of specialized research. Such research work has been going on for many years in all industrial zed countries and this—and actual experimental buildings—have yielded important results and led to gradual progress being made. Such work was the fruit of the spirit of enterprise and courage of individuals who undertook the experiments more or less at their own risk. Generously conceived projects carried out with the help of government subsidy, such as have been realized in the sphere of urban building, are unfortunately not to be found in the farm building sector. We have already mentioned the reasons why such large-scale experiments are difficult to put into effect.

The goal towards which our efforts are directed must be a fundamental rationalization of the whole of the farm building sector. All the processes involved in building, from planning to settlement of accounts must be made simpler and more efficient. Rationalization is possible at all stages of a building project.

Some years ago, leading institutes in West Germany formulated "Principles for the planning and assessment of accommodation for cattle and pigs," thereby making a considerable contribution towards rationalized planning. They have also carried out valuable surveys regarding economical housing designs and have demonstrated that all other conditions being equal, it is the design of a building which determines whether a project will require high or low costs, when the number, size and use value of rooms are the same. Experience is available to support this statement.

It is not, however, enough for buildings to be rationally, i.e. correctly and economically, designed. Thought must already be given at the planning stage to the matter of how plans are to be put rationally into effect. The use of prefabricated building components, for example, requires a *pre*-planning process, that is, preliminary planning, a preliminary thinking-out, a preliminary thinking-through and completion. Mature planning may take longer but will always result in shorter building time and lower costs.

Rational building presupposes rational planning and this requires compulsory standardization of dimensions. This is necessary first of all in order to enable manufacturers of prefabricated components to carry out long-term planning of production programmes. We cannot decree one stan. ard one day and another the next and thus arouse a feeling of insecurity and disappointment within the industry. A clearly formulated programme with compulsory sizes and dimensions will have the desired success. Some of the German *Länder* have already undertaken useful pioneering work in this field and have laid down fixed functional dimensions for farming enterprises. Even though at the moment discussions are still going on within the International Modular Group as to whether the octometric or metric system should be adopted as the standard system of measurement, every encouragement must be given to the increased use of industrialized components for farm building projects and stress laid on the simplification of planning which this will permit.

In industrialized building, where work is divided up into tasks of production and assembly, a distinction is made between various methods. These range from the mobile devices for production on site through fixed-location production to the mass production of prefabricated components. Hence there are various degrees of prefabrication which may be total or partial. When deciding upon the degree of prefabrication to be used for farm buildings, it is important to take into account the fact that components should be of such dimensions as to be transportable using standard vehicles on light roads. They must be suitable for assembly by means of devices which are easily brought to the site and assembled and dismantled without high fixed costs. This means that in every case the size and weight of components must be limited.

Almost all materials in conventional use are suitable for the production of industrialized building components. Such materials include wood and ligneous materials, bricks and perforated bricks, concrete and lightweight concrete, steel and light metal. The use of industrialized building components is recommended where there is a shortage of labour on the building site and where it is possible to make use of large production runs of identical components. Both conditions are fulfilled by farm building.

Prefabricated components have a particularly important part to play in the finishing of a building, where they may be used in a wide variety of ways. Such components include sections of tube fitted together to form a conduit, prefabricated stairs, flooring sections, cribs and feed-troughs, stanchions, drainage systems and other elements used in outbuildings. It is important that the number of such elements should be kept to a minimum and dimensions standardized.

The advantages of building with industrialized components are:

— The quality of the material. No human being can work as accurately and reliably as a machine. Quality and dimensions are uniform, thus simplifying inspection and supervision.
— The saving of time. Production is speeded up. This in turn has its effect on progressive wage costs and inter-payments.
— The rationalized work sequence. Building schedules and working plans provide the necessary conditions for mass production. The same must also be true for finishing work and suppliers.
— Economic efficiency. Mechanical devices only require attention for operation and no heavy physical work, and there is a growing shortage of labour for heavy jobs.
— Improved conditions. Working conditions may be considerably improved. Production is no longer dependent upon the weather and it is therefore possible to work continuously throughout the winter. Seasonal redundancy may therefore be avoided.
— Acceleration of the building rate. Farm building also requires components which may be added to. Mass production must result in standardization. History shows how the various kinds of house and farmyard in Europe were subject to certain norms and standards.

We feel that building with industrialized components is an important step forward for the building industry today. It has already had an explosive effect on a number of fields of specialized study, starting with the classical theory of building and ranging through to finishing work and site management. A completely new science is being developed. Solutions which are technically and aesthetically acceptable are only just emerging.

If we trace the development of building with prefabricated components in various industrialized countries, it is seen to comprise three stages. First there is stiff competition with traditional methods of building—this is the phase through which we are now passing. Then comes a stage of adaptation to modern methods of mass production and finally the expression of a new and individual form. Richard Neutra has said in this connection, "Mass production is a characteristic phenomenon of our time. But it will only achieve value and permanency if technical knowledge is married to an understanding of human needs."

To sum up I would again point out certain facts which must be recognized and dealt with accordingly:

1. The considerable amount of building which will be necessary in European farming industry over the next few years can only be coped with if farm building undergoes a fundamental process of rationalization.
2. This rationalization must extend to the whole process of building and include the work of planning, preparation for building and the actual building work itself.
3. At all stages of building *greater* co-ordination must be achieved between farm building and other branches of the building construction industry.
4. Long-term planning is a must if farm building is to be rationalized. This should be in the form of something like a continuous 5-year plan.
5. A standard European modular system for farm buildings must form a basis for the production and use of industrialized components.
6. A generously conceived programme for experimental buildings, including some used for purposes of comparison, with all the countries of the ECSC taking part, must be drawn up and carried out under the supervision of a central authority.
7. Work must be carried out to develop functionally efficient service buildings, economically viable structures, suitable prefabricated elements and architecturally satisfying designs. The means required for this purpose should be applied for.
8. A committee should be formed to carry out this programme, composed of experts from management, economy, science and industry.

Jacques PINSON

Directeur de la Fédération nationale de l'habitat rural
Paris

Rural Buildings in France[1]

(Translated from French)

For 1966, expenditure on farm buildings may be put at FF 1,400 million. This has been estimated from loans granted by the Regional Agricultural Investment Funds, with the portion allocated to housing subtracted and recalculated on the basis of the growth of the building firms' turnover.
In 1963, the amount of steel used in farm buildings proper was quite large; it is generally thought to have been around 53,000 tons for steel sheds alone.
In the course of the years for which we have figures steel and timber frames have tended to replace supporting walls.

Percentage Share of Different Types of Load-bearing Structures in All Buildings Not Used for Housing[1]

Type of Building	Supporting walls			Reinforced-concrete frame			Steel frame			Timber frame			Other structures		
	1962	1963	1964	1962	1963	1964	1962	1963	1964	1962	1963	1964	1962[2]	1963	1964
Agricultural Buildings	39·9	33·8	30·4	10·6	9·4	5·3	30·6	33·7	37·4	21·1	13·4	23·3	5.5	2.0	3·6
Industrial Buildings	22·3	23·2	19·8	25·9	29·2	28·8	39	46·2	48·3	0·9	0·6	1·0	12·2	0·5	2·1
Storage Buildings	19·5	26·4	20·3	19·5	27·9	22·1	48·4	44·1	53·5	1·3	2·3	2·8	10·3	0·3	1·3
Garages	44·7	44·7	40·7	30·4	32·5	25·5	15·7	19·8	29·1	0·3	0·6	0·8	8·6	2·7	3·9
Trade Premises	35·2	25·1	36·1	38·7	50	31·3	15·8	24·5	21·0	0·3	0·4	0·7	9·9	0·1	2·3
Offices	25·1	23	19·8	58·9	64·7	56·3	7·6	12·1	18·9	0·1	0·1	0·5	8·3	0·1	4·5
Education	31·1	28·3		59·3	69·1		3·7	1·5		0·8	0·4		5·5	0·3	
Health and Welfare	40·2	37·6	41·5	43·9	53·8	47·2	7·1	7·1	6·9	1	1·5	1·2	7·3	0·5	3·2
Hotels etc.	59·1	48·2		31·2	48·7		0·9	0·3		0·7	1·3		7·5	2·1	
Various	38	35·2		22·8	58		13·8	5·5		0·8	0·7		13·8	0·5	
Total (average)	29·1	29·2	27·5	31	37·7	29·7	28·2	29·5	35·5	2·9	2	4·7	9·7	0·7	2·6

(1) Calculated from known floor surfaces.
(2) Including unspecified.

(1) This paper covers all aspects of rural buildings in France, but owing to lack of space the only parts reproduced here are those dealing with the construction of farm buildings. A copy of the unabridged text may be obtained from the High Authority.

Edouard MINART

Ingénieur régional de la Fédération nationale des groupements de productivité agricole
Saint-Laurent

The Place of Steel on the Farm

(Translated from French)

Location and description of the farm:

— Cultivated area:	60 hectares on the edge of the Landes, in Gironde;
— Cropping:	30 hectares of maize for corn, of which 10 equipped for irrigation, 30 hectares of grass (temporary leys);
— Livestock:	30 Limousin cows;
— Labour:	2 male labour units;
— Sales:	Maize corn sold to a co-operative; Weaned Limousin calves sold to fatteners;
— Layout:	Free-range cattle shed with self-service feeding of hay and silage in winter; Rotated grazing with permanent access to cattle shed in summer;
— Soil:	Landes soil-podzel rich in organic matter;
— Climate:	Atlantic with frequent dry spells.

Steel utilization:

	Weight in kilograms
1. Fields	
Leys fenced in 10 hectare block with barbed wire — 4-point barbed wire — 7 km.	1,000
7 000 staples	55
Electric fence: 14 kms. No. 13 polished wire	390
2. Equipment	
a) Motive power:	
245 h.p. tractors	3,600
b) Tillage:	
3 ploughs	600
2 mounted harrows	300
1 culti-packer	700
1 spring time harrow	150
1 seed harrow	400
c) Seeding and manuring:	
4-row precision seed drill	320
fertilizer distributor — working width 3 m.	250
d) Crop cultivation:	
Weeder	300
Mounted sprayer of 400 litres capacity	100
e) Harvesting:	
Hay tedder	200

			Weight in kilograms
Medium density baler			800
Maize elevator			500
Mower			150
1-row corn picker (maize harvester)			1,200
3 trailers			2,800
Flail forage harvester			800
f) Irrigation:			
Diesel-driven pomp — 3 cubic m. per hour			380
Pro memoria: sprinkler equipment made of aluminium			
g) Storage:			
Metal maize crib, capacity 160,000 kg.			6,000
3. Buildings			
— Metal framed shed, clad in steel plates			
covered area: 715 square m. — Height of uprights: 5.20 m. — H-section uprights (230 × 100)		framework	11,000
Sheet cladding area 170 sq.m.		roof and cladding	4,500
proposed: — metal roofing of forage silos: 240 m2.	2,500		
— cow stalls with ties: 25 m.	900		
— tubular barriers in cowshed: 40 m.	500		
— cattle balance	500		
— cattle crush	300		
— horizontal			
— 2 silos 20 m. long × 6 m. wide; "subma" cast concrete blocks (could be in sheet steel)	3,500		
— Water supplies Motor pump — 2,000 l. tank — 100 m. of galvanized steel piping			800
		actual total	37,295
		possible total	45,495

4. Notes:
- — Great variety in the use of steel is found everywhere, except in irrigation equipment.
- — Replacing wood more and more (speed of erection, strength, can be dismantled and transported) especially for enclosures for animals.
- — Use of a welding set is becoming common on farms of any size.

Desiderata from the user's point of view:
- — Increased strength and quality of steel for all equipment and parts subjected to stress; examples: construction of the spring tine harrow
  tubular construction of the weeder;
- — Abandonment of the classic bolted construction for agricultural machinery and equipment;
- — Corrosion resistance: to salt air, to attack by ammonia;
- — Quality of the paintwork on the cladding of sheds and barns;
- — Use of anti-corrosion paint on metal fencing stakes (the wooden stake should be done away with).

Jean-Joseph THIRY

Directeur du Centre belgo-luxembourgeois d'information de l'acier
Bruxelles

Establishment of Model Farms Making Extensive Use of Steel

(Translated from French)

The job of Steel Information Centres is to encourage the use of steel for all possible purposes. The larger the number of individual consumers or firms to be reached, the costlier this procedure is. Now in the case of agriculture the number is very large indeed — getting on for half the population of the country concerned. To be really effective, such a campaign would therefore need to make use of the major advertising media — radio, television, films, national newspapers — and to include representation at fairs and exhibitions, organization of lecture tours, and so on. All this would require a good deal more in the way of funds and staff than our Brussels Centre possesses.

Accordingly, we have worked out a different idea, namely to set up in each of Belgium's nine provinces, and perhaps also in the Grand Duchy of Luxembourg, a model demonstration farm on which the buildings, sheds and silos, the stabling and dairy installations, the forage and manure handling equipment and the farm machinery would be made as far as possible of steel.

This farm would be a private venture, running on its own resources but also receiving some financial assistance either from the Government or from the industries concerned, and perhaps from ECSC, in return for an undertaking.

(a) to provide sleeping accomodation for ten or a dozen trainees, farmers' sons and farmers' daughters, who would spend periods of a week or two there in rotation helping with the work of the farm and so acquainting themselves with the operation of up-to-date equipment;

(b) to allow the Steel Information Centres to arrange periodically for parties of farmers to see the farm and the model installations.

If suitable premises were available on the spot, short talks and film shows could also be given.

The idea would not be to build entirely new farms, but to make use of existing holdings run by young and forward-looking farmers and already in the process of extension and modernization.

Ing. Giovanni SODDU

Presidente dell'Ufficio italiano per lo sviluppo applicazione acciaio
Milano

(Translated from Italian)

I wish to emphasize the importance and interest of the proposal made by M. Thiry, of the Belgian-Luxembourg Information Centre for Steel, on setting up mechanized agricultural experimental centres within the ECSC.

These centres would be of the greatest value in developing better agricultural buildings to provide the basis for a highly qualified agricultural construction industry.

I hereby wish to express our full support for this move which could be realized practically by the establishment of two centres, taking into account the requirements of agricultural buildings in Southern Europe and those in Northern Europe, which can vary considerably owing to the difference in climatic conditions.

Ir. Cornelis 't HART

Instituut voor Landbouwbedrijfsgebouwen
Wageningen

The Use of Steel in the Construction of Farm Buildings

(Translated from Dutch)

Most builders have recently been making increasing use of steel and concrete, materials now enjoying great popularity. Concrete is nearly always used in combination with steel in the form of prestressed or non-prestressed reinforced concrete.

This is equally true of the building of agricultural premises, a more up-to-date term than "farm buildings" as used in the title of this paper. To many people a farm suggests a building in keeping with its peaceful and pleasant rural surroundings, where men and animals live in close proximity, and the haystack, midden and the outbuildings (if these can be called buildings) are traditional features built of such traditional materials as clay, timber, thatch, rooftiles and bricks.

"Agricultural premises" sounds so much more businesslike than "farm" and also carries a suggestion of keeping up with the times. Agriculture has, in fact, become "agrobusiness", and the change is reflected in the buildings. "Agricultural structure" has not the same connotation as a farmhouse affording shelter to the farmer and his family. Nowadays the house is often sited at some distance from the other farm buildings, the general architectural effect being one of lopsidedness. Here, then, is a whole new field for the architect.

In the remainder of this paper I shall only discuss agricultural structures other than the farmstead. These may be further subdivided as follows:

a) barns: at present mainly used for storing and processing farm produce and cattle fodder and for housing farm machinery;
b) livestock housing: cattle-sheds, pigsties, poultry houses, etc.;
c) barns which include provision for housing animals.

I intend to limit my remarks to a number of barn and shed designs now in fairly common use in the Netherlands.

Barn roofs always used to be fairly steeply pitched at an angle of about 45°, this also being suitable for tiled roofs. This gave a good deal of headroom, all of which was utilized in the past but has been rendered superfluous by modern methods. The wooden frames were subject to heavy strains from the wind and their own weight. The roof structure of older buildings is an obstacle to the use of machines for the storage and processing of farm produce, the logical development being lower pitched roofs (20° to 25°) and a lighter roof cladding (corrugated asbestos-cement sheets), improving the distribution of the load on the rafters.

Operational considerations gave preference to a squarer barn layout and fewer points of support. Some layout drawings and views are shown in *figures 1* and 2. These are projects in which prefabricated concrete components are used for the walls.

Both barns are 24 m. wide. The length of the building is so many times the 4.50 m. module. The frames, placed 4.50 m. apart, are portal trusses resting on four points of support; the side portals have a span of 6 m., the middle portal one of 12 m. Thanks to the welding technique, for example, a statically-indeterminate steel frame of this kind permits the use of slender sections and small corner reinforcements, and the barn contains few obstacles. The horizontal loads borne by the points of support are small and readily absorbed in the foundations, and nowadays it is a very simple matter to calculate statically-indeterminate frames as programmes have been worked out for the exact solution by computers of this type of problem for all possible loads and combinations thereof. The charges made for this work are very reasonable and the solutions are often sent back by return of post.

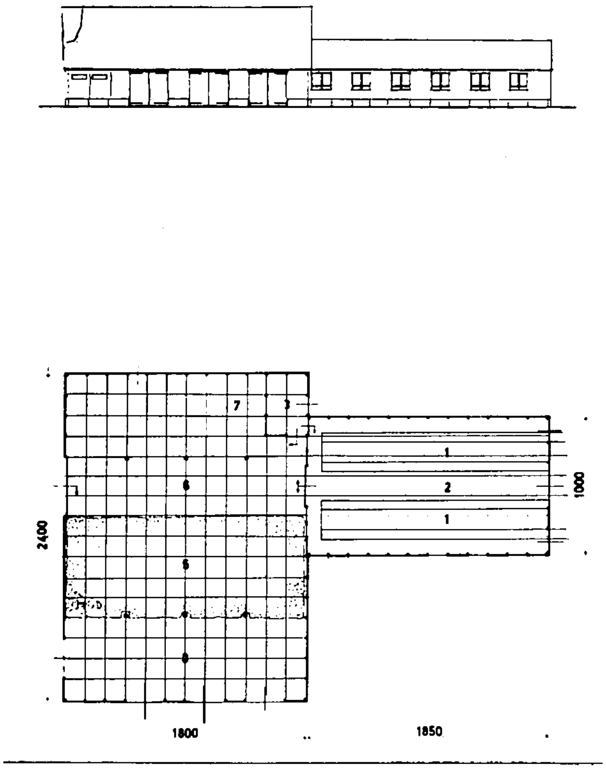


Fig. 1

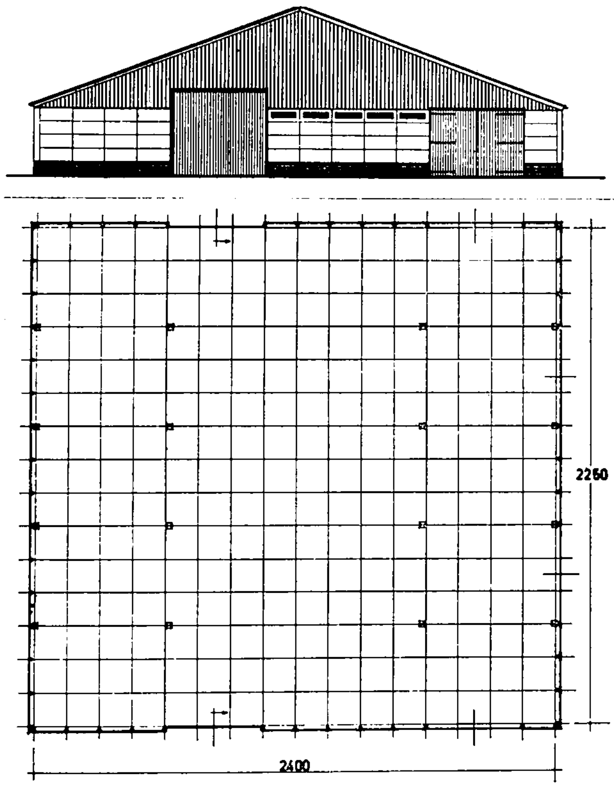


Fig. 2

The steel frame can be rustproofed fairly satisfactorily by grit blasting followed by a zinc compound spray, for example, and a paint finish.

The steel structure is also easy to transport and assemble. The middle portal has a bolt connection at the top, enabling the side portals to be bolted to it.

Another new design of the loadbearing structure uses a clear span of triple-hinged frames. This type of structure is often made of glued bent-wood frames, but the free passage profile is still much restricted by the great height of the section in the corner and the 2-2.50 m. rounding-off radius; in this respect a steel triple-hinged frame is an improvement. When IPE sections are used a height of about 30 cm. with a clear span of 20-24 m. is sufficient, and the structure can be reduced to the right height (about 60 cm.) by cutting the section open and welding wedges in the angle over a distance of about 1-1.50 m. from the angular point. The modern CO_2 process, which gives good, rapid and inexpensive welds, can be conveniently used for angle welding. Frames placed 6 m. apart instead of 4.50 m., combined with a well-built purlin, result in a roof structure competing in price with timber, despite the additional cost of rustproofing.

Temperature is kept at a suitable level by means of effective wall and roof insulation, no overcrowding, and good ventilation. The roof is pitched at the same angle as in the barn, the line of the lowered ceiling being determined by such factors as the number of animals accommodated, the headroom above the dunging area and passage, and good ventilation in the house profile.

A framework can be obtained by drawing within the resultant lower and upper lines of the roof structure a number of triangles with angles adapted to the maximum distance of the purlins for the asbestos-cement roof cladding. Steel sheets for fastening wooden purlins and ceiling joists are welded to the upper and lower edges of the purlins.

The whole building design is based on the use of as many prefabricated components as possible and take-down walls, enabling doors or windows to be fitted later on, or the entire front to be taken down and moved when the building is added to as livestock numbers increase. This is why the front of the house is also provided with a truss from the beginning. The walling and frames can be fabricated and assembled with such precision when good concrete and welding templates are used that wooden purlins and ceiling joists can even be prepared wholly in the workshop and the holes drilled in advance, and the building can be rapidly assembled without the need of a saw or drill.

For the designs discussed steel has made a notable contribution to solid and up-to-date construction of farm buildings that are satisfactory as regards use and maintenance and no more expensive than the traditional type of building. This development is due to ideas worked out and put into practice by the industry, with the help and information given by government research institutes.

Steel also enters in modern methods of constructing farm buildings. Efficient, economic and solid steel structures have been manufactured for building barns, often with clear spans of 20-24 m. and stalls. Use is made of portal structures, triplo-hinged frames and frameworks.

Dott. ing. Ivo TRICARIO

S.A.E. s.p.a.
Milano

Prefabricated Steel Farm Buildings

(Translated from Italian)

Of all building materials steel is undoubtedly the one that in the last few decades has been used for the widest variety of purposes.

The steel industry's wide production range provides semi-finished products of all sorts that can be extensively used in all types of farm building. So in agriculture as elsewhere steel is being accepted as a material particularly suitable for the development and reconstruction of the buildings needed to meet the requirements of modern production methods.

The use of rolled steel products can lead to the quicker erection of cheaper and better buildings suited to the advances in farming techniques.

Farm buildings everywhere are having to be built or adapted to meet the varying needs of modern practice. These often do not call for a permanent form of building but rather for one that can be adapted or enlarged from time to time as needed. Requirements are changing so rapidly that it is no longer economic to build to last indefinitely. In farm buildings, whether farm houses, stabling, shelters or barns for the processing and storage of produce, etc., traditional brick is being replaced by steel to erect buildings which can be easily moved or altered.

This change-over is not always easy: it involves choosing principles of construction usually unfamiliar to those accustomed to traditional ideas. Here too, therefore, there is bound to be a difficult period in which the fewest mistakes must be made while new materials and methods are being introduced.

The prejudices and reservations of obsolete ideas must be overcome to secure the acceptance of prefabricated steel products for purposes to which they are specially suited. These include open barns, hothouses, stabling, and other buildings which are today being more and more widely used because of their advantages to a farming industry, that is producing increasingly for a competitive market.

The use of steel allows farm buildings to share the technical and economic advantages of prefabrication. As the subject is so vast only its more important aspects will be here considered.

Looking at the successive stages through which a building passes—its general and detailed planning, its construction and assembly, its use and maintenance—it will be seen that the advantages offered by prefabrication are considerable at every stage. The chief advantage, however, from which all the others flow, comes at the design stage.

Applying the term "prefabricated" to the building as a whole, even the design may be said to be prefabricated since, unlike that of conventional buildings, it does not take account only of the special needs of a particular user which would often condition the whole design, making it unsuitable for any other purpose. In contrast the prefabricated design is not specialized but can meet any requirements at the lowest cost.

When planning a number of similar prefabricated buildings the greatest attention must of course be paid to the standardization of all components common to all. Any one can then easily be converted into any other by adding the standard components.

Whilst this allows the maximum standardization, yet if used for framework of different sizes it has the drawback that components of dimension suitable for the largest buildings have to be used as they are in the smaller buildings where lighter ones could be used.

In addition to standardizing, as far as possible, all the components in buildings of the same type, it is very important that their details should be so designed as to let them be used in as wide a range of other types of buildings as possible. In ferrous construction these principles are followed even for buildings designed for special purposes. There are many details—attachments for purlins and portal-frames, foundation fixings for stanchions, connexions between wall sections and many others—which can be standardized and used in quite different buildings. In this way the advantages of prefabrication can be introduced into at least part of conventionally constructed buildings that cannot be regarded as prefabricated.

It must here be explained what is meant by prefabrication.

In ferrous construction practically everything is prefabricated; all the components are factory-made like ordinary commercial products and work on the site is normally limited to assembling ready-made components, but nevertheless the need to plan everything down to the smallest details and the difficulty of any modification once work has started become apparent right from the design stage.

The term "prefabricated" is, however, usually restricted to structures "predesigned" on the above principles and so constructed as to be stock items.

This immediately shows the other advantages that flow from prefabrication. As manufacture is not subject to any particular delivery date, but depends only on the number of actual and estimated orders, all the difficulties usually met with in obtaining materials disappear since all estimates can be made in good time and from accurate data.

Moreover, the estimated quantity needed to meet orders for a number of months and to keep stocks constant can be adjusted to the production potential.

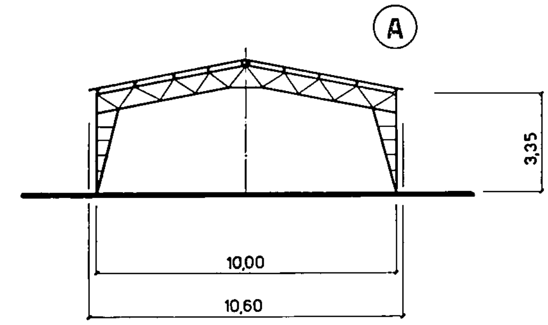
In a factory geared to mass production several months' requirements should be produced at a time provided that the stock of finished parts does not exceed the economic maximum. For a smaller factory the minimum output could, subject to the factory's capacity, be what is necessary to meet steady sales. The need to hold stocks should not therefore impose a heavy burden. In either case production costs could be kept as lows as the factory's equipment allowed. In this way the customer can be offered at reasonable prices components that can be used for many purposes.

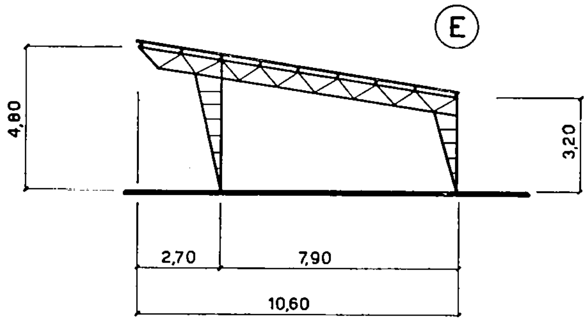
Further, the stockpile in the first case and the even rate of production in the second ensure that orders can be quickly met. For the customer this means a further significant saving by shortening the time during which capital earmarked for the purchase is idle.

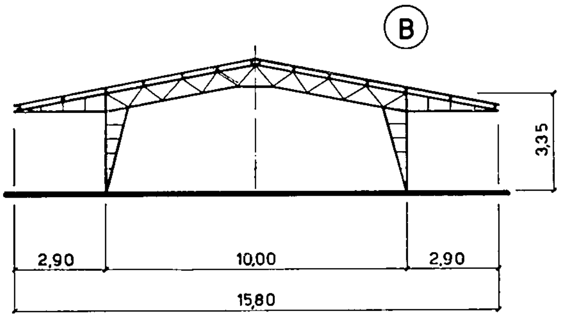
Constructional-steelwork engineers acquire in their normal work ample experience of construction and erection required by the conditions of prefabricated structures.

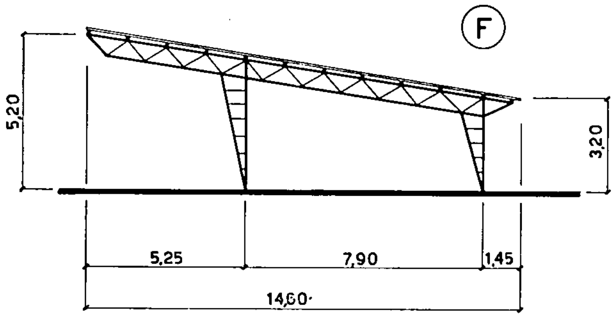
Factory equipment is particularly suitable for mass production, and offers the added possibility, again by the use of mass-production methods, of carrying out hot-dip galvanizing of all the components, thus eliminating the need for initial painting on the site and for subsequent maintenance.

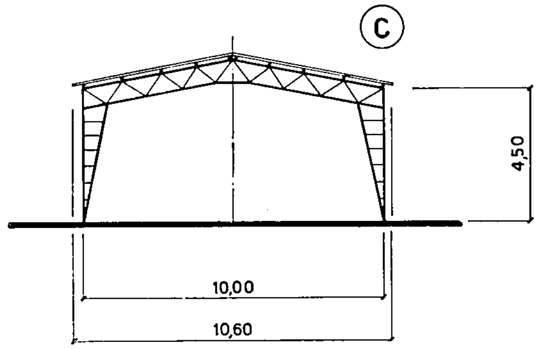
The system of prototype testing, widely used for mass-produced steel components, enables the design work to be supplemented and checked by thorough practical tests. In this way the various types of component can be tested up to breaking-point, so that the safety factors of the design against overloading can be accurately determined. Such tests carried out on a number of specimens give the best guarantee of safety.
In the prefabricated farm buildings (see *figures*) maximum economy and simplicity have been the chief considerations.

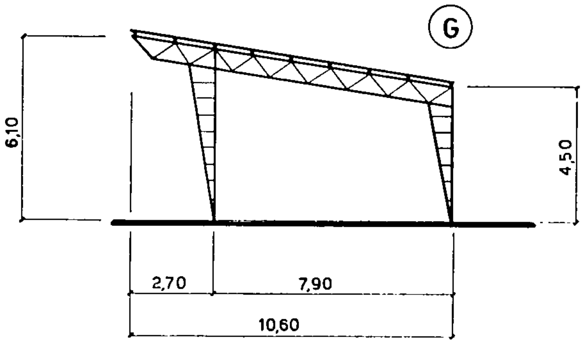


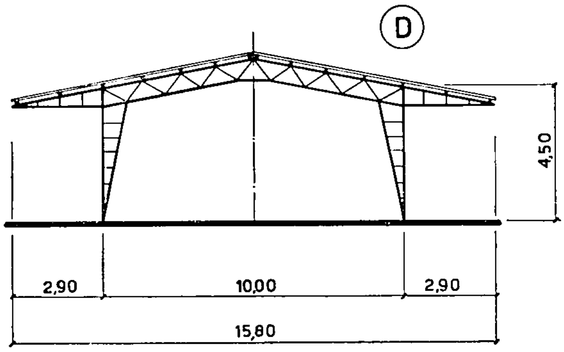


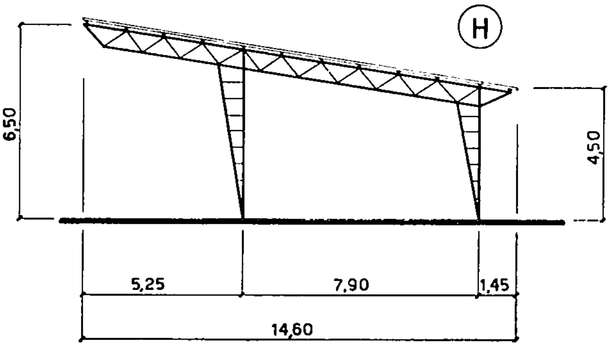




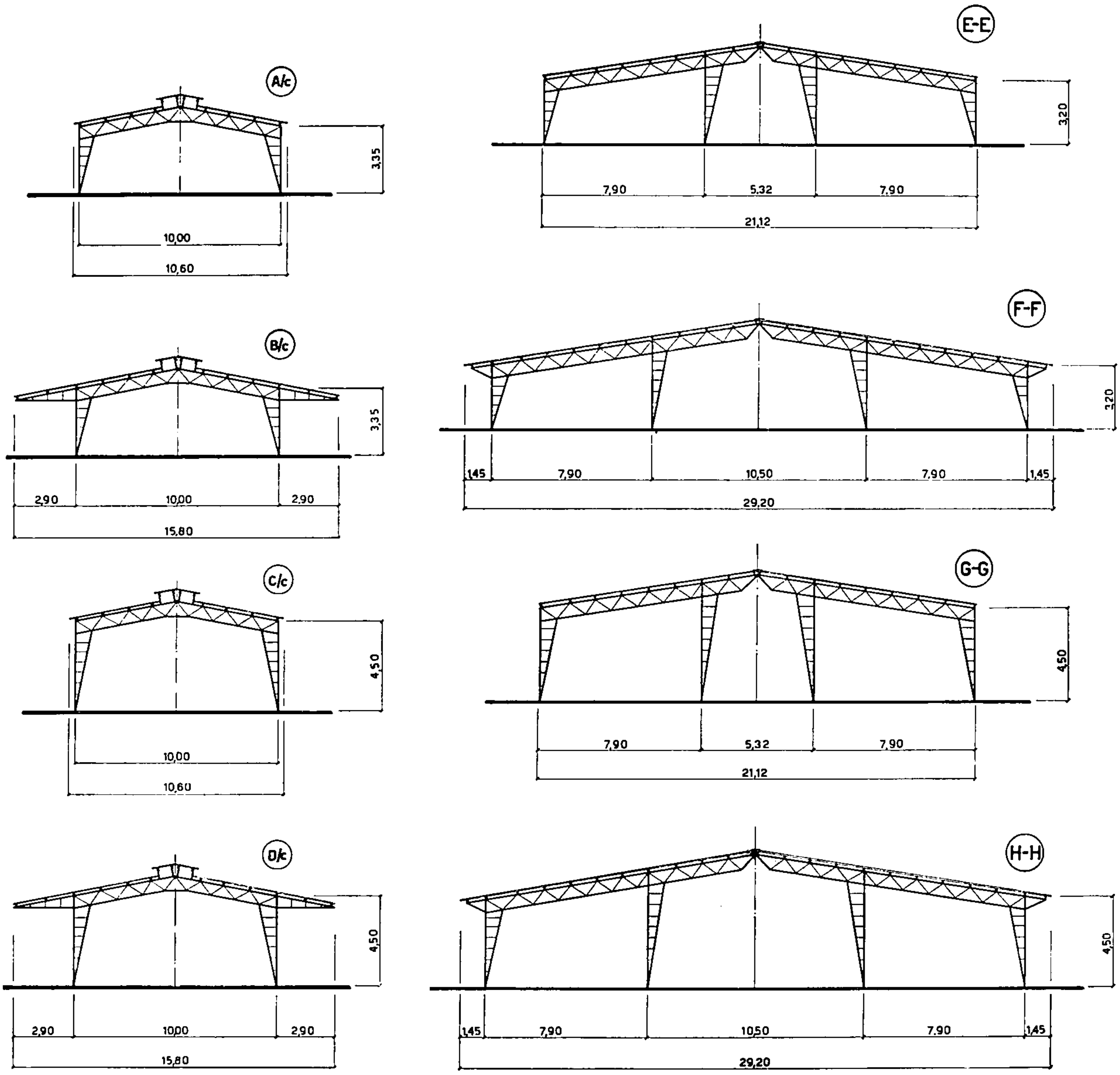








To achieve minimum structural weight, the method of obtaining different spans by using standard components has not been adopted because these would, of course, have had to have scantlings to suit the largest span.
Instead, two quite different types of shed were shosen, one with double-pitch roof and the other with single-pitch. These two types are themselves susceptible of considerable variation by the use of stanchions of various heights and of side trusses.
As shown in *the figures,* by using one type of roof truss together with a lateral extension, ventilator, and stanchions of two different heights, there can be obtained the series of double-pitch buildings A, B, C and D. Similarly, for single-pitch structures, the various types in the series E, F, G and H can be obtained by combining a roof truss with different side extensions and different stanchions.



There is thus a whole series of alternative assemblies, some original, others developed later to answer individual requirements and subsequently included in the catalogue to meet similar demands. Between them, they provide overall spans ranging from 10 to 29 metres.
These structures have purlins and portal-frame stringers of special light channel-section, in high-yield-point for normal steel according to requirements. The lattice members are of angle section. Each portal frame is

made in several factory-welded sections bolted together on site. The small number of connexions which have to be made on site (the roof truss, whether single or double pitch, is in two sections, and the stanchions and side extensions are in one piece) allow very easy assembly without skilled labour, a most important point.
The framework and its nuts and bolts, as supplied, are hotdip galvanized. This ensures protection from corrosion for many years without periodic maintenance.
Foundation plinths pre-cast in reinforced concrete have proved valuable in reducing the number of operations and so further expedite the erection of these farm buildings. These plinths are supplied to order, together with the framework.
They are of such size and weight (about 100 kg, each) as to be easily transported with bolts already fixed in position for anchoring the portal frames. It is therefore not even necessary to cement them in after the structure has been assembled.
As stated earlier, these buildings have been designed as open-sided sheds for farm use. However, as their design allows them to withstand wind pressures of 60 kg./sq.m. if walls are fitted, in many cases they have been provided with different types of covering and used as enclosed buildings such as stabling, shelters for materials, etc.
The example given is, of course, only a modest instance of the large and constantly increasing number of similar uses.

Ing. Rosario MASSIMINO

Amministratore delegato della ponteggi tubolari Dalmine-Innocenti s.p.a.
Milano

(Translated from Italian)

The use of steel in agricultural buildings and structures could undoubtedly be greatly increased and Mr. Potenza's interesting paper has illustrated the current move, in Italy, towards the production of agricultural building units and sections on a mass scale.
Over the last ten years in Italy the use of tubular scaffolding has been steadily increasing, and consequently that of movable pipe/joint structures. So for several years now we have been trying to promote the use of tubular steel structures in agriculture. Various structures have been introduced such as: standings and lean-to roofs for open stalls, chicken-coops, silos for maize, sheds for farm machinery, barns for drying tobacco, etc and other sheds of various types and sizes. This method, using the same materials as those used in ordinary structures but in a mobile pipe/joint form, enabled us to penetrate the agricultural market because of the advantages offered as regards ease of transport and possible storage, and because the structure was assembled by the firm actually selling the materials and designing the individual structures. These advantages made it easier for steel to enter the field of agricultural construction and buildings.
As we have already said, mass-production of such units is making the use of steel in agriculture even easier. It should, however, be emphasized that greater use of steel is not only due to economic and financial factors but also to the ease with which the prefabricated structures can be transported and assembled. The most efficient solution is still to offer on-the-spot erection of the various metallic buildings designed to meet the farmer's many requirements.

Diplomlandwirt Georg KOCH

Deutsche Gesellschaft für Landentwicklung GmbH — Entwicklungsbüro
Stuttgart

Industrial Processes for the Construction of Agricultural Buildings

(Translated from German)

The present situation as regards the use of steel in agricultural buildings

Hitherto, steel has only been applied on a limited scale in West Germany to the construction of agricultural buildings by the traditional methods that are prevalent there.

Steel frameworks have been used only in individual cases. Steel sheet has captured only a limited part of the market for roofs and walls. Steel as a construction material for windows and doors likewise has to face stiff competition from other materials. Only in the construction of the interiors of stalls by industrial methods has steel constantly extended its field of application.

The main reason is that the susceptibility to corrosion and the need for maintenance have to be set against the excellent static properties and the low transport weight and volume in relation to a specific project. Furthermore, the price of steel has hitherto been so high as to preclude its use on an extensive scale within the confines of traditional building methods.

The entire range of agricultural buildings is now, however, in the throes of a far-reaching process of evolution. This concerns

— not only planning from the points of view of operation and the organization of the work,

— but also the methods and processes used in the carrying out of the building work.

The current situation and the future programme for the construction of agricultural buildings

The situation facing agricultural enterprises, in response to which solutions of building problems are now being sought, is characterized

— by the development of agriculture from a self-contained way of life to a form of enterprise standing in a definite relationship to the world around it and, more particularly, to the market;

— by the transformation from a largely traditional activity with a high degree of uniformity between individual farms into enterprises planned by modern methods to meet the needs of a particular case, and which thus differ more or less from one enterprise to another;

— by the development from general farms to simplified organizations with specified objectives and towards the formation of ever larger units.

The forms of organization and the methods of coping with the work used to be of a similar nature and dictated the traditional designs of the farm houses in the different types of countryside. Moreover, until very recently they made it possible to develop in groups standardized forms of agricultural building, which were the "ideal solution" for a given type of husbandry, i.e. for frequently recurring planning problems.

Today, however, the basic fact is that as the result of the widespread development and differentiation of the types of unit

— the forms of organization,

— the size of the unit,

— the methods of keeping our domestic animals and

— the methods of dealing with the work load

standard types of agricultural building are being used less and less. If one nevertheless tries to keep abreast of developments by introducing ever new standard types, one runs the risk of not being able to produce the type required by the market.

At this point we are faced with the fundamental problem of finding an alternative to standard planning.

At present and in the future we can standardize certain constructional and operational units based on dimensions and concepts of animal anatomy and hygiene, economics etc., such as:
— temporary stalls for cows or a given number of linear metres of temporary stalls,
— cubicles for cows or a given number of linear metres of cubicle space,
— the clean-out bay for fattened pigs or a given number of linear metres of clean-out bays, and also
— a certain highly efficient and highly differentiated operational unit such as the duplicate-quadruplicate herring-bone milking pail, or
— certain storage units, or
— certain machine-bay units.

These operational units are erected in every farm building in accordance with the same well-tried principles and to the same dimensions, irrespective of the size of the unit, its organization, and the methods by which the work is dealt with.

In view of this state of affairs, the requirement of agriculture is not buildings for given types of operation, but development of a unit construction system consisting of units capable of multiple application, grouping and linking together, with which it is possible to erect buildings adapted to every type of operational unit. A system of this kind should also be designed from the beginning so as to be capable of extension and adaptation.

This requirement, which first arose merely as an alternative to standardization in response to operational developments, represents a considerable step towards the concept of prefabrication.

The introduction of prefabrication into agricultural building programmes

The building industry on which the agricultural industry has to depend for its building projects is distinguished, apart from market fluctuations, by insufficient capacity, hence increasing costs, and a low rate of construction and poor workmanship.

The traditional method of building, in which plans, construction work, and details are studied to supply solutions in individual cases, and invitations to unskilled persons to submit tenders or the placing of orders with these persons, can be rationalized only to a limited extent.

Experts are of the opinion that only permanently established industrial mass production of components will raise building capacity and thus reduce construction times and improve the quality of workmanship. West German agriculture is still a long way from the industrialized mass production of components for farm buildings. So far, prefabricated buildings have been slow to make their appearance.

A group of prefabricators of steel-concrete has been supplying the market with industrial buildings made from light steel-concrete skeletons. In addition, a large number of small firms is supplying lightweight prefabricated farm buildings. These two types of building have made only a small contribution to agricultural building work as a whole.

Conclusions concerning the use of steel

As prefabrication forges ahead, it will doubtless also acquire a larger share of the market for agricultural buildings. At present it is hard to estimate probable yearly expenditure on agricultural buildings. The share of prefabrication in the market is likewise difficult to estimate.

In principle, there are market prospects for steel as a building material alongside concrete and lightweight structures.

Its advantages are:
— the outstanding static properties of steel,
— the low transport weight and small volume, in relation to the project,
— the easy machinability into structural elements.

The disavantages are:
— the susceptibility to corrosion and
— the need for maintenance.

The extent to which steel will be used will depend on the success achieved in solving these problems. Prefabrication should always be organized with the object of ensuring that the general contractor can supply the installation fully erected and ready for use, at the fixed price, and by the agreed delivery date.

What should be the essential features of a system for the assembly of prefabricated parts for steel agricultural buildings?

Modern agricultural buildings must be constructed in the form of skeletons if they are to satisfy the criteria of extensibility and variability. Steel skeleton structures would be eminently suitable for this purpose. Our thorough investigations and practical experience have led us to the conclusion that a skeleton for the assembly of prefabricated parts of agricultural buildings can make do with very few pre-selected dimensions.
The width between supports is today generally fixed at 5 m. (see *Fig.*).

Possible combinations

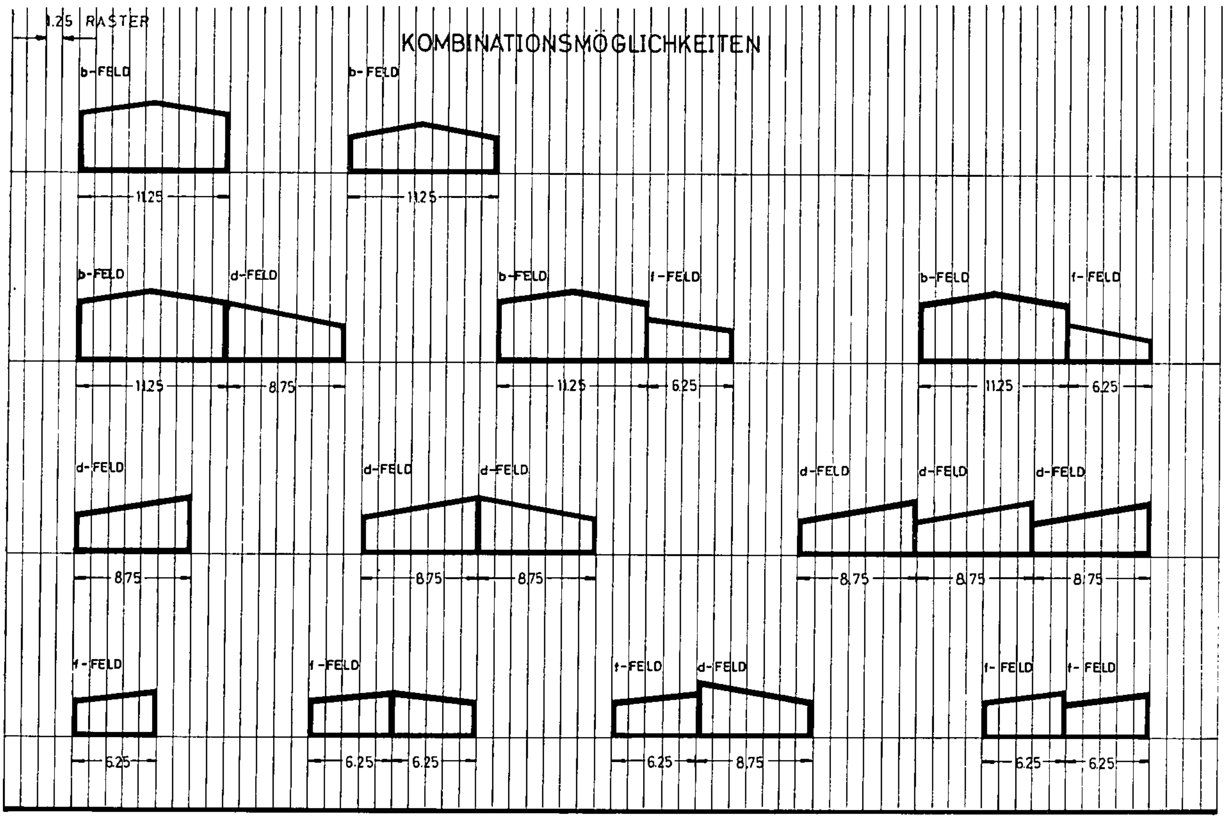


Fig. 1 1.25 metre = one frame structure unit. Feld = span

Truss spans of 6.25 m. and 8.75 m. for lean-to roofs and 11.25 m. for ridged roofs will suffice.
This gives us the following units as "bricks" for the composite system:
11.25 m. × 5.00 = b-span; 8.75 m. × 5.00 = d-span; 6.25 m. × 5.00 = f-span.

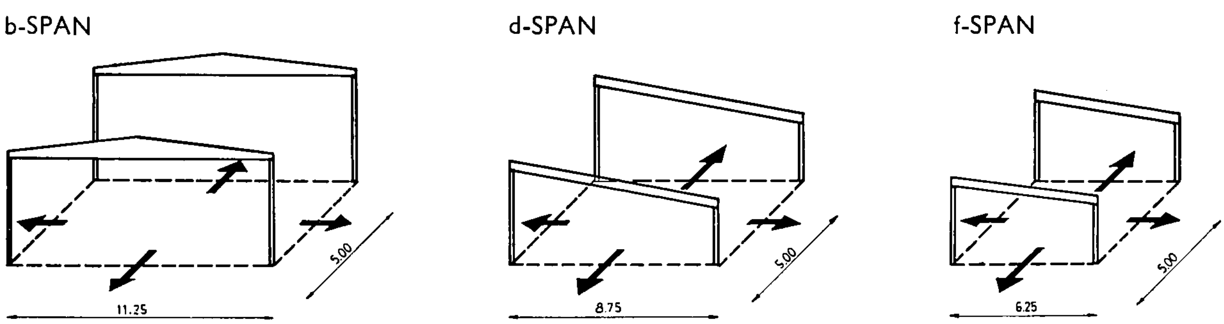


Fig. 2

The spans can be grouped and linked in any desired order. The heights of the supports are thus variable.
Walls in which steel is used must preferably comply with the following requirements:
— they must be easy to assemble and dismantle,
— they must be fully resistant to corrosion, and need little maintenance.
They must also possess the following physical properties: adequate heat-insulation and heat-storage capacity, stability of dimensions under temperature fluctuations. The statutory and anticipated fire-prevention regulations must be observed.

Conclusion

1. Agricultural and constructional considerations clearly indicate the unit construction principle for the planning and erection of agricultural buildings.
2. Thanks to its specific properties, steel has prospects as a material for the prefabrication of agricultural buildings, alongside traditional methods and the prefabrication methods using concrete and wood.
3. The steel industry should create an organization, which would offer the agricultural industry a broadly based system of building on these lines.

Dott. ing. Ivo TRICARIO

S.A.E. s.p.a.
Milano

(Translated from Italian)

I wish to come back to some general points common to several papers and draw a few conclusions which I consider important.
Today manufacturers (and particularly structural steel manufacturers) can offer farmers a very wide range of prefabricated buildings of every shape and size with high standards of quality and ease of erection. Incidentally, easy erection, with little need for hoisting equipment, is a basic essential for these buildings which, although very numerous, are individually too small to warrant the use of heavy plant and equipment from an economic standpoint. This produces a situation, in Italy at least, where the industry is potentially capable of supplying a product of a higher quality than that required by the user.
Consequently the finished products are, in my opinion, too numerous, too strong and therefore heavy (because they are built to the specifications required for industrial buildings) so that standardization and the resulting maximum economy have not yet been attained as regards agriculture, except insofar as the manufacturers are accustomed to using mass production.
So I think it is important that specialists in agriculture should try to work out standard requirements in the lowest possible number of variations for general use, so that the industry can direct its experience of production along well-defined and common channels.
Being personally concerned with design, I also feel that considerable savings could be made by adopting minimum safety standards for these particular structures which would be lower than those required in civil building (according to a theory already outlined in Mr. 't Hart's paper).

Jean MAGRON

Service des études agricoles
Office technique pour l'utilisation de l'acier
Paris

Farm Sheds

(Translated from French)

In former times, farm buildings made of traditional materials and in different sizes for different purposes were suitable enough for an age when production techniques were hardly progressing at all, since under such conditions the capital cost could be written off over a good many years.

However, once agricultural methods did begin to change, it was found so extremely difficult to alter and extend these buildings that farmers came more and more to prefer to put up new ones more in line with their requirements.

From 1918 up to around 1950 there was not much change in the stockbreeders' requirements in this respect: it was more the growers of cereals and mixed crops who sought to modernize their arrangements for housing their corn sheaves, their hay, loose or in bales, their increasing number of mobile implements and appliances, and their supplies. As these fairly well-defined requirements were pretty much the same everywhere, the manufacturers of farm buildings were able to some extent to standardize their production.

In these favourable circumstances, the metal storage shed soon took pride of place, since it was possible to mass produce the necessary standard components and so to offer ranges of structures to meet practically all requirements.

The fact that these lightweight structures, though originally used solely to store equipment and harvested crops, were actually suitable for all sorts of other purposes had much to do with the adoption of new techniques such as open-stall stabling, indoor drying of hay and grass, on-farm storage and treatment of grain, and so on. The progressive improvement and co-ordination of these techniques has led to the establishment of production units forming part of a streamlined chain, the object of which is to turn out products as finished as possible, this being, of course, a more remunerative mode of operation.

The changes both in the farms' technological requirements and in their organizational set-up make it probable that considerably more of these various structures will be wanted as time goes on. I do not propose to give a detailed account of the different types, as this would be outside the scope of my paper; the subject is, in any case, being dealt with by other speakers. I shall therefore simply endeavour to indicate the main lines along which the farmers' requirements are currently developing.

Specialized production units

Some lines of production require purely single-purpose buildings tailored strictly to their particular needs, but these are so essential in the sectors concerned that mass production would be fully warranted. Pig rearing and fattening pens, poultry houses and glasshouses, for example, with their respective equipment, form production units in their own right, and must therefore be specially designed to provide the beast, bird or plant with everything that can possibly conduce to its satisfactory development—shelter, warmth, light, air, water and food—while at the same time ensuring the maximum productivity of human labour: in other words, the fullest mechanization of crop- and stock-raising operations.

Convertible multi-purpose structures

The trend is also towards greater specialization, in line with the requirements of industrialized agriculture, in the design of the more all-round shed.

1. Cattle-breeding and housing: the steady progress in stock-breeding methods is making it necessary to have structures that can readily be adapted to requirements, i.e. with plenty of space and able to accommodate such adjuncts to stockbreeding as milking parlours, a dairy, stocks of fodder, silage alleys, concentrated feedstuffs, and so on.
2. Storage of hay: desiring to make themselves as independent of weather conditions as possible, farmers commonly dry their hay indoors either by cold or, sometimes, by heated ventilation.
   It seems likely that fully artificial drying methods and equipment will before long be increasingly adopted. The sheds needed for these purposes must have 6-8 m. headroom with the steelwork well spaced to allow maximum utilization of the internal volume.
   As there is a good deal of condensation from the amounts of water evaporating, I should like to remind manufacturers that the sheds need to allow thorough ventilation, and to be specially designed and coated to withstand corrosion better than they do at present.
3. On-farm storage of cereals: as the amounts harvested are larger and, thanks to the use of combine harvesters, also got in more quickly, farmers are obliged to store them temporarily on their own premises, for although the central storage co-operatives have been trying hard to install the necessary capacity they are not able to take the entire grain crop during the actual harvesting. Moreover, the grain on leaving the harvester is sometimes moist, in which case it can only be stored either in ventilated bins or after drying.

On-farm pre-storage facilities are thus in effect processing installations which take in grain that is damp and full of foreign bodies, and after an interval of varying length put it out again dry and clean, in short, upgraded. (Present capacity of this type totals at least 20 million quintals; this is, however, less than a tenth of the total harvest, and can be expected to be stepped up fairly considerably.)

The average farm's equipment consists of a receiving pit, handling and cleaning apparatus, storage bins and cold-air-ventilation or warm-air drying compartments. In some parts of the country drying plant is not necessary and cold or only slightly warmed ventilation is enough. For maize, however, which is now increasingly got in by combine harvester, batch or continuous dryers are pretty well essential.

To get the stored grain out again and on to the delivery lorry requires powerful handling equipment or else a loading hopper to reduce the loading time to a minimum. The sheds for housing this apparatus must be of the design and dimension of collecting silos on a small scale (which is in fact what they are), due account being taken of the often considerable condensation resulting from drying (maize dryers can give off 500 kg. of water vapour or more an hour, which has to be evacuated). Also, it is common sense to allow the framework of the structure to do part of the job of supporting or fixing the apparatus housed, so as to make the most of the steel skeleton.

Mention should also be made of the "maize crib," a structure built specially narrow to enable the drying to be done by natural ventilation; steel is an excellent material for making these sturdy and durable. (They are mostly made by small or medium-sized firms or by self-employed country craftsmen.)

Multi-purpose ancillary structures

With the steadily-advancing mechanization of outdoor operations, more and more machinery of more and more different kinds is coming into use. Consequently, arrangements have to be made for the housing and maintenance of the machines, representing as they do a substantial slice of the farm's capital. Lightweight buildings, which can readily be enlarged or altered as the need arises, are the answer to this problem of garaging and servicing the machinery.

Conclusion

French farmers' requirements are developing in two main directions.

a) There is a need for low-level structures of limited span specifically designed for use in combination with particular types of equipment to form self-contained production units; this type of building could also be employed for storing and servicing equipment and implements.

There is in Europe, and especially in France, a felt want for a range of lightweight structures consisting entirely of prefabricated components which could be put up and taken down as required by the farmer himself, if necessary with the assistance of a local tradesman, thus meeting the need on many farms for temporary ancillary premises.

b) Also required is a taller and more general-purpose structure with a steel framework strong enough to take other stresses than those imposed by the roofing or cladding.

In most cases the changed conditions I have described make it doubtful whether the ambient air in country districts is necesarily as non-corrosive as was generally assumed up to the last few years.

Given mass produced standardized components for the structural framework and ultra-long roofing and cladding components enabling the roof and sides to be low-pitched and the framework simplified, the steel shed should be well able to maintain and indeed increase its popularity, by meeting the farmers' need for buildings that can readily be adapted for various purposes and present no problems as to upkeep, and thus helping them to overcome the new problems of industrializing their means of production.

R. MARTINOT

Chef de la section technique centrale de l'habitat rural
Ministère de l'agriculture
Paris

Investments Required for Livestock Farming in France[1]

(Translated from French)

At the present moment in France, livestock farming is the subject of considerable attention by the public authorities. It is a fact that the development of new techniques accompanied by a slow, but noticeable, change in farming structure requires alterations to methods, sometimes ancestral in origin, but still being used. In addition the younger generation does not take kindly to the bondage involved by livestock farming and especially by cattle farms. The changes required have obviously many aspects—genetical, animal health, feeding—but here we shall only concern ourselves with equipment.

Some of the factors involved

Even though livestock farming, poultry-keeping apart, is still generally an "artisan", under-equipped activity, it is none the less true that certain progressive experiments have shown the possibilities which exist for increasing the productivity of labour, and the necessary scale of investment. The table which follows indicates the number of animals which can be looked after by one man (working 8 hours a day for 365 days of the year, i.e. a theoretical maximum) and the capital investment required (buildings and fixed equipment).

(1) Lack of space has obliged us to omit the second part of this paper dealing with future investments in France. A copy of the unabridged text may be obtained from the High Authority.

Type of animal	Number of animals per worker	Investment per worker FF
Dairy cows	60	150,000
Baby beef	500	500,000
Sows	80	80,000
Fattening pigs	1,200	400,000
Sheep (not for milk)	600	240,000

One cannot help being struck by the size of the investment required by modern methods of livestock keeping. Some of the figures quoted above are higher than those in industry, heavy industry apart. It should also be added that technical obsolescence may necessitate a very short period of amortization.

Modern buildings for stock raising are characterized by two trends: specialization and mechanization. In fact animals are housed not only separately by types, but also separately by their stage of development. Some piggeries are devoted to farrowing and suckling, others to in-pig sows and others to fattening. Mechanical equipment, fixed or otherwise, is also increasingly used in these buildings—machine milking removal of feedstuffs from their place of storage to the trough, dung removal, etc.

It is true that there are considerable differences in the types of buildings required for housing the different types of animal. Piggeries are generally of low ceiling height, well insulated and mechanically ventilated. By contrast, an open-stall unit for dairy cows will usually take the form of a simple structure of fairly considerable height cladded on three sides, not insulated and open to the south or south-west, to facilitate the removal of accumulated litter, although the increasing use of cubicles suggests that as time goes on farmers may come to prefer lower and possibly completely closed buildings. It is not impossible to imagine an all-purpose skeleton building, capable of being fitted with different types of internal installations. Given the considerable variation in the types of feed given to ruminants and the difficulty of mechanizing the collection and distribution of hay, this is no easy problem, yet it is a fundamental one for the industrialization of livestock buildings. It would be made considerably easier if the prospects opened up by the distribution of dry feeding matter in the form of pellets or cakes were to materialize in the near future.

In all these buildings, much of the framework will undoubtedly be of steel. It is probable that, in low buildings, which are often insulated on the inside of the roof, solid trusses will be increasingly preferred to lattice-work trusses. They are easier to maintain, give a better clearance in the centre of the building and have a more satisfactory appearance.

A number of internal fittings may also be made of steel, such as those used to keep animals apart (stanchions supporting divisions between stalls, railing in piggeries, partitions between cubicles in cow-houses, grilles over dung-channels, etc.).

But the most important use of steel will undoubtedly be in mechanical equipment. We need only mention the various types of mechanical conveyors for feedstuffs (auger, chain, etc.), unloaders for tower silos, mechanical cleaning equipment for cow-houses, milking and dairy equipment.

Finally, for large cattle units, steel can be widely used in the construction of tower silos for the storage of coarse feedstuffs. Concentrated feedstuffs are increasingly kept in small-scale silos outside, from which they are extracted by auger conveyors. This arrangement can be used for feeding fattening pigs, dairy cows in the milking parlour, etc.

There appears to be a big market in France for indoor farm equipment and even for "industrialized" buildings, provided always that a sufficiently multi-purpose system can be evolved for cattle.

The present scale of farmers' investments in new construction or conversion of buildings for livestock raising is not very well documented (with the exception of repairs). Taking only investment made with government aid or assistance from the Crédit Agricole, the Agriculture Committee of the Fifth National Plan considered that this should not exceed 350 millions in 1964. This figure is , however, contested by some people, who believe it to be well below the real one.

Patrice LOUTREL

Fédération nationale des centres d'études techniques agricoles
Service bâtiment
Paris

New Stock-raising Techniques Call for New Type of Buildings ([1])

(Translated from French)

The small local builder will change considerably. The builder of tomorrow will be an assembler, putting up industrial prefabricated units. He will form part of a team, able to erect complete buildings from the foundations to the framework and including its internal fittings.

What appears difficult today, when almost all materials arrive on the site in their raw state and in small units, will become quite feasible as farmers define their needs more precisely, leading to standardization of products.

The advantages of mass production are obvious. It is sufficient to note here that the majority of people are quite satisfied to buy ready-made clothes. It is reasonable to assume that cheap mass produced units will give complete satisfaction to farmers, provided the quality is good and the article well designed.

In this connection I cannot help thinking of the words written by a great French town planner, Le Corbusier, as early as 1920 (Vers une architecture—published by Vincent Freal):

"Mass production is based on analysis and experiment. Industry must take an active interest in buildings and make mass produced units for houses. Mass production must be introduced." Why should it be different for agriculture?

Towards closer links between agriculture and industry

There are two aspects of the "analysis and experiment" mentioned by Le Corbusier:

— farmers must make known their requirements, their technical needs and help with the development of experimental models before demanding the manufacture of cheap mass produced units;

— manufacturers must analyse their own position in the face of these problems and experiment with new assembly-line techniques and servicing methods so that they can offer the cheapest solution to the special, but ever more precise, needs of this vast agricultural market.

It is essential for farmers and manufacturers to meet each other; the former must set out his problems, but understand the difficulties of industrial manufacturing; the latter must try to comprehend agricultural factors and adapt his services to them, as he searches for how "mass production can be introduced."

No means of publicising information should be neglected and on this point I would like to make a suggestion: instead of distributing glossy brochures showing a picture of their factory, companies would do better to send out a catalogue on ordinary paper, clearly setting out their different types of equipment, with their technical characteristics, the methods of installation, maintenance and use, and under what conditions they are sold. Such a catalogue should include numerous diagrams and photographs, as a farmer can learn far more from these than from reading a text.

To try to market a product without indicating its capabilities, or how it is installed or even maintained (especially for equipment containing steel, where corrosion is likely, although easily avoided) will always backfire on the seller; a farmer who is not satisfied with a product is likely to look elsewhere in future.

It is not enough to manufacture a cheap, good quality product. The manufacturer must consider how to market his product and must set up a sales organisation adapted to his customers in the agricultural community. Quite often it is not worthwhile sending a representative to visit the farmer on his farm, as the latter is surrounded by all sorts of agricultural problems and does not readily appreciate the manufacturer's special

(1) The first part of this paper has been omitted. A copy of the unabridged text may be obtained from the High Authority.

service. The farmer prefers to go to a distributor where he can meet experts who will give him useful information, and will show him the various types of equipment on display.
The farmer is influenced by what he sees; he is interested to learn where he can see new equipment, to have the names of the first farmers to use it. Nowadays he is quite willing to travel 100 or 200 miles, or even go abroad, if he knows that by making such a journey he will find the answer to his problem. Such contacts can be useful, and just recently led a Ceta-study center in the Massif Central to place a favourable contract with a factory by combining several fairly large orders for the production of metal sections for slurry gratings.
During the years to come, manufacturers will have to be less and less concerned with selling a single finished product, instead they will have to offer a complete service. Different manufacturers would do well to group themselves together so that they can cope with this vast agricultural market and offer complete units. In the same way as a purchaser of a new car does not go to an electrical goods store after having obtained his car, in order to have the lamps, dynamo and horn fitted, the farmer of tomorrow will no longer want to deal with two different concerns when it comes to carrying out a straight-forward building scheme. He will want to deal with a general contractor or constructional engineering company.
Let us hope that close co-operation between agriculture and industry will solve all these problems in the future. The Ceta-study centers can play an important role in this co-operation.
Agriculture is not a world apart from the rest of society, and its development is influenced by the same economic factors that influence other sectors; the only difference in its constant development is in the size and level of its problems.
It is unthinkable to imagine a better world with a united Europe, strong and well-balanced, if any sectors are left out of this development, whether they be agriculture or the steel industry. More and more we must be prepared to look at the problems of others, to work together for the future and well-being of all.
Finally I would like to express the hope that such a meeting as this arranged by the High Authority of the ECSC will help to strengthen the links between agriculture and industry.

Michel FRISON
Ingénieur agricole

Service technique de la Fédération nationale des producteurs de lait
Paris

The Use of Steel in Liquid-manure Cow-sheds.

(Translated from French)

France, a country with a tradition of dairy farming, is on the eve of a far-reaching revolution in its production methods, which have hitherto been extremely conservative. In view of its great potential as a milk-producer and the recent promising opening up of export markets, particularly in the Common Market and the developing countries, this development means that producers will have to raise their output by specializing, concentrating their means of production, and improving their methods.
The fact that most, if not all, French dairy farms are small, more or less general establishments run on traditional lines and with low productivity, does not constitute a handicap. On the contrary, cow-sheds that have been written off long since can be replaced with no regrets by modern highly productive layouts. Consequently, investment in buildings is likely to be concerned more with new buildings than with improvements.

A modern cow-shed is a veritable factory, where the cow, a "machine tool," converts the raw material (fodder) into a refined marketable product, milk, with calves and droppings as by-products.
The aim in such a plant is maximum production:
— by harvesting and storing the raw material (grass) with the minimum loss of its nutritive value (the problem of conserving fodder by drying and silage);
— by obtaining the maximum output from the "machines" (the problem of selecting animals and keeping them in good health);
— by producing high-quality milk (the problem of milking and of the health of the herd);
— by keeping down labour costs (the problem of work-organization);
— and finally, by exploiting the by-products, in particular the liquid or solid manure, to the full.
Up to our own times, most cow-sheds have been designed by the farmers themselves and constructed from available materials: wood, stone, and "merchant iron".
From now on, the milk-producer will be looking for a complete installation which will give him a co-ordinated and efficient production unit to make his work easy and raise his output to the maximum, and to ensure that he can write off his capital in the normal way. This leads to the concept of the "turnkey" cow-shed mass-produced and designed by specialized technicians and architects who are abreast of the developments in dairy farming techniques.
These industrialized buildings will make use of modern industrial products: steel, plastics, treated wood, etc. Steel, which is suited to mass production, is likely to become increasingly important as a material for these structures and lay-outs.
While nutrition, collection, and conservation are the basic considerations in dairy farming, it is clear that the question of waste products will need care and attention if one is to avoid imposing a heavy burden on operating costs.
How can steel be used to recover and spread liquid farmyard manure? The techniques of handling strawy manure are ancient and widely known, and are susceptible to complete mechanization. On the other hand, straw is becoming more and more expensive. For this reason, the liquid-manure technique is bound to become more widespread, and indeed even to be the only one used in modern units.
Liquid manure ("Lisier") is the mixture of urine and dung produced by animals, to which washing water may be added. This is, therefore, a liquid product. It can be stored in sealed pits, moved, and spread by means of implements currently in use for liquids. In order that these implements shall operate successfully it is particularly recommended not to mix animal droppings with straw or other litter, but on the contrary to make the mixture more fluid by adding water.

Steel in the lay-out of liquid-manure cow-sheds

— Tethered animals

Under this system the animal is attached to a fixed point, and is fed, milked, and deposits its droppings at that point. Consequently the distance from which its food must be brought and to which its dung must be removed is greater the more animals there are. This long-established method is becoming ever rarer and its place is being taken by free stabling. In the case of new buildings, it now comes under consideration only for small herds (fewer than 30 cows).
To make tethering efficient, every part of it must satisfy certain criteria:
The manger is usually made of concrete, but it is not impossible to make it of metal; cost will be the decisive factor.
The tether must allow the animal the least possible longitudinal movement.
There are three entirely satisfactory types: the Dutch, the American, and hobbling from behind. Metal chains and tubes are generally used for this equipment.
It is essential to have a partition consisting of metal tubing between every two cows, so as to force the animal to stand perpendicular to the drain.
In the tethered type of stabling, the animals are not free to move over the gratings. Metal gratings are the only suitable ones, because they allow the dung to escape into the drain, their bars being thin. However, they

must comply with certain clearly defined standards; they are generally made of galvanized mild steel, more rarely of cast iron, which is more expensive and less effective.
The area allowed for each animal is about 0,8 m^2 (100 × 80 cm), which means a weight of metal of 15 to 30 kg., depending on the model.
The drain is below the grating. Its purpose is to collect the liquid manure and convey it to the storage pit. Again, it is made of concrete, but it would not be impossible to make it of metal. Here, too, cost will decide.

— Free stabling

Here the animal remains at liberty in a restricted, partly covered-in space; it comes to the feeding and milking points itself; on the other hand, there is no centralized point for its droppings.
Free stabling has certain advantages (milking-room, free feeding, simple design) which make it attractive to an increasing number of farmers.
It is divided into four sections, each with a clearly defined purpose:
— the covered-in rest area;
— the exercise yard, wholly or partly in the open air;
— the feeding area, preferably covered in;
— the milking area, with its waiting area.
Two types of free stabling can be distinguished according to the design of the rest area:

1. Classical free stabling, with straw litter on rest area floor.
The animals sleep on deep litter, 5 to 6 kg. per head being strewn every day.
This method which was first tried in the United States in 1945, was introduced into France in 1955, and is still widely used; however, it has certain disadvantages:
— it requires a large amount of straw;
— a high ceiling is needed, because of the accumulation of litter;
— the cleanliness of the animals is in doubt;
— equipment is needed for collecting and spreading the manure;
— the animals must be dehorned.
Because of these disadvantages, French breeders have come to prefer free stabling with cubicles.
2. Free stabling with cubicles.
The rest area is made up of individual cubicles, where the animals find comfort and peace and can keep clean.
The partitions between the cubicles consist of metal tubes; metal is superior to wood because of its strength, ease of erection and disinfection, compactness, absence of splinters, appearance, etc.

— The liquid-manure pit

This is a covered or open sealed tank for storing the liquid manure in winter (2 to 5 months). It must have a sufficiently large volume, about 100 m^3 for a shed for 20 cows; 1.5 m^3 per head of cattle per month's stabling. The classical material is concrete. Recently, treated wood and flexible plastics have been tried. A metal liquid-manure pit has been put on the market.

Steel for equipment for collecting and spreading

Liquid manure is collected and spread either discontinuously with drawn spreaders, or continuously through pipes.

— Drawn spreaders

Occasionally they are made of wood or polyester, but usually of metal. These are sealed tanks.
In the case of mechanical spreaders the spreader is filled and emptied by a pump or an attached system. In this case the tank is made of light steel sheet 1 to 2 mm. thick.
With vacuum spreaders the tank is put under vacuum for filling by suction and under pressure for spreading. These tanks are of sheet steel 4 to 5 mm. thick. Their capacity is 1,500 to 4,000 litres.

This is the most up-to-date solution, as these spreaders are self-filling and spread the liquid very uniformly over a wide area (8 to 10 metres).

— Spreading through pipes

This is certainly the best solution if the area of distribution is around the installations.
It dispenses with the need for a tractor and avoids loss of time on filling and transporting the spreader and returning it empty, the movement of heavy vehicles over the land, etc.
The manure must be very liquid, and therefore diluted (at least 3 parts of water to 1 of manure), so that the tank must have a very large capacity.
Another solution consists in having an additional pit for dilution.
The equipment (pump, tubing, and sprinklers), is virtually the same as that used for irrigation by sprinkling; this method is obviously of great interest, and it has two purposes, irrigation and fertilization.
This technique has already been widely used with success in Germany and Switzerland. It is not yet widely used in France, because it depends on the redivision and consolidation of farm holdings, a difficult but not insoluble problem.
The liquid-manure cow-shed described here is a recent introduction and is still not widely used. But the need remains of paramount importance to renew farm buildings. We can measure the potential demand of this sector of the agricultural industry, in particular for this type of farm buildings, by the fact that last year only some 7,000 cow-sheds of this type were built in France for 1,200,000 farming concerns. This market is at present restricted, but could expand rapidly if industry could offer milk-producers mass produced buildings and miscellaneous equipment designed for efficiency and easy write off.

André MORINEAU,
Ingénieur agricole
Groupement des producteurs de la "Viande du Valois"
Senlis

Designing Buildings and Installations for the Application of the "Viande du Valois" Method for the Production of Young Beef Cattle

(Translated from French)

Since 1961 the technical agricultural study center of Senlis (Ceta), in co-operation with the Agricultural Co-operative for the Senlis region, has been concentrating on two main lines of study and research, viz.
a) Grain production and processing over the next ten years in the light of Common Market developments,
b) The possibilities of using cereals for feeding young beef cattle.
In the course of fact-finding tours in France, Belgium, England, Switzerland, Italy, Germany, Yugoslavia and the United States valuable information and bibliographical data were assembled. Using the results of ten years' research work by Mr. Favresse, Agricultural Engineer at the "Institut de Gembloux," Belgium, we have developed the method, known in France as the "V.V." (Viande du Valois) method for the production of young beef cattle. This method can be summarized in one sentence:
Exploiting the potential gain in weight of young steers by unlimited provision of dry, pelletized feeding

stuffs of balanced formulae (grains, dried fodder, cattle cake, vitamin and mineral additives) to produce animals with a high yield of quality meat in a minimum of time in the open-stall system.
Throughout our study we came across certain more or less imperative requirements which compelled us to look out for entirely new methods, so that hitherto accepted principles had sometimes to be discarded.
We have sought and are trying to obtain: standardization of the product supplied, planning of production in line with demand, satisfaction of the tastes of the majority of consumers, contractual relations between those involved in the distribution chain. For this, the following economic factors should be taken into account:

a) Capital investment in real estate
   — reduced to a minimum,
   — specialized but nevertheless reconvertible.
b) Capital investment on movables
   — quicker turnover,
   — calculated risks,
   — improved profitability as compared with conventional beef-production methods.

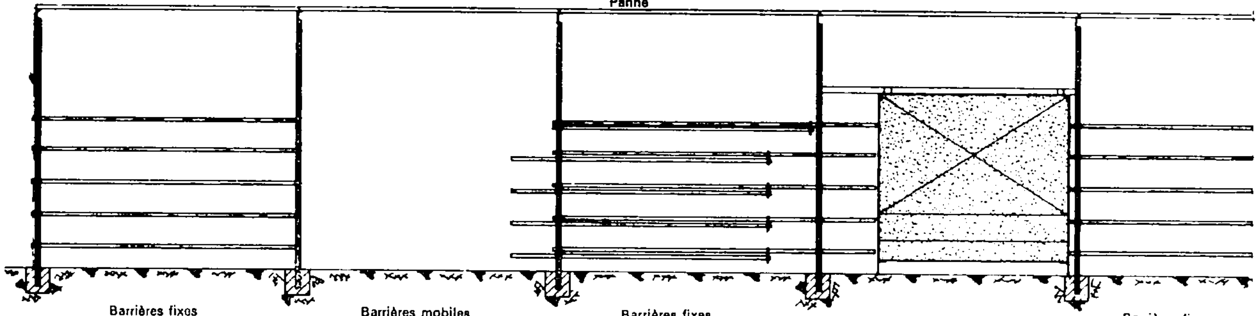
We shall now introduce you to the "V.V." building with the aid of two sketches and describe the "V.V." feeders, thus confining ourselves strictly to the uses of steel in buildings and equipment disigned for stockbreeding.

The "V.V." Building

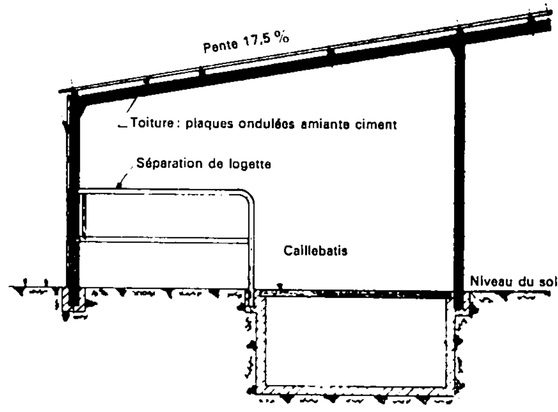
Type: It is a low lean-to shelter with cladded sides and back. The high front is open to allow the air to circulate freely without causing draughts. Accustomed to weather variations in our region, the cattle easily stand up to low temperatures but are adversely affected when spending long periods in hot sun.
Aspect: The open front faces S.E. The roof slopes at an angle of 17° which corresponds to the azimuth of the rays of the sun in the winter solstice. Consequently in winter it gets the full benefit of the sun as soon as it rises while in summer the shade spreads rapidly and by midday covers the whole area.
Cubicles: (*Fig.* 1): As one of the secrets of success is to keep the animals calm we had to use every possible method of avoiding clashes among the hypersensitive and fierce male animals. We find that they only fight when there is some unusual disturbance and that instinctively they prefer quiet. The way the work is organized makes it necessary to leave the animals completely free to move around so that they can feed and drink as and when they want and can stale and dung in the places provided, i. e. on the grating over the dung pit; the bedded area has to stay clean without requiring, any further attention.
The group of a maximum of 12 animals has 12 individual cubicles. Each animal can go into these, lie down and get up without disturbing its neighbours. The dimensions are such that the animal can go in and lie down without difficulty but cannot turn round. As soon as it gets up to move around it has to leave the cubicle and thus cannot dung on the bedded area.
The dimensions must be adjustable for animals of different sizes. The standard width adopted is 0.90 m for 6-12 months old. This is reduced to 0.46 m. by a swinging bale consisting of a beam fixed to the front rail and suspended at the back by a chain to form a movable partition dividing the original cubicle in half. The length of the cubicle can be reduced at the front by an adjustable sloping panel fixed to the tubular steel frame of the cubicle.
Barriers and pens: Outside the cubicles the animals are kept within a small area

   1.80 sq. m. for the 2 - 6 months old,
   3.60 sq. m. for the 6 to 12 or 13 months old,

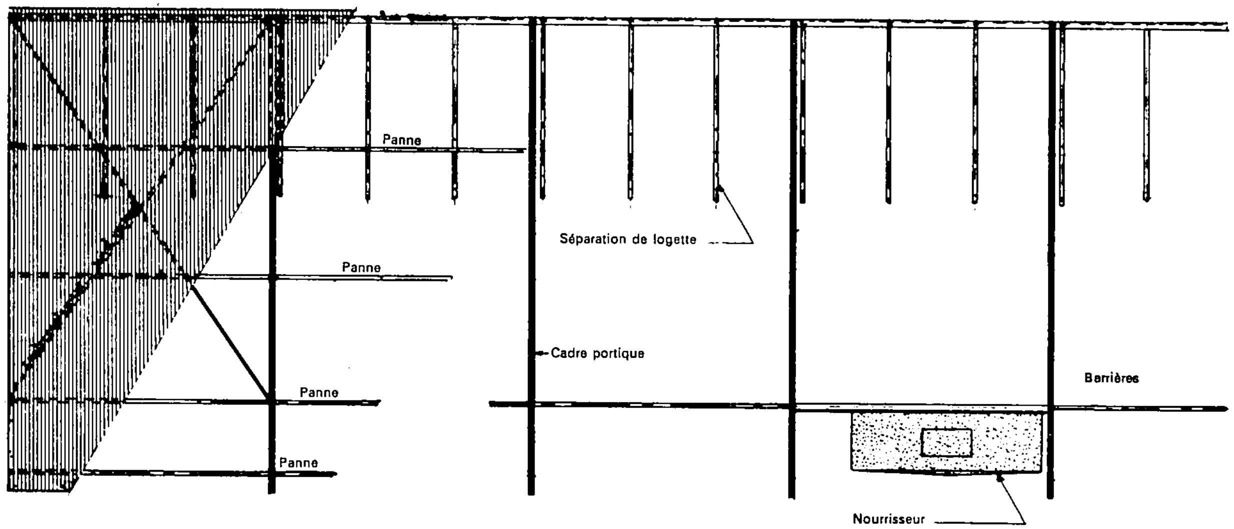
to prevent excessive exercise which would limit potential gains in weight and to ensure that the animals move around on the grating so that the dung falls into the dung pit.
The exercise yards are surrounded by tubular steel barriers secured by pins so as to make them easily adjustable.
As the animals are moved only four times a year for weighing, twice for vaccination and, exceptionally, in cases of accident or sickness, we do not provide doors but merely sliding tubes to give access.



Section AA-Long side with barriers



Section BB



Plan view

Bordage pignon en plaques ondulées amiante ciment ou en bois	= *Gable end cladding of corrugated asbestos cement sheeting or of wood*
Panne	= *Purlin*
Bordage long pan	= *Long side cladding*
Barrières fixes	= *Fixed barriers*
Barrières mobiles	= *Movable barriers*
Nourisseur	= *Feeder*
Séparation de logette	= *Cubicle partitions*
Pente	= *Pitch*
Niveau du sol	= *Level*
Toiture	= *Roofing*
Caillebatis	= *Grating*
Cadre portique	= *Portal frame*

Fig. 1: Open stall system—sheds—longitudinal and transverse sections

The pens for treatment, weighing or shipment are also of tubular steel which is both strong and light and above all has no sharp edges or rough surfaces dangerous to men and animals.

"V.V." Feeders

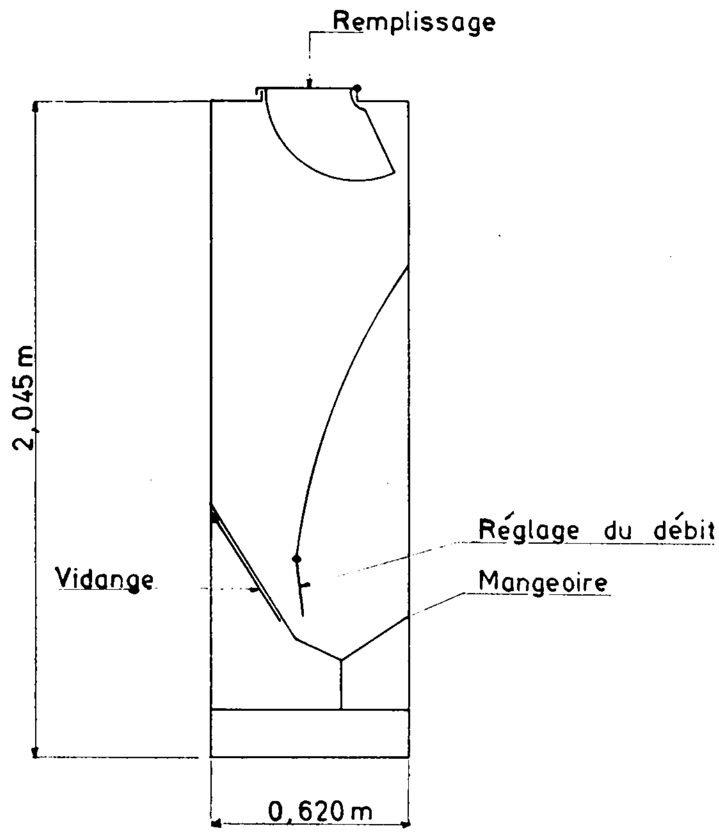
Type and method of feeding: The main requirements were to reduce working hours and to ensure that the feeding stuffs had maximum effect; so we discarded the traditional feeding methods (hay, straw, pulp, silage, etc.) and used manufactured feeding stuffs in cube or nut form, of balanced formulae based on the knowledge we have gained to date, which can certainly be improved upon. Our tests over the past five years on more than 3,000 animals have proved that if cattle are accustomed to this method of feeding from an early age they can thrive on it, since a one-year-old "V.V.-feed Normandy bull weighs 450 - 500 Kg. as against 300 - 350 Kg. when fed by the conventional method.

There is the further advantage that we can keep a constant and close check on the composition of the feed since we know the raw materials and can analyse the manufactured products. Adjustments can be made at any time.

The nuts, dry, solid and normal feeding stuffs, lend themselves to any type of mechanical handling.We have found that when the feed is freely available all the time the animals instinctively take as much as they need and no accidents occur. An efficient self-service system is possible if the feed is well balanced and complete.

Equipment: The device has no motor; the animal itself can make the amount of feed it wants fall down from the container.Wastage and deterioration of the fairly expensive feeding stuff must be avoided. The container is a hopper with a capacity of about 1 cubic metre, thus holding sufficient feed for 12 large V.V. animals for 7 days (750 Kg.) (for details see *fig. 2*).

The flow of nuts into the trough is regulated by the opening of a trap-door so that the movement of the animal's tongue causes the nuts to slide towards the bottom of the trough. As its supply of feed is ensured, the animal feeds peacefully as much as it wants at a time. The shape of the trough, a wide-open V, causes



Remplissage — filling
Vidange — emptying
Règlage du débit — regulation of flow
Mangeoire — manger

Fig. 2: Feeder

the feed to collect at the bottom, where the animal eats and licks up the nuts and powdered fragments without leaving any moist waste which might go mouldy and cause poisoning.
A trough 2 metres long is amply sufficient for 12 large animals. Feeding habits change and the young steers come to the trough frequently (rarely more than two at a time) and feed peacefully since they know that they have free access to the food supply.
The "V.V." feeder must of course be inspected at least once a day to make sure it is not clogged. It is also essential to empty it completely at least once a fortnight to ensure that the nuts in the hopper are in good condition; a trap door is provided at the rear of the hopper for this purpose.
Over the three years it has been in use, this device has proved to be one of the most reliable means of obtaining the best results from the "V.V." method.

Dott. Pasquale SCIARRETTA

Officio Studi Comansider s.p.a.
Roma

Loose Housing for Cattle with Prefabricated Steel Cow-sheds

(Translated from Italian)

Over the last 10 years there have been great changes in cattle husbandry in Italy. The determining factor is the need for mechanization which is compelling farmers to change the size, shape and layout of the various services in cow-sheds. New materials and new building methods have to be used because work inside the buildings has to be just as highly mechanized as work in the fields.
The cow-shed design should be flexible enough to be readily converted if it becomes necessary to change the system of production, or if new techniques are introduced by advances in animal husbandry.
In some countries animal housing is very simple; in certain cases it consists of just a covered yard to keep the rain off, the object being achieved by erecting light, mobile sections which can be modified as required.
The basic concepts to be borne in mind when applying these techniques can be summarized as follows:
— simple buildings, reduced to the indispensable minimum, at the lowest possible capital cost per head;
— the possibility of converting the buildings for probable future uses, looking ahead to likely advances in production techniques or even in animal husbandry;
— the possibility of quick erection and dismantling for re-use on the same farm or elsewhere.
Buildings made of prefabricated steel sections fully meet the requirements listed above and enable important technical problems to be economically solved. Among other advantages, prefabricated metal buildings are particularly suitable for loose housing for animals and offer the following benefits:
— low installation costs in view of the exellent properties of the material used and the low cost of maintenance;
— superior resistance to both weather and conditions of use, and durability;
— ease and speed of erection and dismantling, with complete recovery of all materials for re-use on the same farm or elsewhere;
— possibility of extending the building by adding standard units as required;
— ease of transporting the single sections, even over difficult terrain, because of their low unit weight;
— the buildings are completely hygienic as they can be kept clean by hosing down;

— the installations offer better possibilities for mechanizing the various operations (feeding, milking etc.).
Having listed, though in summary form, the positive features of prefabricated steel buildings, I would now like to mention some types of loose housing which have proved very successful on various types of farm in Italy.
The first example is a building for the loose housing of 50-60 calves. This is, therefore, an installation of limited size, suitable for medium size or even small farms. This is a very attractive feature of loose housing, and it has been shown that it can be profitably and economically introduced on medium size and small farms as well as on large farms carrying several hundred head of cattle.
An installation of this kind comprises:

a) a shed with partially enclosed sides to provide shelter for the animals, covering an area of 320 m²;
b) an exercise yard where the cattle live in the open air, covering an area of 520 m²;
c) another shed, most of which houses a feed store with a capacity of 1.200 m³ of forage. Adjacent to this building, which provides cover for the men preparing the rations, and equipment is the feeding rack which has a small projecting roof to keep the rain off the animals while they are feeding;
d) an enclosure formed of prefabricated tubular steel units, each 2-4 m. long, joined by means of special clamps.

Fifty to sixty calves can be fattened in a yard of this size. The cost of an installation of this kind, ready for use, is under 3 million lire which works out at 45,000-50,000 lire per head.
An economic study carried out in an installation of this type has shown that the proportion allowed for depreciation and maintenance is 28% below that for an equivalent cow-shed of conventional type. There is also the economic advantage that all services can be mechanized despite the relatively modest scale of operation, and this represents a factor which will subsequently lower the total annual costs.
There is one other fact which should receive due consideration: because the installation described is built up from standard units, it is possible to construct a shed half the size to take 25-30 head of cattle, and this would meet the needs of the smaller farmer.
The same type of shed can be suitably extended to provide loose housing for fattening 100, 150, 200 or more calves. In this case the cost of the building tends to be relatively lower in proportion to the increase in the number of cattle.
It is obvious that these buildings constructed from standard units are so versatile that housing designed for fattening calves can readily be modified to take a dairy herd. A cow-shed of this type, but modified for the loose housing of 50-60 dairy cows and equipped with a milking parlour, will cost about 4 million lire, ready for use.
After speaking of some of the features of these installations which make a real contribution to the spread of the loose housing system, even in areas where small farms predominate, I want to describe a recent example of a large installation. On 4,000 hectares near the coast of Rome Province, two "animal husbandry centres" have been set up, and these must be among the largest in Europe, housing 2,600 dairy cows. These centres have been built by the use of prefabricated steel structures selected from one of the nationally available standard ranges.
Each centre comprises accommodation for cows, accommodation for heifers, feed stores, calving pens, bull pens and sick-bay.

Accommodation for cows

Capacity: approx. 700 cows, subdivided into 4 groups. The covered yard in the rest area is 32 × 180 m. and the total roofed area is 5,760 m². There are three partly paved outside yards attached to the covered yard.
Each group of dairy cows enters the feeding and milking yard in turn and remains there for three hours. The rest of the time the other three groups are kept in the three partly covered and paved yards. This arrangement allows each individual cow to have 20 m². of open and partly paved yard available to her during the 9-hour rest period. To explain how this system works, here is a timetable showing the dairy roster.

There are four groups, each containing 176 cows.

	1st milking hours		2nd milking hours		total hours
Group 1 milking Groups 2, 3 and 4 resting	3		3		6
Group 2 milking Groups 1, 3 and 4 resting	3		3		6
Group 3 milking Groups 1, 2 and 4 resting	3		3		6
Group 4 milking Groups 1, 2 and 3 resting	3		3		6
	12	+	12	=	24

The changeover between the group that has just been milked and the next is effected via a small collecting yard where the cows are held for about 5-10 minutes, just long enough for the next group to enter the milking yard.
The herdsmen are divided into three groups, each working an 8-hour shift. The milking and feeding operations are as labour-saving as possible and include a modern machine-milking parlour and vacuum milk lines. In view of the distance involved, it was thought advisable to divide the milking yard into two self-sufficient parlours. In the layout we are discussing the milk is collected in the centre of the milking yard. The milk is simultaneously vacuum cooled and collected in tanks of a suitable size which are taken as required to the farm's own small dairy for further treatment.
With feeding also the work is carried out in the most laboursaving manner, and the building includes a barn 12 m. wide from one side of which the feed vehicles carry the forage to the cows, while the hay and silage for feeding the animals is brought in on the other side and placed under cover. This feed preparation area serves both the cow and the heifer units.

Accommodation for heifers

Complementary to the dairy herd unit is another loose housing unit for about 300 heifers intended for replacements. As mentioned above, the heifer yard is served by the same feed preparation area as the cows. This yard also comprises an exercise and a rest area, in addition to the feeding area. Each heifer has available to her 25 m^2. of uncovered, partly paved yard and 8 m^2. of covered yard.

Feed stores

These are situated next to the cow-sheds and have a capacity of 24,320 m^3., or storage space for the equivalent of 3,650 tons of hay, sufficient for 120 days' feed for the 1,000 cattle housed, in consideration of the fact that the farm has good prospects for providing fresh forage. The location of the feed stores was arranged to facilitate handling stores and easy distribution within the cow-sheds.

Calving pens

It was considered appropriate to include special calving pens. It was thought that pens for 50 cows would be sufficient as times of calving would be staggered. The normal type of stall was chosen, the standings being on the long side. The cows and their calves will occupy these pens during the colostrum period.

Bull pens

The number of bulls needed was based on the assumption of natural mating. Ten bull pens, therefore, were provided and a covering room.

Sick-bay

It was thought essential to equip the dairy unit with a 20-cow-shed to provide a sick-bay and isolation area. The cost of setting up the two Dairy Centres, including the milking machinery, worked out at 135,000 lire per head, which is a thoroughly economic figure in view of the high quality of the building and the very modern and complete equipment.

As regards the cost of running the Centers, the relevant data are in course of preparation. It is, however, anticipated that in these centres one herdsman will manage 40 cows, whereas in conventional tied houses one herdsmen is needed for every 16 cows. Thus, the new installation will give a saving of over 50% on labour. It has also been found that there is less food wastage because the heifers eat what is left in the feeding passage; with the old system, on the other hand, considerable amounts of forage were irrecoverably lost when they fell on the bedding in tied stalls.

It is estimated that the reduction in food wastage may amount to 7 - 10% of total feed costs. Moreover, there is a substantial saving in straw. In the Centres daily spreading of straw in the bedded area is necessary only during the winter months; the litter itself is changed once every 2-3 months because the soil is sandy and has good natural drainage. There is thus a saving of over 50% on straw.

The two examples described—one a small to medium size cow-shed, the other a very large complex unit—offer a further proof that prefabrication and steel together can make a genuine contribution to the improvement of livestock housing by cutting both capital and running costs.

G. HIPPOLYTE

Vallourec
Valenciennes

Shelters for Free Stabling

(Translated from French)

At the request of the Ceta at Senlis, this type of shelter was investigated with a view to its use for the intensive rearing of cattle. This type of breeding—the products of which are known to the general public under the name of "Baby beef"—promises to become widespread in France, with Government sponsorship and through the lead given by certain groups of breeders who are determined to break with the traditional inflexible and too costly methods.

The breeding unit comprises a set of long low buildings, arranged as far as possible in parallel lines, according to the space available.

Each building has the following characteristics:

—Width between post = 4 m.

— Roof sloping one way only

— Clearance under roof 2.7 m. to ridge
2 m. to lowest point
— Roof of asbestos cement
— Shingles, bottom of long wall only — asbestos cement
— The longitudinal pith modulus of 2.7 m. means that all multiple lengths can be used.

In these structures the framework is of cold-rolled sections and accounts for 56% of the weight of the assembly. The tubular barriers and partitions account for the remaining 44% of the total weight.
In order to make this structure easy to move, extend, and modify on the spot, all assemblies are bolted together; the weight of the heaviest part does not exceed 20 kg.
Moreover, great pains have been taken to achieve simplicity, and the number of assemblies has been reduced to the minimum compatible with the needs of the stock-breeders and of the cattle.
If mass-produced with suitable tooling this structure will be low in cost price, and appears to be a typical example of the application of steel in agriculture.

Bernard FABRE
Ingénieur

Fédération nationale des groupements de productivité agricole
Grenoble

Research on Lines of Approach to the Problem of Constructing a Cowhouse with Vertical Storage Facilities

(Translated from French)

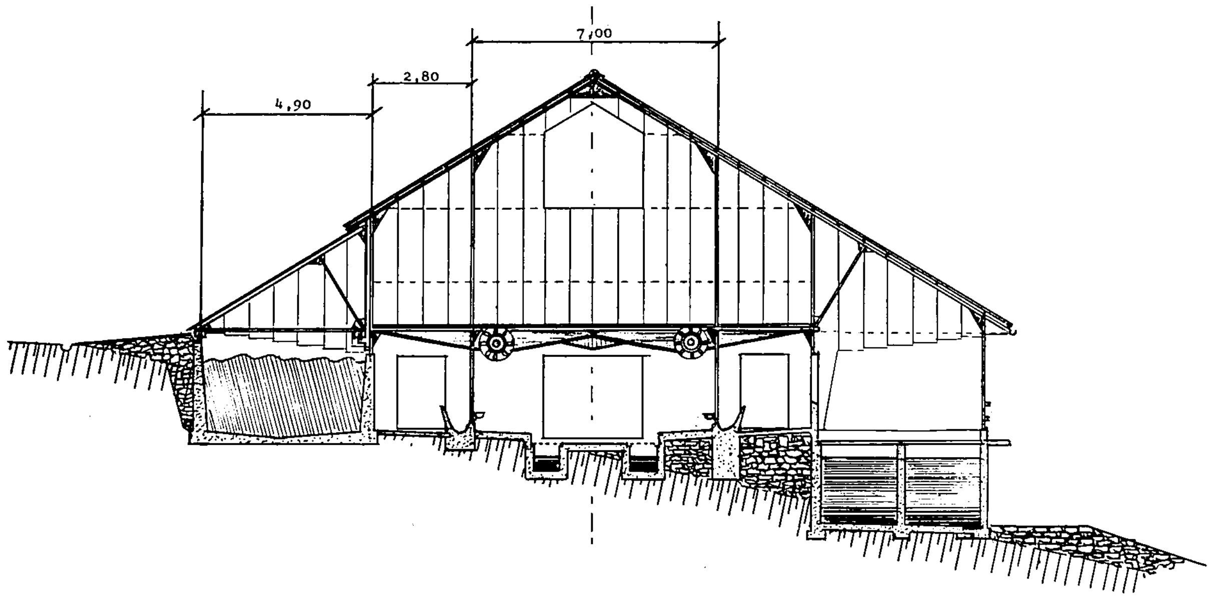
Efforts made in recent years to modernize buildings and plant for livestock breeding have generally been concentrated on single storey buildings placed next to one another, with horizontally effected mechanical handling (*see Fig.*). In hilly areas siting possibilities are often limited because of the slope of the land. In several respects climatic conditions would favour the construction of cow-sheds with a second floor where hay and straw could be stored.
Present and future importance of livestock farming in France in hilly country is such that this type of building is of wide interest and it is worthwhile to study the relative problems.

Economic considerations involved in the choice of the type of construction

Amortization possibilities of the building: a study of 40 livestock farms since 1956 to the present day has led to the two following conclusions:

i) with the rapid development of farming techniques, longterm amortizations are out of the question (ten years for light construction)
ii) the margin of gross income which can be alloted to the amortization of buildings is relatively inelastic.

Interest in prefabrication: In view of the above, it can be easily understood that farmers needing to erect or extend a cow-shed wish to know a priori and as accurately as possible the total cost involved in the investment.
In this field it would help if manufacturers were to prepare a standard form for estimating purposes enabling comparisons on returns per beast housed, or per cubic metre of feedstuff, and straw stored.



The following three factors are of importance in the estimate:

a) site variables,
b) the constant of the superstructure and the machinery installation,
c) variable proportion as to the number of bays.

They would tend to prefer solutions involving the use of prefabricated components quickly amortizable (the amortization period depending on the technical and economic factors of livestock breeding and not upon the life of the building), easily erected to form new buildings or extensions to buildings, all of which would emphasize the advantages offered by the principle of prefabricated multi-purposed building units.

Economic flooring for farm buildings

The importance of the flooring in such a building is worth looking into, as we feel this aspect has been rather neglected, and we would like to contribute the conclusions of our research over the past few years:
Reduction in the net price as a result of a reduction in the load bearing areas:

a) from the fact that in a cow-shed there are a number of areas not covered by the movement of either the beasts or their handlers, it would appear possible to use these areas for the siting of the internal supports of the building and thus break up the load bearing areas into smaller parts subject to almost constant stresses;
b) moreover, it seems that with joint calculation of framework and flooring the structure could be lighter and therefore more economic compared with a building in which the flooring is calculated separately and then added to the supporting framework.

An aggregate framework could be constructed from a small range of standardized components, which would be a further source of saving.
Reduction of the net price by the use of certain components for two or more simultaneous functions. In the same way as there is a relationship between flooring, framework supports and roofing, there is also a wide choice of other major items of construction and equipment which could be used.
We give below as examples the most common:

a) a prestressed concrete trough could act as the foundation tie for a line of framework supports,
b) the ceiling of the cow-shed braced against the wind by a profile of the "seagull's wing" design, could also house the ventilating system for the post-drying of the hay in the barn. Such a profile would also prove itself of value from lighting point of view and for the satisfactory thermal insulation and air conditioning of the cow-shed.

Conclusion

French hill farmers would wish us to study, bearing in mind their technical and economic problems, modern solutions involving prefabricated standardized components thereby enabling them to construct buildings which, though more or less different would be based on the same prefabricated components.
The success of any commercial programme depends in the first place on the adoption of a module for the spacing of framework supports, as well as for the dimensions for flooring and handling areas. In the second place a choice has to be made between the different technical solutions depending on the comparative figures for corresion, insulation and condensation, not forgetting that aesthetic merits or otherwise of fascia and roof are important factors for rural preservation in hilly areas of attraction to tourists.

P. LUCCHINI

Section technique centrale de l'habitat rural
Ministère de l'agriculture
Paris

Steel in Modern Piggeries

(Translated from French)

For some years now we have been witnessing rapid developments in construction techniques for animal housing. The greatest innovations have undoubtedly been in the pig industry. These may be summarized as follows:

- progressive adoption of indoor housing where the pigs are kept under excellent artificial atmospheric conditions (optimum temperature and humidity, and adequate ventilation) The feed conversion factor is thereby minimized;
- mechanization of most of the labour, such as feeding, mucking-out and regulating temperature and humidity. The pigman's work is confined to management and he can therefore devote more of his time to supervise the animals;
- as the traditional country craftsmen have been unable to keep up with the growing demand, some manufacturers on the lookout for new production lines have during the past year begun to make prefabricated piggeries which are "ready-for-use" and ordered from a catalogue.

The "prefabricated" system has the advantage of relieving the farmer of the worry of finding contractors and co-ordinating their work. Nearly all the manufacturers offer workable units which, while not perfect, are better than the average traditional buildings.
It must be admitted that most of the manufacturers only use small quantities of steel. Where the buildings consist of a supporting framework filled in with asbestos-cement panels metal parts, particularly in the ceiling, can cause condensation when there is insufficient ventilation. In any case they must be protected from corrosion.
For effective ventilation air-currents should be able to pass over the whole area and there should therefore only be the minimum of resistance. The fronts of the pens are therefore most commonly made of tubes (four or five 20/27 gauge steel tubes to a height of about 1.10 m.). Tubes also facilitate inspection of the animals. Some constructors also use tubes for partitions between the pens; in our opinion, however, this can lead to biting between the pigs in neighbouring pens.

Steel troughs are suitable for all types of feed.When, however, it is in liquid form it is essential for the troughs to be rinsed after feeding. This operation has been made very simple and even automatic in some instances. The steel troughs are so light that they can be fixed on the front rails of the pens without making opening difficult. They can be made continuous which enables them to be filled by mobile conveyors.
Some constructors have solved the problem of the throughs being fouled by providing for the inversion of the troughs after feeding.
Steel can also be used as the main material in advanced design piggeries.
Examples of two American models may be quoted.

Piggery Type I

This has been in commercial use in Europe for nearly two years, particularly in Italy. One was also built in France over a year ago. The building is rectangular in shape and has a dimension of 28 × 9.5 with vertical walls and a low-aspect gabled roof.
Walls and roof are of hot-galvanized, deep-ribbed steel sheet 1 mm. thick. The roof is self-supporting with steel tie-beams that prevent side-thrust on the structure.
Insulation: Internal thermal insulation of the building is essential and this is provided by expanded polystyrene panels 5 cm. thick bonded on to the walls. The ceiling, which is suspended from the tie-beams, is insulated in the same way.
Interior equipment: The building is divided longitudinally into two unequal sections. On one side 18 pens 3.04 × 1.56 m. for weaners of 20 to 45 kg. On the other side of the gangway there are 18 other deeper pens (5.18 m.) of the same width for pigs of over 45 kg. (the actual accommodation being about 400 head).
All pens have an insulated sleeping platform and a section covered by a grating where the pigs defecate. The dung passes through the openings in the gratings and falls into a water-filled dunging channel which is closed by a sluice-gate at one end. When this gate is opened, two or three times a week, the dung is discharged instantaneously into a slurrypit.
Feed: This is stored outside in steel bins in the form of pellets or meal and is brought by auger to ad-lib feeders for young stock, or into floor-discharge type metering-hoppers at predetermined times for stock which are being finished-off.
Ventilation: Particular care has had to be given to ventilation owing to the presence of many metal obstructions. Fresh air is admitted either through the roof or through louvres along the sides, depending on the time of year. The foul air is removed through the dung-channel by powerful ventilators operated by thermostat and time switch.
Maximum use is made of steel for internal equipment (perhaps it should be mentioned that the firm making these piggeries is primarily engaged in making self-supporting sections in galvanized steel).
This steel is used for the following:

- interior lining of the outer walls in contact with the pigs. The height of the sheets, initially 1.20 m., has had to be increased to 1.50 m. to prevent the pigs damaging the polystyrene;
- partitions between the pens, using horizontally-ribbed galvanized sheet. These serve a very useful purpose but suffer from the disadvantage of being noisy; however, it may only be a question of securing or reinforcing them;
- gratings. The use of steel for gratings enables the width of the flat surfaces to be reduced and consequently they remain cleaner.Where as with reinforced concrete gratings 6-7 cm. is about the minimum that can be achieved, in the steel gratings currently used, the flat surfaces are no more than 13 mm. wide. Although the gaps are narrower than in ordinary gratings (13 mm. compared with 20 - 22 mm.), the percentage of dung voided is higher (45% of the grating surface): the gratings therefore stay cleaner, and there is less risk of leg damage.

  At first there were some difficulties in using steel for gratings since the cross members rusted very rapidly. This problem seems to have been solved by coating them with an epoxy-resin, which has the additional advantage of making the grating less slippery.

Piggery Type II

A second type of piggery, even more novel, has been operating for some months in Holland, near Amsterdam. The building is cylindrical, 15 metres in diameter, 3.50 metres high, and topped with a cone reaching to 8 m. The walls consist of two sheets of corrugated steel with a layer of expanded polystyrene 5 cm. thick between them. The cone, consisting of several metal sectors, is insulated in a similar way.
Interior equipment: Inside the building there are two tiers of pens arranged around the periphery. They accommodate more than 400 pigs (23 pens of ten at ground level and 23 pens of eight at a higher level). The pens which are wedge-shaped, each have two parts,
— a sleeping platform at the peripheral end, which is the larger part;
— a dunging area, consisting of a steel grating over a dunging channel, nearer the centre of the building.
Partitions between the pens are of welded steel mesh with apertures of about 10 × 20 cm. A movable stairway enables each pen on the upper level to be entered in turn, and is also used for moving the animals.
Ventilation is automatic by means of extraction fans.
Air-conditioning is achieved very simply; hot or chilled water, depending on the time of year, is circulated through steel pipes embedded in the concrete slab of the sleeping platform in each pen.
Feed, stored nearby in steel bins, is carried to the upper level by an auger then gravity-fed automatically into each pen area by a rotating arm.

Conclusion

The use of steel as the main material for constructing fattening piggeries makes possible a number of noteworthy innovations, as can be seen from the two examples we have given.
Provided the optimum ambient conditions are strictly maintained, steel is perfectly suitable for this type of building and, if really well surface-protected at the start, requires very little servicing. Furthermore, when used for lining the inside of a piggery, steel facilitates disinfection.
Nevertheless, we should not be over-optimistic about the possibilities for development of this system.
In the first place, metal buildings are still held to disfigure the countryside. This is probably only a question of familiarity and it may be hoped that prejudice against them will disappear in time. At the same time, many farmers have memories of some disappointing experiences, for example corrugated iron used for roofing sheds, which, despite assurances from salesmen, went rusty and needed periodic painting.
But the main, indeed the only real obstacle is cost. For the same capacity and comparable interior equipment, steel piggeries are 30 to 50% more expensive than steel poultry-houses. Because of this, they are slow to catch on, which is all the more regrettable as this is a time when farmers are very actively engaged in installing modern equipment.
It is to be hoped that those at present manufacturing or importing them, and/or such other European firms as see that this market is worth exploiting, will do something to make them less expensive.

Dott. Pasquale SCIARRETTA

Ufficio Studi Comansider s.p.a.
Roma

Industrial Pig Breeding in Prefabricated Steel Pig Houses

(Translated from Italian)

The need to increase meat production has never been more apparent, not only in response to growing consumer demand, but also for the sake of getting agriculture on to a sounder basis by placing more emphasis on the animal husbandry side.

Unfortunately beef production in Italy has for some years been declining alarmingly, for a variety of well-known reasons: thus in the last three years production has fallen from 4,762,000 quintals in 1963 to 4,532,000 quintals in 1965. On the other hand a significant increase in poultry meat production is in progress: during the same three years, 1963-65, there was an increase of 10%. Pigs showed an even greater increase, with production rising from 3,624,000 quintals dead weight in 1963 to 5,000,000 in 1965; incidentally, per capita consumption of pigmeat increased by more than 25% between 1963 and 1965.

The increased consumer demand, particularly for fresh pigmeat, which had been unjustifiably neglected up till a few years ago, has resulted in a greater interest in pig rearing among stockbreeders. They are concentrating more especially on intensive rearing, following the excellent results obtained by poultry farmers, who have increased their production fourfold in a decade; in view of what has been achieved in various other countries, there is no reason why intensive pig rearing in Italy should not appreciably increase the amounts of meat available and provide a product of the highest nutritional value at a price which the mass of consumers can afford. In short it should be possible by intensive methods to produce some millions more pigs per year, of meat-type breeds, weighing about 100 kg., reared in a cycle of six months, at relatively low cost, certainly much lower than in the case of beef production.

It is clear that this will need to be based on concentration; moreover, it will be necessary to encourage greater breed uniformity, increased use of bought feeds to ensure a high level of feed conversion, and more specialization of buildings.

It is of special importance that the specifications of the buildings should be planned as carefully as possible, since it is absolutely essential that these should be thoroughly hygienic and functional, and should permit really efficient rearing, right up to the stage of complete automation.

For a number of years prefabricated steel structures have been profitably used in the construction of pig houses, just as they have already been widely used in the loose-housing of cattle and in poultry rearing. Prefabrication and steel are now an indissociable combination which is being employed more and more in industrialized building of all kinds, and is proving very satisfactory in the construction of farm buildings too. Prefabrication is the most modern and progressive system, since it enables the components of the building to be produced and tested in specialized plants, so that all that needs to be done at the actual site is to assemble them according to plan. This essential feature of prefabrication avoids the various hitches which tend to occur at the traditional type of site, speed up the project, and simplifies many of the operations.

There is no object here in listing the intrinsic properties of steel, a basic material indispensable to technological progress in agriculture as elsewhere.

The following advantages are gained from the use of prefabricated steel components:

— the installations are exactly in accordance with the farmer's requirements in every detail,since with them it is possible to put up structures of various heights and areas, with doors and windows of the number and size required, and internal partitions of any kind;

— prefabricated buildings are easy to transport even to regions difficult of access, thanks to the light weight and ease of handling of the separate standardized components;

— they are quick and easy to assemble, which results in faster completion of the project and consequent substantial financial savings;

— the structure is very strong and durable, thanks to the intrinsic properties of the steel, which reduce maintenance costs to a minimum;
— it is very easy to clean the steel parts using jets of water with or without disinfectant. In addition, the perfectly smooth surface of the metal offers no refuge for germs, a very important characteristic from the point of view of hygiene;
— adjustment and alterations, both inside and outside, can be quickly effected at small expense;
— the buildings can be taken down without loss of any of the metal parts, for re-erection elsewhere if desired;
— since they are both exceptionally efficient and cheap to maintain, the running costs involved are considerably lower;
— in short, because of the good job they do, it is safe to say that prefabricated steel buildings are a very sound investment.

After this brief account of the general advantages of prefabricated steel buildings for pig producers, I now propose to describe the essental features of an "intensive" type of pig house recently developed in Italy which is proving very popular, as it is simple and practical, highly efficient, fully mechanized and thoroughly hygienic, in short a first-class buy. These pig houses are constructed from prefabricated components of galvanized steel which are highly resistant to corrosion. They are 10 m. wide, 2.5 m. high and 38 m. long. Inside the building there are 36 pens formed by movable partitions of prestressed concrete. They are arranged in two rows along the walls, with a gangway down the middle. The dimensions of the pens are 2.10 × 3 m. for young pigs up to 20 kg. (14 pigs per pen) and 2.10 × 6 m. for pigs up to 120 kg. (14 pigs per pen), with floor spaces of 0.45 and 0.90 square m. per head respectively. The roof and walls are both of galvanized steel, insulated with panels of expanded polystyrol of suitable thickness; in addition, the walls are protected up to a height of 120 cm. from the ground by a lining of galvanized steel, which markedly facilitates cleaning and disinfecting.

The air-conditioning is effected by a ventilation system comprising large fans placed at both ends of a central air duct which runs along the whole length of the building under the floor, with branches to each pen. This has the great advantage of assuring uniform ventilation at floor level, where the carbon dioxide exhaled by the animals and the gases from fermentation of excreta usually accumulate. The air flow is regulated by automatic timing devices which control the fans: the foul air is expelled through two extraction towers positioned at the ends of the ventilation duct. Within the building, there is to every two pens an air inlet operated by the fall in pressure produced by the fans. The fans can change the air at the rate of 15 cubic m. per hour per head.

The pig house is equipped with an automatic feeding system for the distribution of feed in controlled amounts. The feed is automatically lifted from an outside store and is carried into the building by an auger. The auger runs overhead inside the building and distributes the feed into hoppers in the centre of each pen, from which the exact weight of feed desired can be delivered. In practice the operator has only to set the hopper-regulator at the required amount of feed for distribution to each pen; at feeding time an automatic device opens the cover at the base of the hopper and allows the feed to fall through.

Water is supplied by pressure drinking troughs placed inside each pen near the slatted area.

The floor of the pens is partly of concrete and partly of steel slats, the latter being essential for the complete drainage and removal of the animals' liquid and solid excreta. The excreta fall directly into channels under the floor, which have a capacity of 0.30 cubic m. per animal; the slurry remains there for two or three months and is then automatically removed to an outside reservoir, whence it can be pumped into a tanker for subsequent use as fertilizer.

The pigs have a sleeping area and a slatted dunging area; faeces and urine do not accumulate, and since there is a continuous air flow the animals' living conditions are thoroughly adequate to requirements in every way. This prevents disease of all kinds, except of course virus epidemics.

Intensive rearing in pig houses such as these allow of substantial manpower savings, since one man can look after some 500 animals. At the same time the methods and the equipment used make a great difference to the actual work, doing away with the more wearing jobs involved in traditional production methods.

Pierre FAUCONNET

Président de la Fédération départementale des agriculteurs
Saint-Hilaire-sous-Romilly

Some Observations on the Use of Steel in the Construction of Farm Buildings

(Translated from French)

It is not proposed to deal in this paper with farm storage sheds, for which steel is much used and does not appear at present to raise any particular problems. I shall confine myself to the subject, firstly, of steel poultry houses, and secondly, of what is by now, in our part of the world anyhow, definitely a felt want, namely small buildings which can be easily erected by farm labour for use as a tractor and implement store or workshop.

Use of steel for poultry houses

We devoted a great deal of attention to the question of the steel poultry house for industrialized poultry-rearing in 1964-65, when we set up a regional chicken-farmers' association and built a chicken slaughterhouse. It is now a year since the first all-steel poultry houses for rearing meat chickens were brought into service, so by this time we are in a position to assess their value, and also any disadvantages they may have. They are large-capacity structures of 1,000 - 2,000 square m., housing 12 birds per square metre.
Steel has, we consider, several advantages for this purpose:

- it is long-lasting, a very important point in this type of structure, which in view of the moist atmosphere inside needs to be made of simple and sturdy materials;
- in addition, it is undoubtedly more space-saving than other materials, since these structures of 15 m. by 70-100 need very little inside support;
- consequently there is ample room, which is a further advantage as it makes it easier to move the appliances for taking litter in and out, to install fixtures and equipment and so on.

Also, steel is quicker to build with than masonry. A steel poultry house of 2,000 square metres can be erected and fully fitted up in a few weeks, as was in fact done last winter despite the exceptionnally difficult weather conditions.
As regards temperature-proofing, polystyrene plates afford a basic protection which, in conjunction with forced-draught ventilation, ensures that even on the hottest midsummer days the inside temperature is never higher than the outside, and indeed, if the ventilation is turned full on, may be some degrees lower. In the depth of winter too, thanks to the pulsed-air heating system, we have never had any trouble over temperature control.

Pre-fabricated buildings for agricultural enterprises

In our part of France, and in a good many others too, farm buildings are mostly old and unsuited to modern requirements. Many farmers have added to their premises sheds which have come in the last few years to be used for a larger and larger variety of purposes — to store cut hay and grass, cell grain containers, fertilizer (loose or in sacks) and farm machinery, and even to do odd jobs in.
But for these latter purposes the shed is not really appropriate at all. Apart from a few very tall and bulky items such as the combine harvester, the farmer has to use his shed for parking appliances not much more than three feet high. Then again, he cannot get at those at the back without first shifting all the things in front. And the shed is not always a good place to do odd jobs in, either, because they have to be done in a draught and take up much more space than is at all efficient considering the height.

So I feel it would be a great advantage to present-day farmers to have small easily-assembled structures of, say, 20-50 square m. floor space and 3-3,5 m. in height. They would be easy to fit in as they occupy only a small area, and the farmer could install additional ones as and when necessary and as and when he could afford them. They could be used for all sorts of purposes — as equipment stores or workshops, or feedstuffs mixing rooms, or as stores for spare machinery, insecticides, feedstuffs and so on.
Accordingly it seemed to me worth drawing attention to this subject, even though the structures I have in mind may sound rather a minor affair. I feel certain they would catch on in a big way with the farmers, and so constitute a substantial sales outlet for this specialized sector of steel construction.

Dr. Hermann VOGT

Bundesforschungsanstalt fur Kleintierzucht
Celle

Trends in the Rationalization of Poultry Keeping

(Translated from German)

Since so far we have not dealt with the special problems of the use of steel in poultry keeping there is only time here for a general glance at the equipment used in this type of farming.We shall try to give particular prominence to the trend towards rationalization in poultry keeping. On the basis of this account it may be possible to draw conclusions later as to how far steel can be used in the manufacture of this equipment.
These notes will deal principally with information on the rationalization of equipment used inside the poultry house, and the construction of the poultry house itself will only be mentioned briefly in connection with atmospheric conditions in the house; this is because poultry houses in themselves do not basically differ from housing for other types of livestock. Mechanization must be considered principally from the point of view of saving labour. As a rule mechanization cannot be excepted to produce any improvement in the performance of the birds, except perhaps in controlling the atmosphere of the house. On the contrary, there is a danger that over-mechanization may affect the well-being of the birds and thus lead to lower performance. In order to give some idea of the points at which rationalization can most usefully be brought into play, I would like to begin with a few figures about the quantities that have to be moved in poultry keeping; it must be understood that these are very general average figures. A laying bird consumes daily about 130 grams of feed and drinks about 225 grams of water; conversely it produces daily about 190 grams of droppings and 40 grams of eggs; it also exhales about 110 grams of water into the atmosphere of the house. This means that, per bird per year, about 47.5 kg. of feed and about 82.5 kg. of water, totalling around 130 kg. must be moved into the house and about 70 kg. of fresh droppings, 15 kg. of eggs and 40 kg. of exhaled moisture, totalling around 125 kg., moved out. The total quantity to be moved per hen per year is thus 130 + 125 kg. = 255 kg., in addition to which the weight of the litter must be counted in deep-litter systems. (The difference in the quantities of 5 kg. per year or about 15 grams per day arises from the conversion of the feedstuffs into energy by the birds' metabolism.) The annual quantity to be moved in a house with 3,000 layers thus amounts to between 750 and 800 metric tons.

The atmosphere in the house

First, the question of removing 40 kg. annually of moisture exhaled by each bird. This volume may be increased by about half by the condensation of moisture in the droppings, which, when fresh, contain between

75 and 80 per cent of water. Since the moisture content of an optimum laying house atmosphere should be between 60 and 80 per cent, the amount of moisture given off in various ways by the birds should be removed from the house as quickly as possible.

It is also necessary to remove the various gases given off by the birds' very intensive metabolism. Examples of these are carbon dioxide (optimum atmospheric content not more than 3.5 volumes % of CO_2), ammonia (optimum not more than 0.1 volumes % NH_3) and sulphuretted hydrogen (optimum not more than 0.02 volumes % H_2S). The ventilating equipment required to do this has today reached an advanced stage of development and the objective for the future is as automatic as possible a system of control (using the moisture content of the air).

The necessary air changes for the maintenance of a balanced moisture content in the air give rise, in many cases, to an unbalanced temperature; that is to say, the heat given off by the birds is not sufficient to replace the heat lost through the roof and walls of the house and that required to heat the fresh air brought in, so that some kind of additional source of heat is necessary. Air heaters and combined heater-ventilators of a wide variety of types are already in use for this purpose, but further development is required here, since the apparatus so far available is not entirely satisfactory.

Poultry keeping methods

While the basic problems of house atmosphere are generally the same for all systems of poultry keeping, a distinction must be made for the remaining equipment between deep-litter and battery systems.

Deep-litter

The principal type of system used here has a droppings pit and accommodates between six and seven birds per square metre of floor area. The slatted floor system has not proved popular.

Water: Provision of water in deep-litter systems should no longer be any problem today, even for the smallest flocks. The trend is towards cylindrical automatic drinkers. These drinkers are now constructed in such a way that much less water is spilt, so that drainage sumps can be dispensed with. The water system in the house must be equipped with a reservoir for medicated drinking water, although it is possible to use the normal water system in conjunction with a metering apparatus. Development on these lines is still going on. If the water pressure is variable a pressure equalizing valve must be installed.

Feed: Efficient mechanization of feeding is dependent on the size of the flock. While mechanized feeding is not suitable for small flocks on cost grounds, semi-automatic feeding equipment exists for medium-sized flocks in the form of feed dispensers which run along over the feeding troughs; these are certainly capable of still further development. For flocks of over 1,000 birds continuous feeding troughs can be installed; however, the trend today is towards piped feed systems with round troughs, as, with this type of equipment, it is not necessary to dismantle it when the annual cleaning of the house is done.

In order to control the daily feed consumption in the house it is becoming increasingly important to equip these feeding systems with automatic weighing machines.

Rationalization of feeding is not complete unless the feeding chain includes a bulk storage bin, if possible equipped with an agitator so as to avoid bridging. Unless the bulk storage bin is mounted directly above the supply bins of the feeding system, the feed should be conveyed from bulk storage to the bins by means of an auger conveyor. The filling of the bulk bin in the house is done from a bulk tanker.

Eggs: Nesting boxes are increasingly tending to take the form of one-bird roll-away boxes for reasons of egg quality. Egg collection can be rationalized by the provision of a collection corridor behind the nesting boxes. Among other useful equipment for this purpose are egg collecting trays hung from an overhead runway. Development of egg collecting conveyor belts, which take the eggs direct from the nesting boxes to the egg preparation area, does not seem to be fully completed yet.

For reasons of egg quality considerable improvements will be needed in egg preparation and storage rooms, which will have to be equipped with suitable cooling units. Egg graders and egg washing units should also be mentioned here, although the latter with considerable reserve.

Droppings and litter: In deep-litter houses today some 50/60 per cent of the floor area of the house is occupied by the droppings pit, over which drinkers and feeding troughs are mounted. Bars which can be walked on are fitted over the droppings pit and on these the perches are mounted; the pit is covered by a special wire mesh (with mesh openings of 25 × 75 mm. and a wire thickness of 4 mm.).

The droppings remain in the pit for a long while, sometimes for the whole length of the laying period. Their more frequent clearing would be desirable for the maintenance of the atmosphere in the house, but development of the necessary cleaning equipment does not yet seem to be complete, as hen droppings behave rather differently from the droppings of other animals.

If the atmosphere of the house is satisfactory, it is not necessary to disturb the litter in any way, although special equipment has been developed for this purpose. The removal of the litter from the house can be done with front-end loaders or with ordinary conveyors.

Rearing: The special equipment necessary for rearing will not be considered in detail here though mention should be made of the necessary sources of heat (artificial breeders), and in rearing outside, of housing for the young birds, rainproof covers, etc.

Battery systems

Cage and battery systems allow a considerably higher stocking rate per square metre than deep-litter systems: they are becoming increasingly popular, but it cannot yet be said whether this is a permanent or temporary development. As with deep-litter systems there are various stages of mechanization.

Cage systems include banks of cages, flat deck installations and similar methods (approx. 11 birds per square metre of floor area). These systems do not have any continuous droppings removal equipment and even feeding is only partially mechanized.

In battery systems proper there are three or four rows of cages mounted one above the other and usually provided with automatic droppings removal and automatic feeding (approx. 17 to 18 birds per square metre floor area). In both types three or four birds are kept in one cage: larger cage units, as for example colony cages with up to 18 birds in one cage, are not to be recommended.Whether parallel developments in batteries and cages for rearing and for pullets will play any increasing part cannot at the moment be said, since it is only now that the first practical experiments are being made along these lines.

Water: The problem of water supplies in battery and cage systems has not yet been finally solved; the trend is away from the drinking channels originally provided, since losses of food and consumption of water are too high. At the present moment the trend is towards nipple drinkers, although even with these the problems of design do not yet appear to be finally overcome: the drip trays at present provided are only a temporary solution.When using nipple drinkers some kind of water storage container must be provided to equalize changes in the water pressure; this is usually a header tank equipped with a ball cock.

Feed: Feeding is mostly done from mobile feed dispensers or feed trolleys which either work automatically or are pushed along the rows of cages by hand. Continuous trough feeders or pipe feeders may also be used. Similar problems exist in the collection of eggs as with the litter systems.

Droppings: The greatest problem in battery systems at present is the removal of droppings. Since a final and satisfactory solution of this problem has not yet been found I will consider the systems at present used in further detail.

1. The droppings fall on to a metal or glass tray and are removed by a blade which is often mounted on the feeding trolley.
2. Droppings fall on to an endless plastic belt which is moved automatically or by hand and cleaned at the end of the battery by brushes or by a scraper blade.
3. Droppings fall on to bitumised paper or plastic foil which either rests on a strip of wire netting ("toilet paper" system), or else on an endless belt of metal sheets ("roulette" system). In both these droppings are not removed daily but at intervals of several weeks.

Prof. Dr. H. L. WENNER

Institut für Landmaschinen der Justus Liebig-Universität
Gießen

Application and Effects of Technology in Modern Cattle Stalls

(Translated from German)

Whereas practically every outdoor agricultural process, i.e. those carried out on ploughlands or pasture, has in the last 20 years fallen under the influence of technology, a wide range of indoor agricultural processes, in particular certain operations connected with animal husbandry, have thus far resisted advanced mechanization.

This applies especially to the rearing of dairy cattle, which today still involves an exceptionally high proportion of manual labour. However, modern solutions have presented themselves in the meantime and given suitable design of buildings as well as the use of the appropriate technical aids there are prospects of considerable labour-saving in cattle stalls.With developments as they are at present one can even consider that the rationalization of dairy-cattle husbandry would in future set free large reserves of labour in the agricultural industry.

This state of affairs becomes abundantly clear if we take a concrete example by tracing the development of a 17-hectare farm, i.e. a family farm of the size that is predominant in Western Europe.

Stages of Mechanization and Labour Requirements on a 17-hectare grazing farm with 20 cows

Outdoor work Indoor work	Team work Manual labour	High degree of mechanization Manual labour	High degree of mechanization Mechanized tethering stalls	High degree of mechanization Mechanized pen-barn
Labour requirements Man hours/year required	2.5 6,200	2.0 4.900	1.5 3,300	1.0 2,500
For outdoor work For indoor work For so-called movable work	32% 55% 13%	13% 70% 17%	19% 62% 19%	24% 52% 24%

The change-over from team working to a high degree of mechanization of the outdoor work went ahead with extraordinary rapidity between 1950 and about 1965. For instance, in the case of the 17-hectare farm it reduced the labour force required from 2.5 to 2.0; the share of outdoor labour was thereby reduced from 32% to only 13%!

Efforts during the past 5 years to reduce the preponderance of indoor labour, which in the meantime has risen sharply, have met with further success. The replacement of manual labour indoors by the mechanization of the tethering stall has led to the same high rate of labour saving as in outdoor operations; a 17-hectare farm can now manage comfortably with a labour force of 1.5, and the proportion of indoor labour has fallen from 70% to 62%. The highly mechanized pen-barn at present offers the best prospects for future large-scale labour-saving, in the present instance a further 0.5 man, so that it will be able to make do with a labour force of one. This example thus shows very clearly the importance of the modern design of farm buildings and the well-planned use of technology.

Of course the difficulties in the way of all proposed improvements to indoor operations must not be overlooked. The machinery and implements for field work can to a great extent be supplied ready made for use on any farm; but individual planning and construction of the technical aids to indoor work is in most cases necessary in order to adapt them to the local conditions as regards the available buildings. In this respect the only exception would be a large number of exactly identical new buildings—that is, complete farm units. But the provision of extensive new agricultural buildings will be frustrated by the very high capital cost, so that the improvement of existing buildings, generally in the form of conversions, will play the more important part.

In this situation the further difficulty arises that there has been no sign of the genuine development of an agricultural-machinery industry composed of large firms with the necessary competence to make complete, exhaustive tenders for all the installations needed for indoor farming operations; instead the customer finds himself dealing with a multiplicity of small firms tendering piece-meal for the widest range of machinery for facilitating the work of the farm.

In every step taken to improve cattle-farming, the strictest attention must be given to the close relationships and the interaction between the design of the buildings and the selected methods of mechanization. Considerations of labour organization, and above all of economics, should be the criterion for the scope of mechanization and the right and proper expenditure on buildings. It frequently happens that skilful design of buildings will eliminate the need for costly machinery. On the other hand, the right kind of mechanization can reduce building costs. Only by making due allowance for this interaction between the buildings and the machinery can the optimum results be achieved in farmwork.

The relative preponderance of the different categories of work involved in the economy of the farmyard gives an indication of the priorities for expenditure aimed at the saving of labour on dairy farms.We can distinguish between the following main groups:

1. Milk-production.
2. Straw-spreading and dung-removal.
3. Feeding.
4. Other work, such as cattle-tending.

Distribution of Labour in Cattle Stalls (Milk cows and progeny, 20 — 30 head)

Operation	Tethering Stall (milking machine, wheelbarrow, pitchfork)	Compartment pen-barn (milking pen with 2 milking implements, wheelbarrow, pitchfork)
1. Milking	41%	70%
2. Straw-spreading and dung-removal	30%	10%
3. Feeding	22%	13%
4. Other operations	7%	7%

According to this evidence, in both tethering stalls and pen-barns it is milking that should in the first instance benefit from labour-saving machinery and investment, as this operation requires by far the greatest proportion of farmyard labour. This applies equally to the tethering stall and the pen-barn.

The labour requirements of the other operations are subordinate to this. This is particularly true of the pen-barn, which moreover requires less time in absolute terms.

Admittedly, dung-removal and feeding mainly involve the heavy and unpleasant physical work of loading and transportation, which are ripe for mechanization. For instance, on a 20-cow farm, 240 tons of fresh dung, 160 tons of green fodder and 120 tons of silage and hay are moved in a year, which makes 25 tons per cow per year for dung-removal and feeding alone, more than a railway truck load! The mechanization of these operations is thus to be considered mainly from the point of view of facilitating the work.

There are many technical aids from which to choose in order to improve the efficiency of the tethering stall, which is by far the most predominant type and still preferred in new installations. Pail milking is labour-saving as compared with hand milking, but suction plants bring about no further major economy in the use of labour; it is rather to be seen as a means of facilitating labour and improving milk hygiene. The daily work of dung-removal and feeding can be done with tackle, push rods and chain conveyors, tractor loaders such as front loaders and threepoint loaders, and with pumps and pipe lines for handling liquid manure. All these pieces of equipment and installations are distinguished less by the amount of labour they save than by the capital expenditure that they require. As a rule the marginal hours of labour are saved by incurring a disproportionately high cost. Comparison between the implements used shows that on family farms the mechanical aids most in evidence are those which extensively save and facilitate labour at a modest cost.

Mechanization of the tethering stall (25 cows, 365 days)

Category of work	Mechanization	Labour required Man hours/cow/year	Capital outlay required DM/cow
Milking	Manual	108	1
	Pail	53	96
	Suction Plant	52	170
Straw-spreading and dung removal	Manual labour	30	4
	Front loader	8	40
	Tractor scoop	8	80
	Push rod and chain conveyor	8	200
	Grate arrangement for liquid-manure handling	5,5	200(¹)
Feeding	Manual labour	17	12
	Front loader or grab running on rails	10	40
	Cutter and worm	8	440

(¹) Extra cost for building.

However, the pen-barn requiring between 80 and 50 man-hours/cow/year is in general more economical than a modern tethering stall, which needs between 110 and 80 man-hours/cow/year, depending on the size of the herd; this applies equally to herds of 15 to 20 cows if the pen-barn has a large group milking pen. Thus the herring-bone milking pen is very attractive even for small herds, since the advantages of keeping cows in pen barns arise principally from the reduction in time and easing of the work of milking; dung-removal and feeding are completely overshadowed by it.

The following means are available for circumventing the hitherto high costs of a large milking pen for a small dairy farm; erecting the milking pen frame oneself with screw connections and galvanized water pipelines, installing the milking pen in the animals' sleeping space, in order to dispense with a separate stall and heating (for instance, in a double row of boxes), and finally, as a stop-gap solution, the temporary use of the existing pail milking machine converted for use as a suction plant.

Of the pen-barns with the manure handled in solid form, the deeplitter box is the one with the most advantages; its straw-consumption is low (0,5-1 kg. of straw/cow/day), its space requirements are lowest (4m².⁄cow), and it can be adopted well when conversion is necessary. All the other types of pen-barn particularly those with partitioned floors, generally involve higher costs for buildings and mechanization.

There are also great differences in the feeding of silage, which are actually of minor importance as far as labour economy is concerned. The flat silo with self-feed for the animals or with feeding from a front loader and fodder racks or rack trucks is the simplest method. The high-level silo with extraction cutter and feeder mechanism requires the most capital. Thus, also in the case of pen-barns there are only minor differences in labour requirements (between 60 and 80 man hours/cow/year for 25 cows), but investment costs vary widely (between DM 2,800 and 4,000 per cow for buildings and machinery for 25 cows). To convert the tethering stall in question to a pen-barn with boxes need not cost more than DM 1,500 of capital investment per cow, including the construction of the silage space, provided that the most favourable solutions are adopted.

Because of all the advantages it offers, it is above all the pen-barn with boxes that promises a genuine means of rationalizing dairy farming. In so far as plans for new developments are nevertheless based on the tethering stall, it should be possible to use the buildings and machinery for pen-barns without great trouble and expense. This applies particularly to prefabricated farm buildings, since a long production series of one and the same hangar building seems to be feasible only if it is equally suitable for a tethering stall or a pen-barn.

Bernhard SCHWARTING

Friedrichshafen

Properly Designed Buildings and Installations

(Translated from German)

The mechanization and rationalization of agriculture started with outside work. Tractors have proved more efficient than horses for most operations, whatever the size of the farm. Transport and machinery have been adapted for use with tractors, followed by the rapid development of all sorts of machinery for the cultivation of woodland, field and meadow. As a result, outside work is now largely rationalized.

Steadily increasing labour shortage on the one hand, and mounting demand for better quality and greater productivity on the other, make it imperative that the whole farming process should be rationalized, which means inside work as well.

This object is increasingly being achieved by what has been called the "container farm." *(Fig. 1)*

The container farm is one where crops and feed supplies are stored away from the buildings housing livestock, in green fodder and hay silos, hay towers and cereal silos. This siting of farm buildings according to their purpose makes for the greatest rationalization of inside work. It is also labour-saving, which is important, since moving feed about is still one of the heaviest and most time-consuming jobs on the farm.

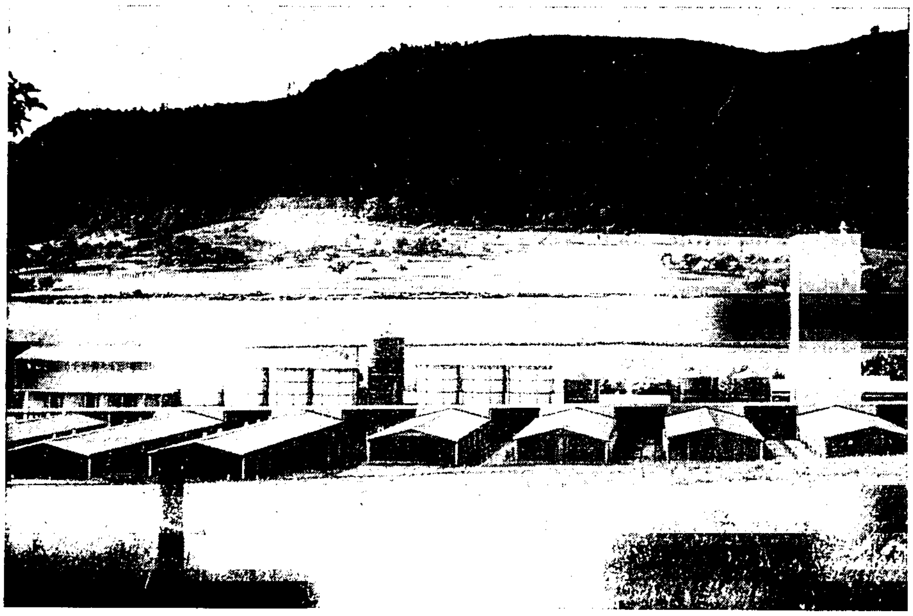
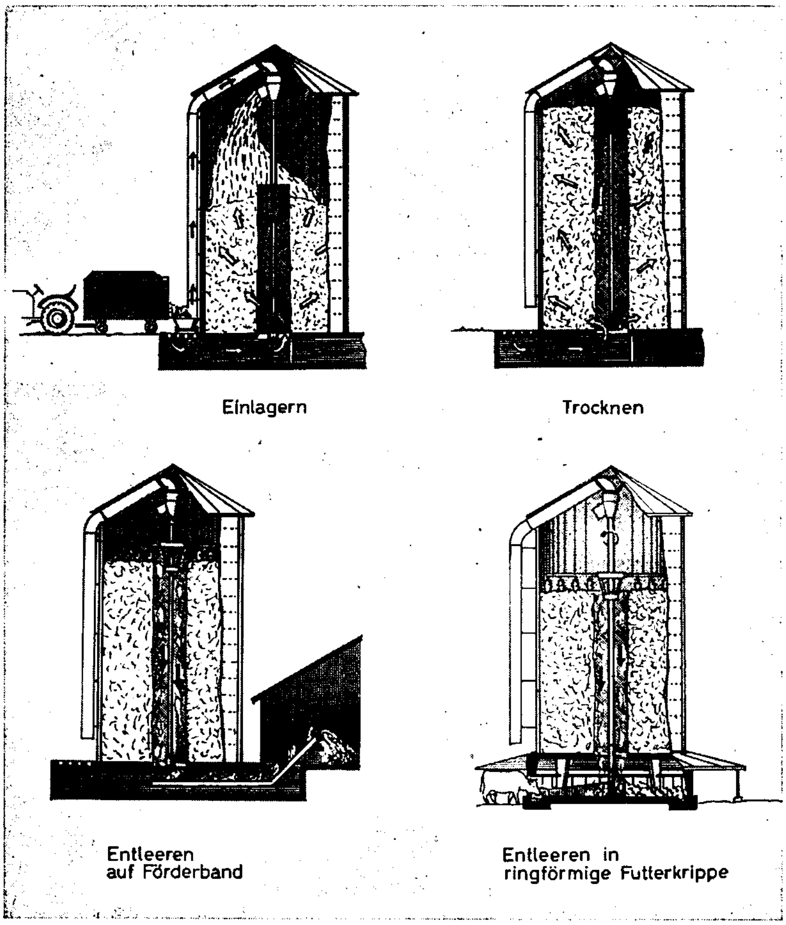


Fig. 1

The container farm offers the following advantages:

1. It can largely be constructed from pre-fabricated components, which means shorter building time and considerably lower building costs. For example, a 450 cubic m. hay tower can be put up in three or four days without scaffolding.
2. There can be a real saving in other farm buildings if these no longer have to support the weight of feed storage on an upper floor.
3. There is a further saving in that storage in containers occupies between 30 and 50% less space than storage in ordinary farm buildings. Almost the entire space inside the container is usable.

4. Loading and unloading the containers, transferring the feed to where the livestock is kept, and the actual feeding process, can all be fully mechanized with very little technical trouble. Such complete mechanization cannot be achieved with any ordinary farm layout, except perhaps at a prohibitive cost.



Einlagern — Storage
Trocknen — Drying
Entleeren auf Förderband — Emptying by conveyor belt
Entleeren in ringförmige Futterkrippe — Emptying into a circular manger

Fig. 2

5. Container farms offer greater security against damage by fire. It is a known fact that in some countries the cost of large numbers of farm fires may run to millions of pounds.
These losses can be reduced greatly by storing inflammable crops away from livestock housing. If a fire starts, it can be localized easily and total loss avoided.
Steel has proved an admirable material for the containers, whether they are to hold silage, hay, straw or grain. It is, however, essential that all components should be galvanized, enamelled, or otherwise protected against corrosion.
The problems of loading and unloading the silo and bringing the feed to the stock were first solved with green fodder. These silos are air-tight and fitted top and bottom with loading and unloading devices. The material used may be concrete, aluminium, enamelled steel, or plastic.
Since the introduction of the hay tower it has also become possible to feed hay entirely mechanically. As the hay tower is still a novelty in some areas, it is worth explaining its construction and function briefly. The hay tower is an upright, cylindrical container with a diameter of 7.10 metres and a height of 14 metres. Its framework consists of eight steel tubes tied together by circular segments. The cantilevered roof is made of U-sections with a galvanized covering. The tower is clad externally with sheets of corrugated asbestos cement, with openings for ventilation. Inside there is a central mast, powered by an electric motor to rotate vertically. A distributor fixed to the top of the mast, and directly under the roof, ensures even distribution of the crop as it enters the tower. A bell is also fitted to the central mast and can be moved up and down it. The bell's outer casing can be removed and replaced by an emptying device. This device consists of three

arms, each carrying four tined wheels which rake through the hay. The wheels are set at an angle to the movement of the arms.

The hay tower can be used as a crop drier, as well as for storing the rough fodder to be used on the farm. The crop may be loaded into the tower while containing as much as 40 to 50% moisture, and dried down to 16 or 18%.

There are three phases to the operation of the tower. *(Fig. 2)*

1. Loading the crop: The cut hay is blown up over the distributor rotating on top of the mast, and is thus spread evenly into the tower.
   As the level of the hay rises in the tower, the bell rises too, forming a ventilation shaft beneath it as it does so. Loading and distribution are both completely automatic, and replace a particularly arduous and time-consuming form of labour.
2. Drying the crop: A fan built into the base of the tower pumps air along ducts in the concrete floor, up the ventilating shaft and through the freshly loaded hay. The moist air then escapes upwards through the ventilators in the tower's asbestos cement walls. Cold air is normally used, but if the crop is very wet or the atmosphere particularly humid warm air may be used. In this case the air temperature is raised by something like 5 to 8%.
3. Unloading and transporting the crop: Preparing the tower for unloading is quick and easy. The bell casing is dismantled and the wheeled clearing arms attached in its place. As the central mast is rotated, the arms descend steadily, sweeping the contents from the edges to the middle of the tower. The hay falls down the shaft made by the bell during the loading process and is then conveyed directly to where it is needed.

The means of conveyance may be a blower, travelling feed table, or belt. If the stock is kept in an open yard the tower may conveniently be mounted over a circular manger, which is supplied directly from an appliance fitted to the lower end of the central mast.

The tower can also be used for storing chopped straw.

Special containers are as useful for storing and drying cereals as they are for silage and hay. The prefabricated components are made of hot-dip galvanized steel. *(Fig. 3)*.

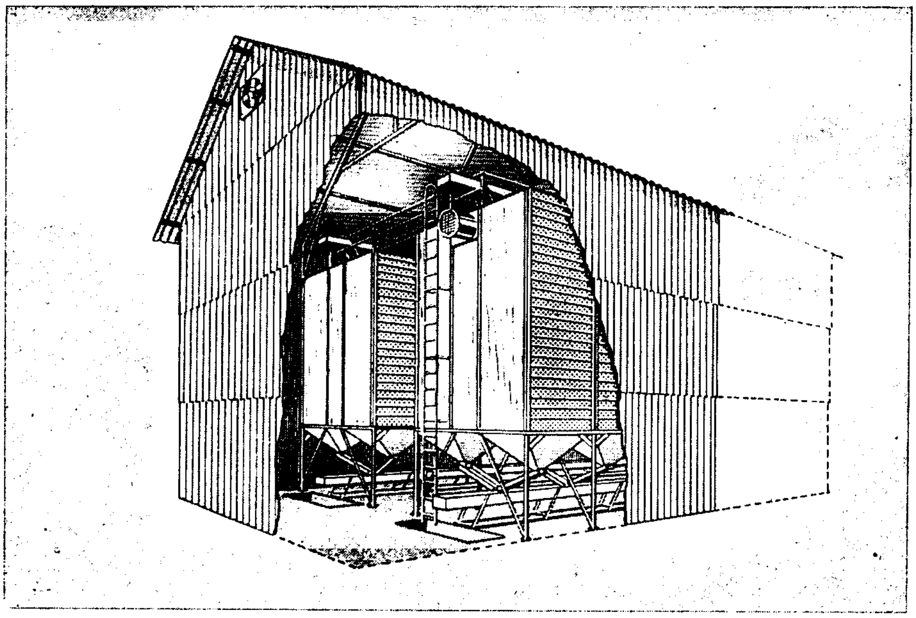


Fig. 3

Both the building components used and the method of operating modern silos and hay towers on the container farm show that they can give the farmer the means of rationalizing indoor work while at the same time improving quality and output.

J. LASSON

Fédération nationale des groupements de productivité agricole
Paris

Steel-walled Silo Clamps

(Translated from French)

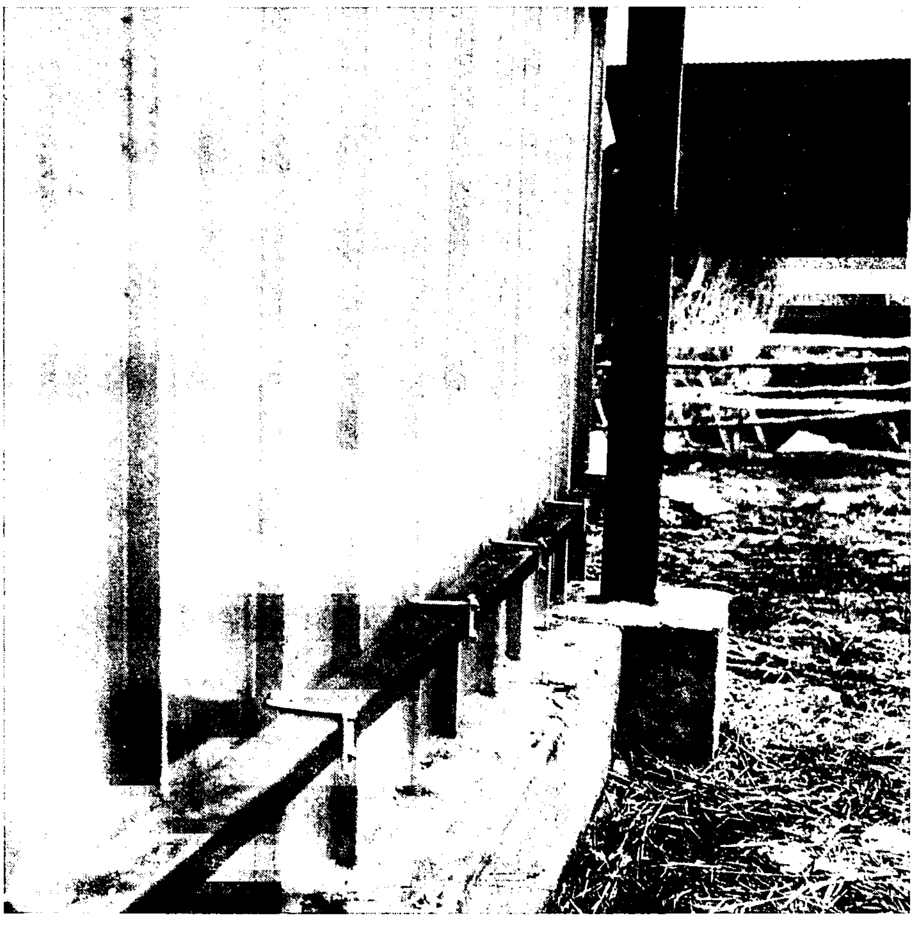
The French breeder of to-day has realized that in order to increase his output it is vital for him to grow more grass.

As in other countries it was soon realized that grazing during the spring is simple but that there was a problem in preserving the grass for winter feeding. It was not long, therefore, before the silage making system was started.

Many types of silos were tried and included the mound-type; pit; clamp; tower and steel-walled silo clamps, and it is the latter which for reasons of economy is now being used most extensively.

For two reasons the use of steel was not widely known at the outset. Firstly cement and timber both of which are widely used on the farm and backed by publicity, took first place. Secondly it was necessary for the tests undertaken by the OTUA (Office Technique pour l'Utilisation de l'Acier), Ceta (Centre d'Etudes Techniques Agricoles), and the GPA (Groupement de Productivité Agricole) to be completed. These tests were to determine the success of using ribbed sheet steel for silo clamps and proved that two types of wall were satisfactory.

1. The wall consisting of panels mounted on a metal framework, the uprights of which consist of IPE of 140, on which are fitted horizontal rails consisting of UPN or UAP of 80.



2. The wall made of deep ribbed sheets, the angle of which is approximately 120 deg. and which, being thicker, can be sealed direct in the foundation without needing a support framework.

I would like to point out that the silage which was in contact with the walls was of the same quality as in standard type silos. This tends to prove that the ribs with angles of 120 deg. have no harmful effect on the development of silage.

Moreover, thanks to the use of bituminous paints, the sheet steel walls did not suffer at all as a result of the known acidity of silage.With regard to the resistance of these walls to both the pressure of the silage and of tractors and implements, one can say without exaggeration that this has surpassed our expectations. All this would therefore have been perfect had this method been tested and published earlier. (See *Fig.)*.

Allow me, as the Regional Engineer of a French popularization organization which has followed these tests in 1964/65, to express the following hopes:

1. That the steel manufacturers rapidly develop and manufacture a standard operational structure which will meet farmers needs.
2. That much more publicity be carried out to the farming industry.

All steel manufacturers who have an interest in making silos should ensure that necessary materials are available to farmers, i.e. sheets; struts; paints, etc.

Also, they should study production costs closely, so that they are able to quote to their prospective customers accurate costings — for instance the cost per metre of completed silo space.

Finally, they should organize a network of distributors from whom farmers can buy materials *ex* stock, obtain information and any technical assistance in erecting these silos that might be necessary.

When this has been done, and I emphasize that it must be done very quickly, a great step forward will have been taken; but this does not mean that technical tests and studies have been completed and should not continue. If a silo is to be successful, especially if it is in frequent use, it must be given a suitable roof. I believe that if a light metal framework covered with sheet steel is used, the steel walled silo clamp with the added advantage of mobility, will gain popularity in the cattle breeding and grazing regions. And this to an extent will benefit farmers and steel manufacturers alike.

Finally I would like to add that from my experiences in studying this subject, I have found that there are similar problems with other agricultural equipment which could be studied to the mutual interest of farmers and steel manufacturers.

J. C. GARRET,
Ingénieur

Président-directeur général des Etablissements LAW
Senlis

Farm Feed Manufacturing Equipment

(Translated from French)

The preparation and distribution of feed for farm animals has always been one of the hardest and most burdensome tasks for the farmer. Until quite recently such work was hardly mechanized at all and farmers still used a few hand implements and very rudimentary machines. These machines were generally made of wood with a few cast-iron components and some steel working surfaces.

Traditional feed manufacturing equipment was characterized by discontinuity and independence of the various operations. A manufacturing unit was not used, but rather a few tools or machines, each intended for a particular job. Normally, feed manufacture on the farm merely consisted of using a crusher, which

was fed manually or from bags. The crushed meal was also bagged or collected in a flour bin. When a mixture was required it was made with a shovel as and when the need arose.
On the other hand modern installations are characterized by continuous and automatic operation, the elimination of manual handling and absence of personnel.

Continuous operation

The various operations involved in preparing feed should be continuous, without interruptions for putting feed into stock and manual handling. An excellent example of such simplification is afforded by the use of a crusher fitted with a meal conveyor fan. This type of crusher forms a crushing and handling unit, thus enabling the crushed feed to be conveyed directly to a mixer or to storage hoppers, which may be located at ground level or on a higher floor. The crusher may be installed near the cereals' supply point and the mixer or feed hopper near the point of utilization.

Automatic operation

This makes the constant presence of personnel unnecessary and so permits the use of relatively low-power equipment which is cheaper to buy and use and which has a power rating compatible with most rural electricity supply systems. Some farmers may perhaps cause astonishment by quoting daily outputs of 5 to 10 tons of crushed grain from 3 to 6 hp. crushers. Despite the high efficiency of the crushers concerned, such outputs require continuous operation for periods which may attain 10 hours per day. Evidently the electrical apparatus must be of the highest quality, installed with the greatest care and incorporate all necessary safety devices.

Operation without skilled personnel

The various features enumerated above all have the common objective of allowing farmers to manufacture feed without skilled personnel and with very low labour costs. It is felt that whatever the theoretical advantages may be that a farmer could derive from manufacture on the farm, such advantages would have little meaning if they required much skilled labour.

Equipment used in farm manufacture

It would be impossible to describe in detail all the apparatus that can now be supplied to farmers, and so attention will only be drawn to a few important items.
The first farm crushers were fitted with millstones and had wooden frames. This type of crusher continued to be used on a wide scale until quite recently. Quality improved with the introduction of metal and composition crushing elements. Nevertheless, crushing with millstones, even when operating at high speed, involves considerable power losses due to friction.
The crushing efficiency of modern hammer crushers is very good and grading of the output is carried out on a screen or grille, which, however, often has the unfortunate effect of reducing efficiency by impeding the passage of products which have attained the required degree of fineness. The inclusion of a suitably positioned grain removal fan to suck fine grains through the grille partially overcomes this drawback. Percussion crushers in which the fineness of the crushed product is selected by adjusting the clearance between the crushing plate and the crushing ring cone, eliminate most of the drawbacks of the equipment referred to above. These types of crushers have outputs per horsepower/hour which are generally higher than those of most other machines for a given degree of fineness, especially with the rather moist grain that is sometimes encountered, and with certain products having a rather high fat content. Furthermore, these crushers are less prone than most to damage caused by extraneous materials such as stones, wire, etc. It is neverthe-

Cost price of food manufacture (FF)

	50 tons per annum	250 tons per annum		500 tons per annum	
	crushing and mixing	crushing and mixing only	crushing, mixing and cubing	crushing and mixing only	crushing, mixing and cubing
Cost price of finished installation (see breakdown)	6,000	10,000	25,000	12,000	30,000
Annual operating expenses					
Depreciation([1])	600	2,000	5,000	2,400	6,000
Interest 6%	360	600	1,500	720	1,800
Repairs and replacements	200	400	1,000	800	2,000
Electricity (0.20 FF/kW.)	1,000 kW. 200	4,000 kW. 800	8,000 kW. 1,600	8,000 kW. 1,600	16,000 kW. 3,200
Labour at 5 FF/hr.	200 hrs. 1,000	750 hrs. 3,750	1,200 hrs. 6,000	1,500 hrs. 7,500	2,200 hrs. 11,000
total annual cost (without raw materials)	2,360	7,550	15,100	13,020	24,000
Cost per kg. of feed	0.0472	0.0302	0.0604	0.026	0.0480

([1]) Depreciation is reckoned over 10 years in the first example (low rate of utilization) and over 5 years in all the other examples. It is quite certain that real depreciation will take place over a longer period, since the plant is very robust.

less recommended that, where possible, users provide an efficient magnetic separator at the crusher input. Several manufacturers supply excellent and completely reliable magnetic separator systems.

The hp/hour outputs obtainable with good crushers and normal grains range from 25 to 50 kg. per hp./hour for finely ground feeds, usually intended for pigs, to more than 100 kg. per hp./hour for coarser cattle and poultry feeds.

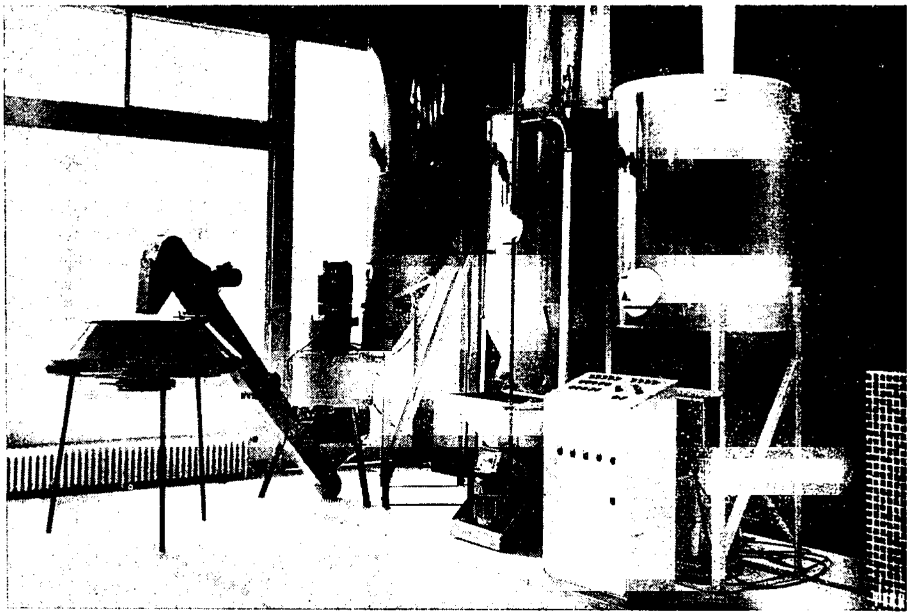
Two main types of mixer are available for dry feed mixes based on cereal meals. Horizontal mixers are the type most used by large feed manufacturers since they allow relatively rapid mixing. The entire input is agitated simultaneously by slowly rotating metal spirals. Generally it takes 3 to 5 minutes to mix a batch and very good quality mixes are obtained with well designed machines. However, these mixers have several drawbacks for farm use. They have high power requirements since the whole mass of materials to be mixed is agitated simultaneously, and they also require suitable handling equipment since they are filled from above and emptied below, thus making mechanical loading equipment absolutely necessary. Finally, the cost and power rating of such mixers, especially when the necessary handling equipment is included, puts them beyond the reach of most farmers.

The various criticisms that can be levelled against horizontal mixers have caused manufacturers to prefer a vertical mixer, which has resulted in a mixing quality at least as good as that of horizontal mixers.

These modern vertical mixers are characterized by the fact that the vertical mixing screw is used not only for mixing but also as a handling device for loading the raw materials and discharging the finished mixtures. This triple action makes such machines economical and easy to use.

Discharge of the final mixture can be effected from the central screw by a suitable chute and valve. The same can be done with an upward extension of the central screw. Such an arrangement, referred to as a "Transfer device," has been patented recently; it enables the final mixture to be discharged rapidly and completely to the storage or cubing press hoppers.

This system of top discharge obviates the need for any other equipment for handling the mixture, which is always advantageous. Handling the finished mixture mechanically always carried the risk of de-mixing the product, especially when a screw is used. For lifting, a bucket elevator should be used and for horizontal transfer, belt conveyors or certain types of horizontal spring screws specially designed for this type of handling applications are recommended.



Feed pressing was quite recently still looked upon as a difficult technique that could scarcely be considered for use on a farm. However, the development in recent years of simple and robust presses suitable for stock farms has filled a gap and enables farmers who wish to use cubed feed to manufacture it.
The power required for cubing varies appreciably according to the composition of the mix, but, as for fine grinding, it normally ranges from 25 to 50 kg. per hp./hour which, for an 8 hp. machine, represents actual outputs of 150 to 400 kg./hr.
Two aspects of using cubing machines that have to be examined very closely are the provision of satisfactory input and discharge arrangements, since a cubing machine will not give good results unless the mixture is properly fed into it. Because floury mixtures flow badly, it is essential to use a suitably designed hopper usually fitted with a vibrating attachment and safety contacts.

Conclusion

There can be no doubt that improvements will continue to be made in these techniques, and that installations will increasingly include all handling, from loading the raw materials to distributing the finished product, for, whatever advantages that feed manufacture on the farm may have, and there are many, it will only continue to expand if it involves small labour requirements. These are the lines along which we are working and, as manufacturers, we can assert that it is as a result of making use of the new possibilities made available by new materials such as special steels, coated plate and so on, and by increasingly reliable and effective electric automation equipment that we are able to supply the European agricultural industry with particularly robust and economic feed manufacturing units that are fully adapted to the evolution of farming trends.
The price of a complete high-energy feed varies, depending on the manufacturer, from 0.60 to 0.63 FF/kg. delivered at the farm for very large quantities. We will assume 0.60 FF for floury feed and 0.63 FF for cubed feed.

The cost of the same feed manufactured by the farmer is:

Investment required about		Minimum annual saving
	A: for 50 tons per annum (1,000 hens)	
6,000 FF	— King feed without cake	
	0.4807 + 0.0472 = 0.5279 FF/kg.	
	or a saving of: 0.60 — 0.5279 = 0.0721 FF × 50,000 kg. =	3,600 FF
	— King feed with cake	
	0.5055 + 0.0472 = 0.5527 FF/kg.	
	or a saving of: 0.60 — 0.5527 = 0.0473 FF × 50,000 kg. =	2,365 FF
	— Novalt feed	
	0.4610 + 0.0472 = 0.5082 FF/kg.	
	or a saving of: 0.60 — 0.5082 = 0.0918 FF × 50,000 kg. =	4,600 FF
	B: 250 tons per annum (5,000 hens)	
10,000 FF	— King feed without cake, not cubed	
	0.4807 + 0.0302 = 0.5109 FF/kg.	
	or a saving of: 0.60 — 0.5109 = 0.0891 FF × 250,000 kg. =	22,275 FF
	— Novalt feed, not cubed	
	0.4610 + 0.0302 = 0.4912 FF/kg.	
	or a saving of: 0.60 — 0.4912 = 0.1088 FF × 250,000 kg. =	27,000 FF
25,000 FF	— King feed without cake, cubed	
	0.4807 + 0.0604 = 0.5411 FF/kg.	
	or a saving of: 0.63 — 0.5411 = 0.0889 FF × 250,000 kg. =	22,225 FF
	— Cubed novalt feed	
	0.4610 + 0.0604 = 0.5214 FF/kg.	
	or a saving of: 0.63 — 0.5214 = 0.1086 FF × 250,000 kg. =	27,000 FF
	C: 500 tons per annum (10,000 hens)	
12,000 FF	— King feed without cake, not cubed	
	0.4807 + 0.0260 = 0.5067 FF/kg.	
	or a saving of: 0.60 — 0.5067 = 0.0933 FF × 500,000 kg. =	46,650 FF
	— Novalt feed, not cubed	
	0.4610 + 0.0260 = 0.487 FF/kg.	
	or a saving of: 0.60 — 0.4870 = 0.113 FF × 500,000 kg. =	56,500 FF
30,000 FF	— King feed without cake, cubed	
	0.4807 + 0.0480 = 0.5287 FF/kg.	
	or a saving of: 0.63 — 0.5287 = 0.1013 FF × 500,000 kg. =	50,650 FF
	— Cubed Novalt feed	
	0.4610 + 0.0480 = 0.5090 FF/kg.	
	or a saving of: 0.63 — 0.5090 = 0.1210 FF × 500,000 kg. =	60,500 FF

Gérard CORCELLE,
Ingénieur agronome

Institut national de gestion et d'économie rurale
Paris

The Milking Parlour (1)

(Translated from French)

The farmer's requirements

When a dairy herd reaches a certain size, a milking parlour becomes essential, but the need for one arises even with small herds because of changes in building use: with loose housing, for instance, a milking parlour is a "must."

The milking parlour comprises:

— stalls on an elevated floor with a tubular steel enclosure for restricting the cow's movement during milking;
— a feeding system, which may be automatic or semi-automatic, made of galvanized steel plate, for distributing concentrates to the cows;
— implements for collecting the milk and passing it into a bulk tank; these are made of stainless steel, but milk pipelines and even bulk tanks are sometimes made of plastics.

Types of milking parlour available to the farmer

There are five main types of milking parlour:
— parallel stalls,
— tandem stalls (2, 3 or 4-stall, the last requiring two cowmen),
— passage stalls (single, double or right-angled),
— herringbone stalls (6 to 10 point),
— rotolactor (rotary type).

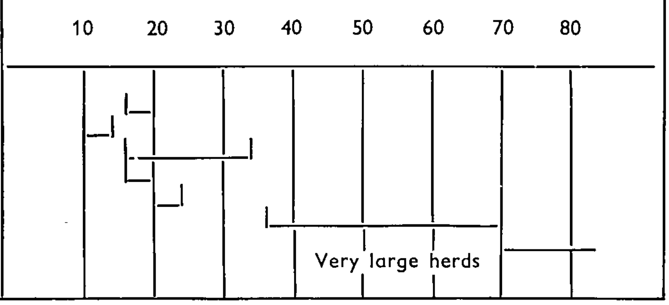
Criteria for choice of appropriate type

Nowadays, farmers are no longer satisfied with the mere look of a milking parlour. They make a carefully considered choice based on a number of points.
First, herd size: while from the purely technical point of view pretty well all the types of milking parlour mentioned give satisfactory results, from the economic point of view it is essential to ensure the best possible return on the capital invested. An excessive expenditure per cow would entail heavy depreciation charges and might make the herd unprofitable.
Next, labour: the labour employed in a milking parlour is skilled, and hence expensive.
So, to get the best out of his cowman, the farmer must give the right tool for the job, bearing in mind that 8 hours' milking per day is the maximum commensurate with high-grade work.

(1) Lack of space has obliged us to omit the second part of this paper. A copy of the unabridged text may be obtained from the High Authority.

This plan is recommended:

Type of milking parlour	No. of stalls	No. of cows in herd
Parallel	2	
Passage	2	
	2×2 right-angled	
Tandem	2	
Herringbone	2×4	
	2×8	
Rotolactor		



Very often the farmer has to make do with existing buildings and these are usually on the small side. It is vital to ensure that lack of floor space does not prevent him from installing the milking parlour appropriate to the size of his herd and thus from getting a good return.

Type of milking parlour	Minimum floor space required (sq. m.)
Parallel	
2 stall	11.44
4 stall	22.88
Tandem	
2 stall in line	20.10
2 stall right-angled	22.56
3 stall U-type	28.60
4 stall 2-row	38.40
Passage	
2 stall	8.40
4 stall	16.80
2 stall right-angled	12.25
Herringbone	
6 stall, 3 point	26.40
8 stall, 4 point	27.95
10 stall, 5 point	28.50

What manufacturers should offer

Advertisements in the agricultural trade journals carry diagrams and photographs of very well-designed milking parlours, but the selling points given for the actual milking parlour in the accompanying copy are vague: merely saying "work made easier, better quality product obtained" does not tell the farmer any more than he already knew when he made up his mind to buy a milking parlour. It would, for instance, be better to follow up the advertisements with technical leaflets describing and illustrating, side by side, the whole range of milking parlours available today.

A poorly designed parlour does not provide the efficient working facilities offered by a suitable selected tool. Here are some of the shortcomings found in farm-built milking parlours:

they are difficult to clean, only one type—the passage type—is built, the stalls are too big, so that the cow's movements cannot be restricted and hence the cowman's milking efficiency is impaired.

The milking parlour must be designed as a highly specialized workshop of suitably proportioned dimensions to speed up farm work.

Essential ancillary equipment

The milking parlour enables work to be done more efficiently. But the desired result will be only half achieved without that essential additional item, the refrigerated bulk milk tank. The milk can of course be stored

Time after milking	Bacteria per cub. cm.			
	Ambient temperature, milk slowly cooled from 35 to 20° C	Cooled to 15° C 1 hour	Cooled to 8° C 1 hour	Cooled to 4° C 1 hour
Immediately afterwards	10,000	10,000	10,000	10,000
2 hrs. after	10,000	10,000	10,000	10,000
4 hrs. after	2,000,000	25,000	15,000	10,000
6 hrs. after	15,000,000	45,000	20,000	10,000
8 hrs. after	30,000,000	100,000	30,000	10,000

outside the milking parlour door in churns which can subsequently be refrigerated by surface or immersion cooling. But once the herd reaches any size, manhandling the churns is going to require far too much labour. So, if the farmer wants to cut out churn handling, he must install a bulk milk tank which will enable him to cool the milk rapidly and send a better quality product to the dairy station.

The above table shows the bacterial count in milk cooled at different times and speeds after milking. This aspect of milk quality is of vital importance since a new regulation recently introduced in France allows low-bacteria milk to be sold at a higher price. The additional outlay on a refrigerated tank, in addition to saving labour, will thus increase the profitability of the milking parlour.

Again, refrigerated storage offers the further advantage of enabling the dairy stations to collect the milk in bulk every other day, if they wish. This shows the far-reaching effects of a well-planned milk-storage system.

Milking parlour output

Finally, far fewer cowhands today are members of the farmer's family. It is highly paid labour, so that a high output is essential, particularly a good output in the milking parlour. On this point, however, it is difficult to advance specific arguments because of the many different factors involved. To get a good idea of the potential level of output, we should have to compare the results obtained in good dairy practice with installations of similar type in various European countries. This would enable us to explain the differences found and attribute them to specific factors.

At a time when the French Government is encouraging livestock farming and the demand for milking parlours is likely to rise very steeply, it would be desirable for manufacturers of steel tubing, galvanized steel sheet and special steels to get together to carry out an objective study of the problem of milking-parlour productivity.

Such a study would enable them to play an effective part in the rapid expansion of livestock farming we are witnessing today.

The milking parlour

The milking parlour is becoming a necessity: it is compulsory in loose housing, and in each case, it permits the increase of the milking flow, as we note an increase of the average effective of the herds.

However, as five types of milking parlours exist on the market, the advantages of one over the other are badly known:

— in the USA, in certain cases, for instance, certain types of milking parlours, where the working efficiency is too low, are rejected;

— in England, the abreast milking parlours are often used with excellent results. In the other European countries, this kind of standing is practically non existent or very badly used.

England would like this very important matter to be studied by the International Commission of Agricultural Engineering.

It would be very advisable to make an objective study of the various systems available in the European countries. This study could well be initiated by the ECSC.

A. GAC
Docteur-ingénieur

Ingénieur en chef du Génie rural eaux et forêts
Ministère de l'agriculture
Antony

The Construction of Greenhouses

(Translated from French)

Greenhouse cultivation in France has made great strides in recent years. Certainly, for a considerable period of time, greenhouse cultivated ornamental plants and cut flowers have gained, merited and justified renown; the same applies to early vegetables produced traditionally under cover, especially by market gardeners operating near urban centres. But the most recent development is the appearance of the often very large greenhouse for the production of vegetables, in particular tomatoes, cucumbers and lettuce.

The reasons for this evolution are many and various. They are largely due to the general economic situation; in view of the improved standard of living, the demand for fresh vegetables tends to persist throughout the year; the market for these vegetables is very large, as it comprises not only one country but the whole of Western Europe.

French producers, especially those who only have a small area for cultivation, seek means by which they can increase their income or obtain an adequate wage. Fickle weather conditions have always constituted a heavy handicap for agriculture; control of production and environmental conditions naturally reduces irregularities and production risks.

Finally, in the face of urban growth, the market gardening belt encircling towns tends to disappear; producers migrate towards the open country and at the same time modernize their undertakings.

The development of greenhouse cultivation in France is rapid. The area of market gardening greenhouses was approximately 10 hectares in 1958, 60 hectares in 1962 and 180 hectares in 1964; it is now about 200 to 250 hectares. The main regions concerned are Orleans, Nantes, Rennes and the Var. The sums invested are considerable, construction costs being approximately 60 to 120 FF per sq. m. of ground.

Newly constructed greenhouses differ from older types to a greater or lesser extent, particularly those which were built during the last few decades and are at present in use in countries where market gardening under glass is a traditional occupation, for example, Holland or Belgium. It is natural that modern methods should take advantage of industrial progress and the growth of scientific knowledge. It is useful to investigate what problems are most likely to arise, to which the attention of the manufacturer should be drawn.

By definition, a greenhouse is an agricultural tool by means of which plants are placed in more favourable conditions of growth than they would have outdoors. Plant growth depends on a balance between various characteristic parameters of the environment; light, temperature, carbon dioxide content, humidity, etc. For every crop, there is, at a certain stage of development, an optimum value as well as a range of permissible variations of each of the factors of the environment. If only one of these factors should deviate to a lesser or greater extent, the plant's development is defective; in the limit, the plants are jeopardized. These are limiting factors insofar as plant production depends in the last analysis on the most unfavourable factor.

With biological phenomena the problems are complex. Response to a change in a value must often be interpreted with care as not only does the behaviour of the plants depend directly on the variation of the parameter but also, the plants, in reacting, alter the ambient characteristics.

In this paper, we shall consider mainly thermal phenomena and the consequences which may be established between them and the design or construction of greenhouses.

Heat exchanges between the outside atmosphere and the atmosphere inside the greenhouses take place in 3 ways:

- Radiation
- Convection
- Conduction

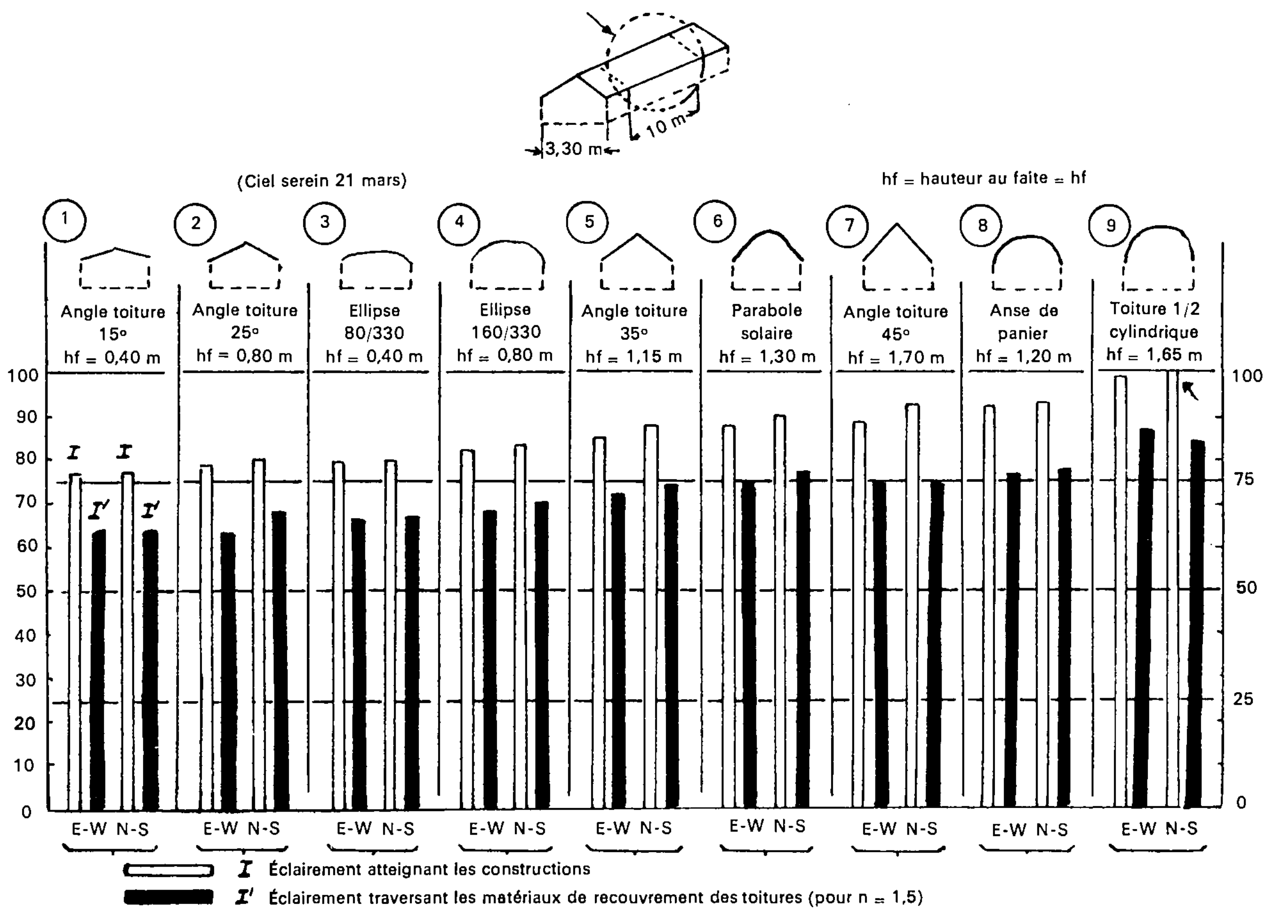
Radiation

A greenhouse is subjected by the sun and sky to radiation of great strength emitted in a narrow band of wavelengths of between 0.2 and 2.5 microns. This band includes, in particular, visible light which is indispensable to chlorophyll assimilation in plants, and the rear end of the infra-red band. It is estimated that the sun supplies the earth with a flux equal to 0.14 W./cm².; the sun is the only permanent source of energy for our planet.

It is plain that the walls of the greenhouse must permit the passage of the maximum amount of natural light, as, particularly in winter, light is likely to be a limiting factor; on the other hand, supplementing of the light by artifical means is uneconomic, except in the case of large scale production ("multiplication" greenhouses and greenhouses for ornamental shrubs).

To capture the light, it is necessary that the shadow cast by the framework be small; it is therefore useful to use thin sectional steel and light beams and posts, and to find coverings in the form of strong thin sheet. For example, in a conventional structure of timber and iron, the framework may account for 14 or 15% of the total surface of the walls and roof. For a greenhouse constructed entirely of wood, this proportion is greater still. The shape of the greenhouse also affects the penetration of light.

Nisen, for example, has made calculations of the lighting of greenhouses, according to their orientation and according to the design of the roof in instances where the covering material is of the glass type *(Fig. 1)*.



(Clear sky 21st March) hf = height to ridge of roof

= I Light reaching the greenhouse
= I' Light penetrating the roof covering (n = 1,5)

Angle toiture	Roof Pitch
Parabole solaire	Solar parabola
Ellipse	Ellipse
Anse de panier	Basket handle
Toiture ½ cylindrique	Semi-cylindrical roof

Fig. 1 : Lighting with different types of roof (after Nisen).

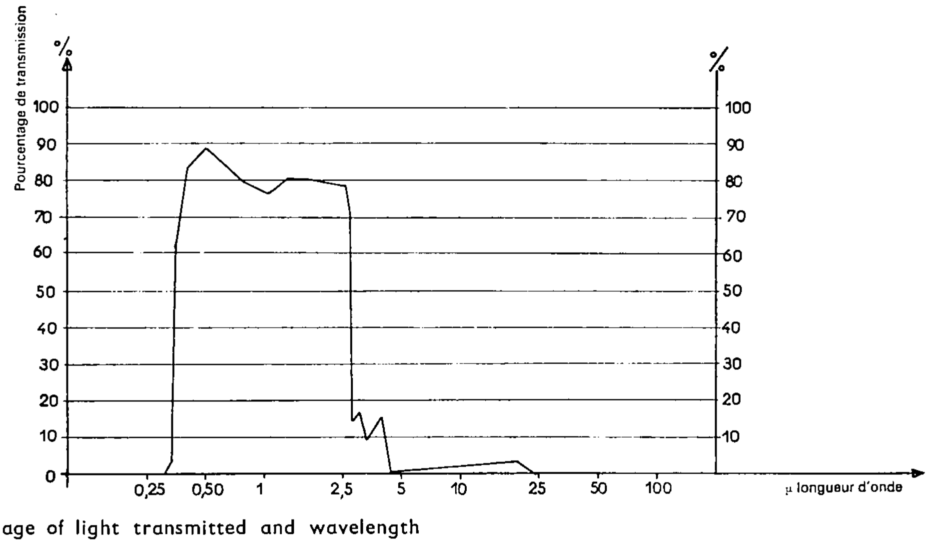
Efficiency is raised by the use of non-symmetrical roofs. In this case, of course, there is the problem of rising construction costs as compared with the increased income resulting from the adoption of a non-symmetrical roof. We feel that for market gardening greenhouses, symmetrical roofs are the most advantageous, for the present at any rate.

The transmission of light depends finally upon the nature and optical properties of the roofing material. In general, the plates and film used, viz. glass, polyethylene and laminated plastics, are permeable to light in the proportion of 75 to 90%. But the covering must also resist conditions such as wind and overloading by snow. The calculations for the framework must therefore take account of the covering materials. For example, with a glass greenhouse, the framework must be more rigid than would be the case for laminated plastics, for these will withstand serious deformations without breaking. With flexible films (polyethylene, PVC, Rilsan, etc.) the framework must not wear out or tear the film. The state of the surface and the finish of the frame are of very real importance.

The walls of a greenhouse must also allow the passage of solar heat radiation, that is to say, they must be permeable to wavelengths of up to 2.5 or 3 microns. They must however limit losses, i.e. they must be opaque to radiation from the ground. This is emitted in a band ranging between 2 and 25 microns with a maximum at 10 microns. Any wall which is transparent to visible light and to the lower infra-red band and which does not transmit radiation of high wavelengths, i.e. which is likely to trap solar energy, has the necessary "greenhouse effect."

Glass, which is the traditional cover for horticultural shelters, satisfies the conditions of the "greenhouse effect." *Figure 2* represents the transmission spectrum of glasshouse glass in relation to wavelengths. The glass is opaque to all radiations of more than 3 microns.

Plastics of films are transparent to visible light, and to the upper infra-red band. They present "windows" in certain wavelength bands. *Figures 3* and *4* (flexible polyethylene and PVC films) show the existence of these windows above 5 microns.



Percentage of light transmitted and wavelength

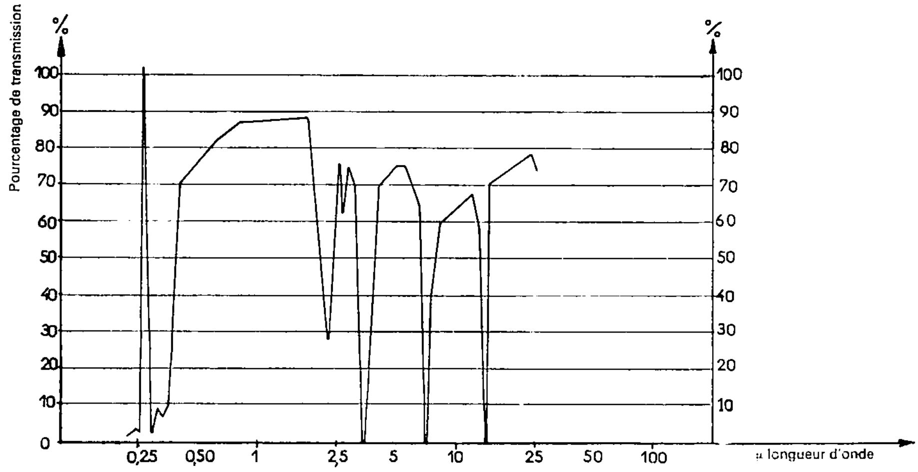
Fig. 2—Spectrogram of the greenhouse glass

Night cooling of plants in greenhouses due to terrestrial radiation into space can be considerable, especially without polyethylene.

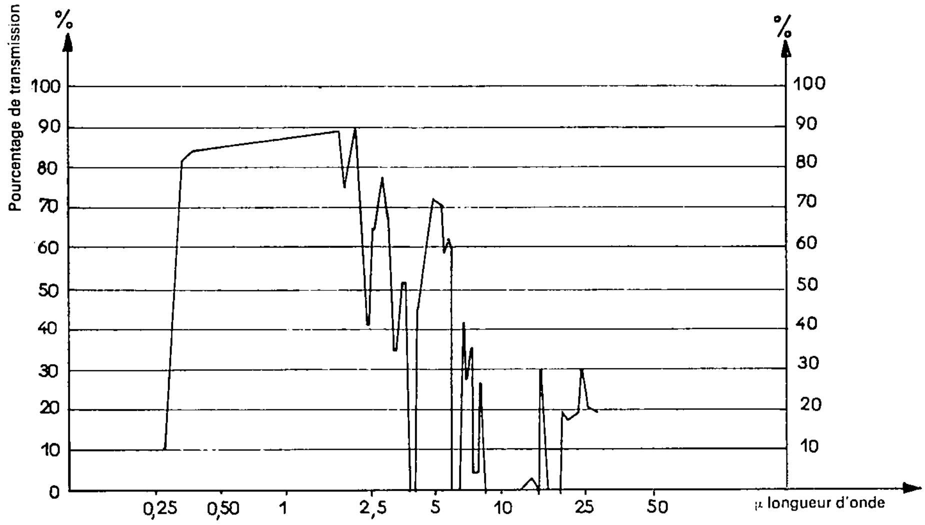
Fortunately, plastics films, which absorb little moisture, if any, retain small droplets of condensation well. Water transmits little, if any, radiation of high wavelengths. Condensation therefore reduces the defects of plastic films. These can therefore be used with profit for the construction of greenhouses, etc.

Conduction and Convection

Exchanges by convection into the outside air and the atmosphere of the greenhouse, and exchanges by conduction through the solid materials of the walls constitute an important means of energy transfer.



Percentage of light transmitted and wavelength
Fig. 3—Spectrogram of a polyethylene film.



Percentage of light transmitted and wavelength
Fig. 4—Spectrogram of agricultural PVC.

It is important to distinguish clearly between exchanges by conduction and convection through tight walls and exchanges through structures which are not properly tight.
If the walls are tight, the thermal system set up can be defined by the overall coefficient of heat transmission K_e:

$$K_e = \frac{1}{\frac{1}{h^e} + \frac{1}{h^i} + \frac{e}{\lambda}}$$

where h_e and h_i are respectively the outside and inside coefficients of convection;
e and λ are the thickness and the conductivity of the walls.

As the walls are thin, the term $\frac{e}{\lambda}$ is negligible. If the framework is of good heat conducting material, the term expressing the conduction of the framework is also negligible. It is shown that although heat losses are greater with aluminium frames, the increase in exchanges with a greenhouse with an aluminium frame in comparison with that of an equivalent greenhouse with an iron or even a wooden framework is small compared with the phenomena of transfer by convection. Finally, in the heat balance of a greenhouse, the nature of the framework matters little.

In brief, in a tight structure, the factor which makes it possible to limit exchanges is interior convection, and the factor which is preponderant in the calculation of the heat balance is wind speed, i.e. the exterior convection. Thus, when the wind speed rises from 1 to 20 m./sec., the exterior convection coefficient h_e is practically ten times higher.
But the walls are not tight. There is a certain flow of air being renewed. This depends upon a number of factors, especially draughts from outside to outside the greenhouse. When experimental measurements are made, it is found that the results are virtually all included in a range bounded by two straight lines, one expressing the maximum renewal R_M and the other the minimum renewal R_m. *Figure 5*, shows the variation of air renewal in a conventional glasshouse, as a function of the wind, when there is no air movement due to forced convention into the inside of the greenhouse.

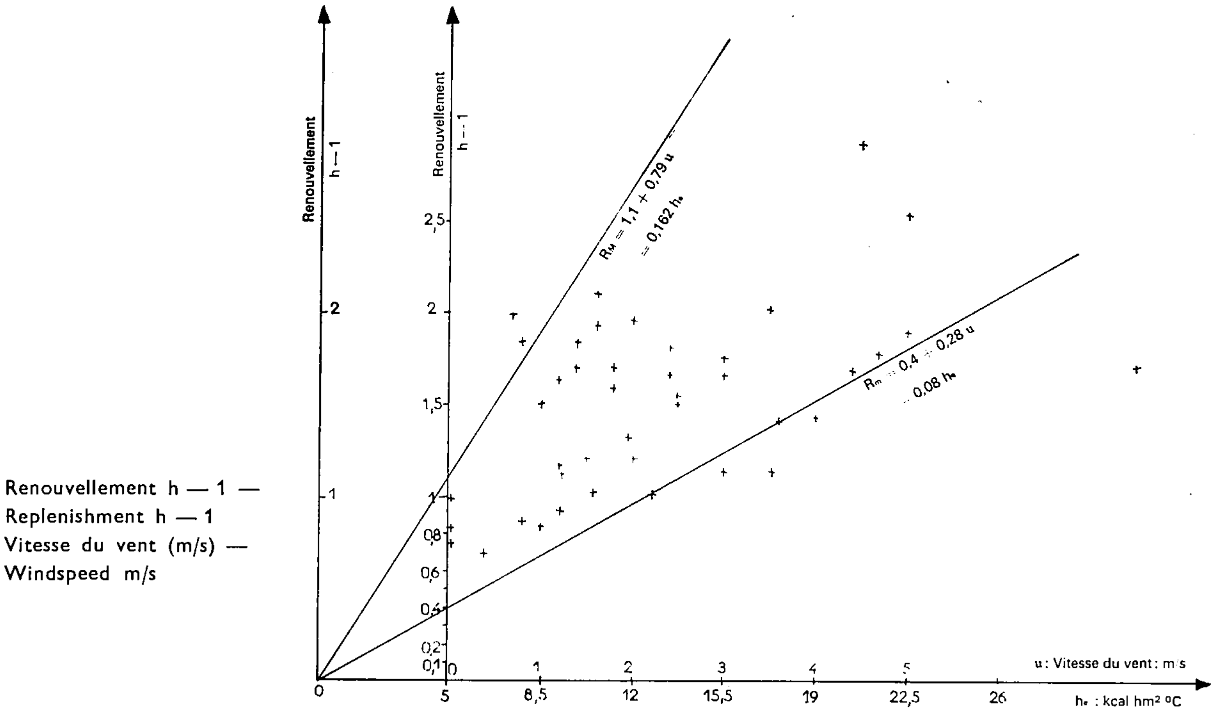


Fig. 5—Air replenishment without forced convection in the greenhouse (glass greenhouse)

The overall heat exchange balance Q can be expressed by:

$$Q = K_e\, S\, (t_i - t_e) + RV\, (i_i - i_e)$$

where K_e is the coefficient of transmission by conduction/convection of tight walls
S the surface area of the walls
t_i and t_e the internal and external temperatures
R the rate of renewal per unit time
V the inside volume
i_i and i_e the enthalpies of air inside and outside.

In the expression for the balance of a greenhouse which is not tight, a term of particular importance is $(i_i - i_e)$. If the atmosphere of a greenhouse is humid, the losses by renewal are more pronounced than those of a greenhouse with a dryer atmosphere, the temperatures t_i and t_e being the same.
For the same relative interior humidity and the same difference of temperature between the inside and the outside, the enthalpy variation increases with inside temperature.
For example, *figure 6* shows the variation of the overall real coefficient of transmission K_r of a conventional glass greenhouse as a function of the outside wind. We have drawn the limiting curves of this coefficient calculated according to the value of the renewal rate and the extreme values of the differences in enthalpy per °C temperature variation. These curves coincide well with the experimental results.

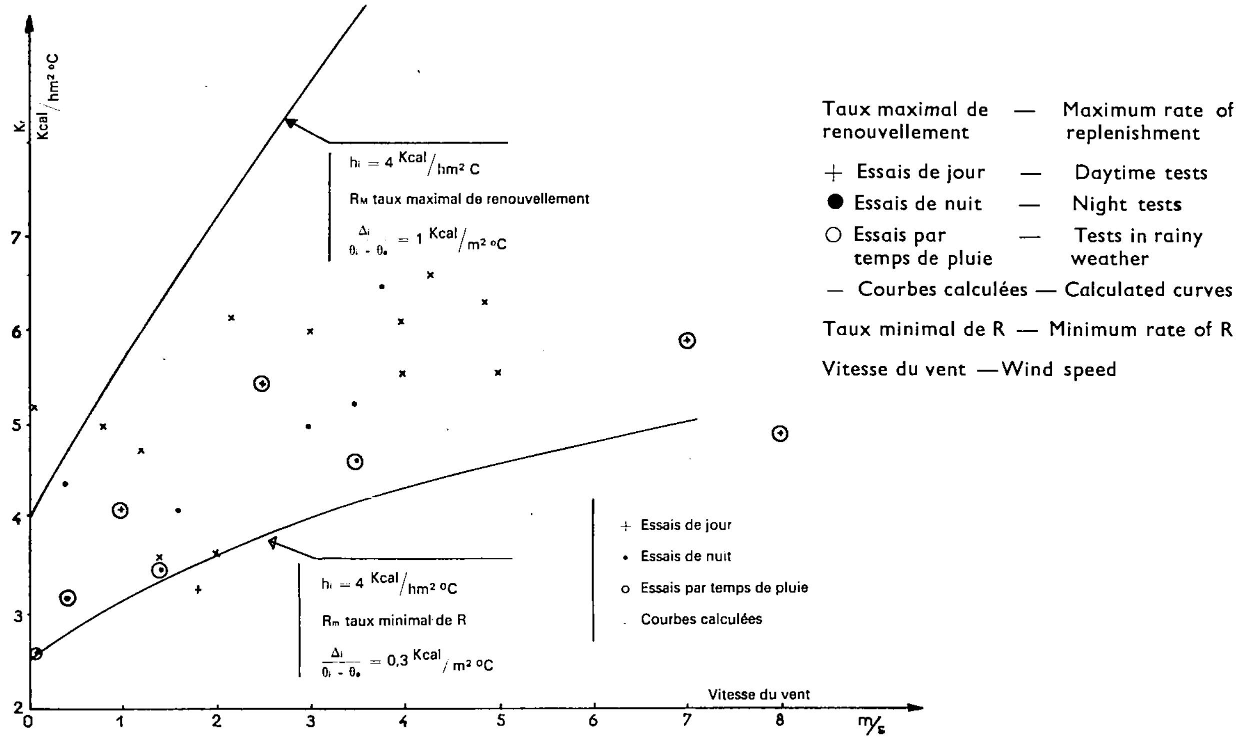


Fig. 6—Variation in the overall coefficient K_r of heat transmission of a greenhouse as a function of the wind speed (glass greenhouse)

Air humidity

During the winter, the humidity inside a greenhouse obviously depends on the temperature of the coldest surface. This surface could be either the transparent covering or the framework itself.

If the wall is colder, the air humidity can be increased by means of a double transparent wall, for example by adding a flexible type of film, but the admission of light will be reduced. Convection near the walls themselves could also be increased. Indeed, an increase in the interior convection coefficient h_i brings about a rise in temperature of the inner surface of the covering. By the same token, convection/conduction exchanges and the renewal rate are of course increased.

Water which condenses on the covering will either fall back on to the plants, as in the case of materials which will not absorb moisture, or not very inclined roofs, or it will collect by flowing down, as with glass in a vertical or sharply inclined position.

If the framework is the colder surface, as in the case of metal frameworks, water will condens on a very small area only and will fall in large drops always on the same spot. This is particularly harmful to the plants below.

It is therefore of the utmost importance that condensation should not occur on the metal framework. We are thus compelled to insulate metal frameworks and eliminate heat bridges. This can be done by giving the "small wood" parts special shapes, (e.g. T-shaped sectional tubes) or by using insulating devices such as putty or joints. Such devices are very advantageous because they often contribute to improving the tightness of the walls, thus reducing the thermal balance. (cf. G. Pons).

Conclusions

The physics of greenhouses make it possible to show and assess the parameters of the environment in which the plants will grow. In this way new greenhouses which will meet more adequately the requirements of growing plants can be designed. So far, industry has suggested special structures such as tower glasshouses, where plants are mass-produced. Designers will no doubt put forward other types of good structures. We feel that any unit fulfilling all the following physical and technical characteristics would be satisfactory:

— a structure as small as possible, suitable for the material for its covering;
— a unit transparent to daylight and spreading it uniformly over the plants;
— a structure capable of resisting the effects of wind, snow and possibly the weight of the plants themselves;
— adaptability to mechanized working of the soil and gathering;
— tightness, particularly to CO_2;
— elimination of cold points (localized thermal bridges);
— adaptation of heating and cooling to meet the requirements of the plants and the outside climate;
— automation, particularly of heating, cooling and sprinkling.

It is clear that any new greenhouse must be suitable for plant production. Biological research should be systematically intensified in various climates. The greenhouses must also be economically viable. It is desirable for manufacturers not to produce greenhouses having only limited applications, but to standardize certain components and increase production runs.

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Dipl.-Ing. R. BOHN

Kuratorium für Technik in der Landwirtschaft e.V.
Fachabteilung Technik im Gartenbau
Bad Godesberg

Greenhouses

(Translated from German)

The greenhouse as a means of production

Vegetables and decorative plants can be grown throughout the year because the natural conditions under which both native and non-native plants thrive can be re-created in the greenhouse. Such growth factors as heat, light, air and moisture can be largely controlled.

We should distinguish between such greenhouses as are solely or mainly entered by gardeners for the purpose of tending the crops, and display greenhouses open to the public (as in botanical gardens).

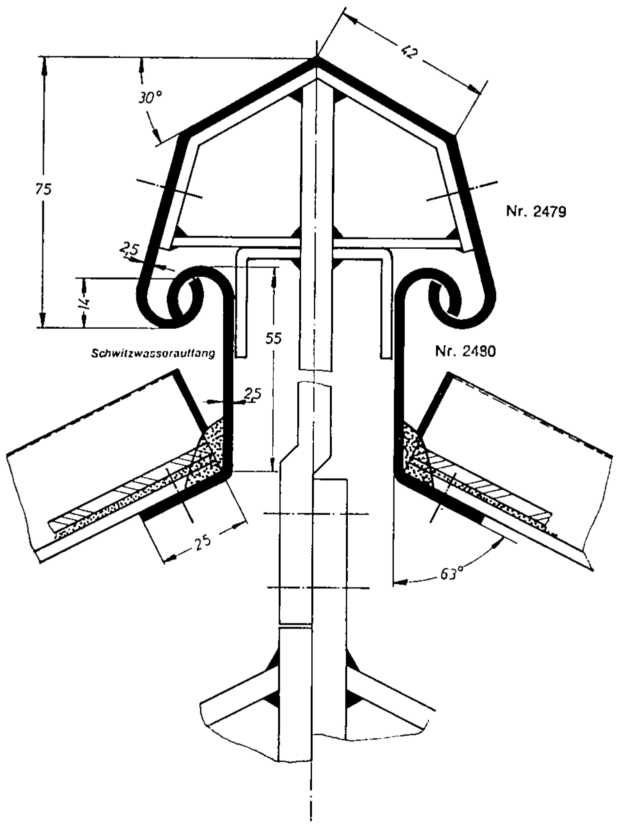
Greenhouses usually consist of a supporting or load-bearing structure (foundation, trusses and purlins) and an outer shell of glazing bars and glass. The crossbars may also be load-bearing members forming part of the structure.
The greenhouse, which began in a simple way, has now become a means of horticultural production. The present standard design in Western Germany is the entirely hot-dip galvanized steel greenhouse. A current development is the utilization of such materials as aluminium and plastics.
Greenhouses are manufactured by a highly skilled industry which has grown from an old-established tradition of craftmanship to a fully-fledged branch of construction of steelwork engineering.

Greenhouse construction in Western Germany

According to the horticultural statistics, in Western Germany some 3,900 acres were under glass in 1950, i.e. 2,330 acres of forcing frames and 1,570 acres of greenhouses. According to the last horticultural census in 1961, about 5,550 acres were under glass, an increase of about 1,650 acres in 11 years, or an average of 150 acres a year. Greenhouse building accounted for most of the increase; owing to the lack of skilled labour few forcing frames have been built in the past ten years.
Taking DM 60-70 as the average price per square metre under glass, we find that West German market gardeners spend an annual average of DM 40,000,000 on greenhouse construction.
The average for 1961-62 and 1962-63 represented a peak in greenhouse building, but it will depend on the trend of the economy as a whole whether business will continue so briskly.
Steel consumption per square metre under glass depends on the design and varies from 12 to 22 kg.

Structural parts

Nearly all trusses are made of solid-walled rolled sections. The joints in the eaves and roof ridge are usually bolted or welded. *(fig. 1)*.



Schwitzwasserauffang — Condens water trap

Fig. 1—Roof ridge in cold rolled sections

It has been proposed to use welded steel framework instead of rolled sections, but the labour and high wage-costs involved make this uneconomic for spans under 20 metres. Most greenhouses in Western Germany have an average width of 12 metres, more or less corresponding to the optimum amount of steel per square metre under glass. This is also a suitable size of greenhouse from the viewpoint of management and maintenance work (cleaning the glass, replacing broken panes).

3,065 mm. has become the recognized standard distance between trusses, being made up of five standard pane-widths of 600 mm. plus the web thickness of the glazing bar and the clearance between glass and bar. The optimum distance between trusses increases with their span, so that a larger distance is possible with wider spans, and vice versa.

Purlins are usually made of cold-rolled steel sections; in the most economic form they are girders running over several supports, the trusses taking the load.

Although the freely-resting purlin with a butt-joint over each truss is not the ideal static solution, it owes its popularity to its suitability for prefabrication and easy assembly.

The pin-jointed purlin, in the form of a series of overhung joists and tie-beams, is statically more suitable and is also a good design for workshop prefabrication and not too difficult to assemble.

The purlins are laid underneath the joints of the roof panes.

The dimensions of the glazing bars in the roof and the side and gable-walls is mainly determined by the width of panes used. The most popular size in Western Germany, 60/200 cm., requires a steel bar section of at least T 30 (DIN 1024), and this section should also be used for the future pane-size of 60/174 cm. The glazing bars need not be statically determined, but one should make sure that the glass does not break when they sag with the outside pressure of continuous loads, wind or snow.

Wider panes would mean that less steel is needed for the glazing bars, but limits are imposed by the risk of breakage of the glass; moreover gardeners do not like very heavy panes because they are awkward to replace, especially in the roof ridge.

A pane-width of 73 cm. is commonly used in Holland; in Denmark the limit is 90 cm.

Statics

Calculations of greenhouse statics are based on the "Technical Building Regulations" of the German Industrial Standards (DIN) as supplemented in 1958 by DIN 11 535 "Code of Practice for Dimensioning and Construction Greenhouses." The latter is intended as a simpler and clearer definition of the principles determining the loads supported by greenhouses, especially the wind load hitherto calculated from DIN 1055. According to DIN 11 535 the dynamic pressure should be 25 kg./m^2. up to a height of 4 metres, and 40 kg./m^2. up to 4-6 m. The values for higher surfaces are specified on sheet 4 of DIN 1055, i.e. 50 kg./m^2. at a height of 6-8 m. above ground level and 80 kg. at 8-20 m. Other specifications in DIN 11 315 relate to snow load, additional and normal loads, stability and wind bracing.

Greenhouses are mainly supported by the framework or trusses to which the roof loads are transmitted via the purlins. The truss transmits the loads to the ground via the foundation.

The frame trusses may be double-hinged, triple-hinged or entirely rigid frames, depending on the statical system employed. The triple-hinged frame is the most popular static system of trusses in greenhouse construction as it is very suitable for prefabrication and comparatively unaffected by uneven settling of the foundations and heat stresses. The truss frame can be calculated and designed with or without tie-rod, the latter usually being secured at eaves-level.

Probably no other European country has such strict regulations as Western Germany for the dimensioning and construction of greenhouses; the resultant building costs put West German horticulturists at a disadvantage in respect to those in other countries.

Standardization in greenhouse construction

Greenhouse construction is at present being standardized in Western Germany by a working party of the German Standards Committee on which all parties concerned are represented, including the authorities. The aim is to rationalize production methods and lower building costs by limiting the number ot types.

It is hoped the procedure by which building permission is granted will be simplified when the various types have been officially approved. The work is based on the following technical considerations:
Standards are in the first instance to be introduced for the fully hot-dip galvanized type of steel greenhouse based on a grid system with a 3,065 mm. horizontal distance between trusses and the space between the gable-walls. Within this grid system greenhouses with nominal widths of 12 and 9 metres are to be standardized first. *(fig. 2)*. The system will also cover other widths in 3.-metre graduations, their main dimension being determined by the system. The grid system makes it easier to automate the manufacturing process and prefabricate interchangeable parts, and it is also expected that materials will be easier to store and assemble.

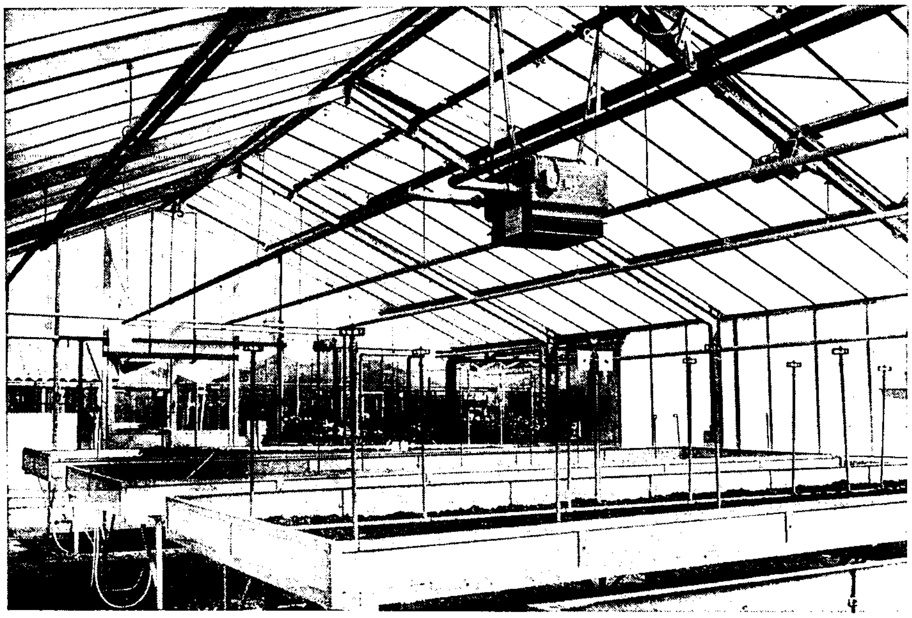


Fig. 2

It should be possible to build both single and block-type standard greenhouses. The trusses will be standard "Euronorm" steel sections and the statics calculated with the inclusion of a built-in tie-rod. The side-walls may vary in height from 2.30 to 2.80 metres, depending on the crop and transport requirements, and any built-in equipment for watering, heating or shading. A 1 : 2 ($\sim$ 26.5°) roof pitch is specified for ensuring good light incidence; the panes will be size 60 × 174 cm.
The eaves are provided with cold-rolled steel gutters for catching and carrying off rainwater, as connecting element when other greenhouses are added on the side, and as a guide-rail for ladders, etc.
The ventilation equipment is not separately standardized because existing patents have to be taken into account and more scope is to be left for further technical developments. The only point specified is that the continuous ridge ventilation should be the width of one pane-length (174 cm.). It should be possible for hinged ventilators to open at least 15° above the horizontal position. The type and size of side ventilation will depend on crop requirements, and here again the maximum possible ventilation cross-sections should be aimed at.
Three sizes of door are available for assembly in the side and gable-walls:
— single door 1,200 × 2,200 mm.
— double door 2,400 × 2,200 mm.
— sliding door 3,065 × 2,800 mm.
(sliding doors are only used in greenhouses having a side-wall height of 2.80 m.).
It should be noted that standardization is still under discussion so that these dimensions are not to be regarded as final.

J. C. SPEK

Instituut voor Tuinbouwtechniek
Wageningen

Steel in Glasshouse Horticulture in the Netherlands

(Translated from Dutch)

Steel has become an indispensable material in the construction of glasshouses. The classic property of steel-maximum strength for minimum dimensions plays an important part in the 60 million m^2. under glass. In glasshouses this means greater light interception for a given strength in comparison with timber as a structural material, particularly during the winter. The table, which gives figures for hot-rolled steel, indicates the remarkably low consumption of materials per unit of enclosed area.

Hot-rolled gutters

In glasshouse horticulture in the Netherlands, the gutter has long been used not only for interception and drainage of water but also for structural purposes. In Dutch Light glasshouses of the Venlo type, for instance, (for cultivating tomatoes, cucumbers and lettuce) the hot-rolled box gutter, 0.2 m. broad and 3 or 4 mm. thick (unit weight 6.75 or 8.75 kg./m.) has been an indispensable load-bearing member for decades. Besides being strong these gutters must also have adequate water-holding capacity and withstand being walked on.

Cold-rolled gutters

Dutch Light complexes have multiple adjacent spans and are built in long runs in units of about 3 × 3.2 m. (9.6 m^2.).
As a result of the tremendous expansion in vegetable growing under glass, cold-rolled gutters also appeared on the market, nearly all 0.22 m. (or 0.17 m.) wide and with a moment of inertia I_x between about 100 and 50 cm^4. and a section modulus W_x between 20 and 10 cm. These values are only of limited interest in statical calculations, as test-loading has shown that the greatest risk is of buckling under double flexure.
These cold-rolled gutters are 2.5 mm. thick as a rule and the various types weigh 5.5 to 6 kg./m. ungalvanized. An important point is that the rolling process has resulted in gutters with a V-shaped base, and water condensing on the under-surface forms a drip line. A simple anti-drip channel (30-30-3 diagonally) makes the entire glasshouse area croppable, and zinc toxicity (e.g. in lettuce) is avoided. Practically all gutters are now provided with standard fittings for preventing drip on the crop.

Consumption of materials per m^2 of enclosed area in glasshouses of various span widths

	Structure: Walls and roof, timber Trusses, gutters and supporting members, steel Footings, concrete (solid)				Structure: All-steel Footings, concrete (solid)			
Width per span	3.20 m.	6.40 m.	12.80 m.	19.20 m.	3.20 m.	6.40 m.	12.80 m.	19.20 m.
Number of spans	12	6	3	2	12	6	3	2
Length	54 m.	54 m.	54 m.	54 m.	54 m.	54 m.	54 m.	54 m.
Width	38.40 m.	38.40 m.	38.40 m.	38.40 m.	38.40 m.	38.40 m.	38.40 m.	38.40 m.
Enclosed area	2073.6 $m.^2$	2073.6 $m.^2$	2073.6 $m.^2$	2073.6 $m.^2$	2073.6 $m.^2$	2073.6 $m.^2$	2073.6 $m.^2$	2073.6 $m.^2$
Timber	9.7 $dm.^3$	12.4 $dm.^3$	14.1 $dm.^3$	13.4 $dm.^3$	0	0	0	0
Steel	4.13 kg.	6.03 kg.	8.91 kg.	12.71 kg.	8.86 kg.	13.31 kg.	15.30 kg.	18.82 kg.
Concrete	12.1 $dm.^3$	12.5 $dm.^3$	13.5 $dm.^3$	13.5 $dm.^3$	12.1 $dm.^3$	12.5 $dm.^3$	13.5 $dm.^3$	13.4 $dm.^3$
Glass	1.22 $m.^2$	1.29 $m.^2$	1.38 $m.^2$	1.42 $m.^2$	1.22 $m.^2$	1.29 $m.^2$	1.38 $m.^2$	1.42 $m.^2$
Glazing bars								
Roof cladding	1.36 m.	1.44 m.	1.48 m.	1.51 m.	1.36 m.	1.44 m.	1.48 m.	1.51 m.
Side cladding	0.68 m.	0.16 m.	0.16 m.	0.16 m.	0.16 m.	0.16 m.	0.16 m.	0.16 m.
End cladding	0.15 m.	0.17 m.	0.22 m.	0.23 m.	0.15 m.	0.17 m.	0.22 m.	0.23 m.

Dutch Light glasshouses

The gutter posts in Dutch Light glasshouses—these have a trussless roof which is secured only against blowing away—are often of steel. Since 1961-62 complete glasshouse kits (with steel glazing bars, ventilator frames, gutters, gutter posts, etc.) of hot-galvanized steel have been on the market. These Dutch Lights, built to specification DIN 11535, lend themselves admirably to carriage and export on account of their lightweight construction:

— centre bay approx. 55 kg /9 6 m^2
— side cladding approx. 100 kg./9.6 m^2.
— end cladding approx. 105 kg./9.6 m^2.
— corner bay approx. 165 kg./9.6 m^2.

All the sections are of cold-rolled steel (for hot-rolled steel the centre-bay materials weigh about 80 kg./ 9.6 m^2.). The concrete footings remain a weak point in this "meccano" design. At present, extension of the gutter posts to 0.60 m. below ground level and standardized socketed foundation blocks seem a considerable improvement.

Single-span glasshouses

In the Netherlands this type of glasshouse consists of a load-bearing structure of trusses of one type or another and a cladding of glass and glazing bars supported by purlins and cladding struts.
This design can be seen in glasshouses with spans of 4.5-25 m. In Aalsmeer, in glasshouses for cut flowers and pot plants, the unit run (the distance between trusses) is traditionally 3 m., and steel consumption in the 21-25 m. truss ranges from 5 to 7 kg./m^2. of enclosed area. The purlins in these glasshouses are often of steel channel bars with the open side uppermost, forming a trough to intercept condensation water running from the glazing bars.
In this sector of glasshouse horticulture the T-section steel glazing bar is not popular. Hollow-section glazing bars are used, though as yet only to a limited extent; little or no condensation forms on the underside of these.
Also of interest is the standardization of 6.20/6.40 m. glasshouses, in which about 7 kg. cold-rolled or 10 kg. hot-rolled steel/m^2. is used in the centre spans.
When considering all the above data it is important to recognize that standard-size horticultural glass, 0.73 × 1.65 m., is the basic item in the design.

Protection of steel

Steel utilization in glass buildings for horticultural purposes dates from the vineries built in fairly large numbers at the beginning of the century. Some of them are still in reasonably good condition. Because these unprotected structures rusted and needed a lot of maintenance, steel went largely out of favour. It was not until 1953 that a hesitant reassessment was made, since users were asking for hot-galvanized structures and some glasshouse builders were still prepared to keep on supplying steel. By about 1960 hot-dip galvanizing of steel for glasshouses (i.e. of the so-called blackgutters) was a practice universally accepted and one for which customers were willing to pay, since it gave freedom from any form of maintenance in the great majority of cases. This has made steel competitive with aluminium which is becoming increasingly used in glasshouse construction.

Assembly and dismantling

The great advantage of steel (if completely protected from corrosion) for constructing the boiler-houses and outbuildings associated with the sometimes very large glasshouse complexes have not been turned to account. Good-quality steel components in the roof and walls are always capable of being dismantled or extended without loss of materials, and need only light foundations. In the Netherlands, where the subsoil in farming areas frequently has limited load-bearing capacity, a particularly important consideration is that insulated steel panels weight only one-seventeenth as much as cavity walls with the same insulation properties.

Conclusions

Steel has proved a valuable structural material on account of its special characteristics and because it can be adequately protected for glasshouse construction. At the same time, we feel that when building for export to countries with climates quite different from that of Western Europe, even greater care should be exercised than is at present the case.
In the Netherlands there is still quite a lot of scope for increased use of steel in horticulture under glass, with all its glasshouses and outbuildings.

Geometra Lionello VENEZIANI

Sider-plast
Roma

Glasshouses

(Translated from Italian)

— Hot-galvanized steel structures with beams made from patented sections linked by special joints.
— Cover with flexible polyethylene sheets, double-walled for greater heat retention.
— Side and overhead apertures (windows and roof-lights), for rational air-flow and ventilation of the atmosphere.

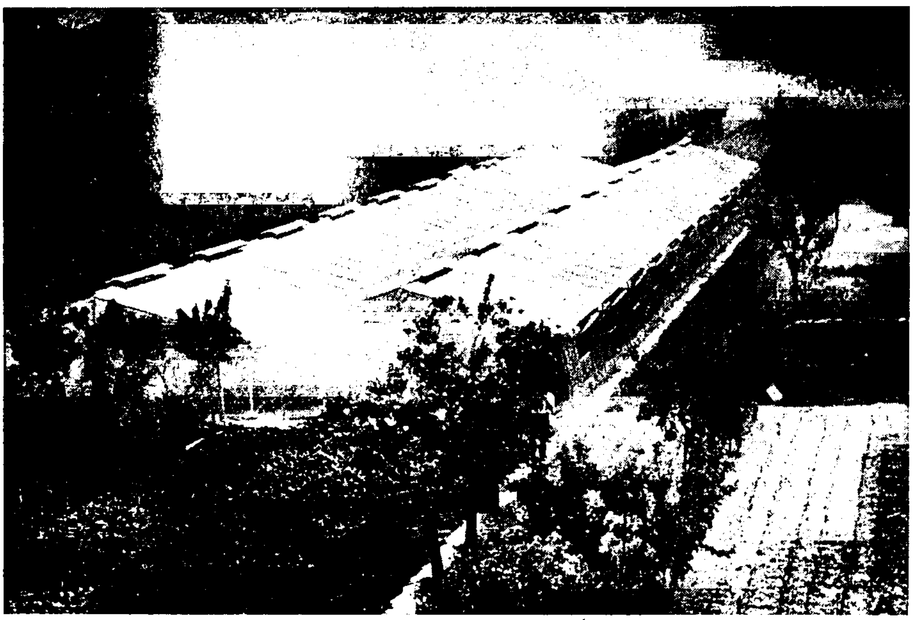


Fig. 1

— Competitive cost: easy and economical erection.
— The glasshouses have been mainly used for growing tomatoes, peppers and aubergines and also for protecting and forcing all types of garden produce in the winter season.
— Glasshouse with an area of around 1,200 sq.m. *(Fig. 1)*
This was supplied to a small farm specializing in outdoor horticulture.
The house was erected between a fruit-orchard and a grain-field.
The farm used the glasshouse, employing labour in the winter season thereby giving a good return. A tomato crop was harvested in the month of April.
— *Figure 2*—Interior of the glasshouse with tomato crop.

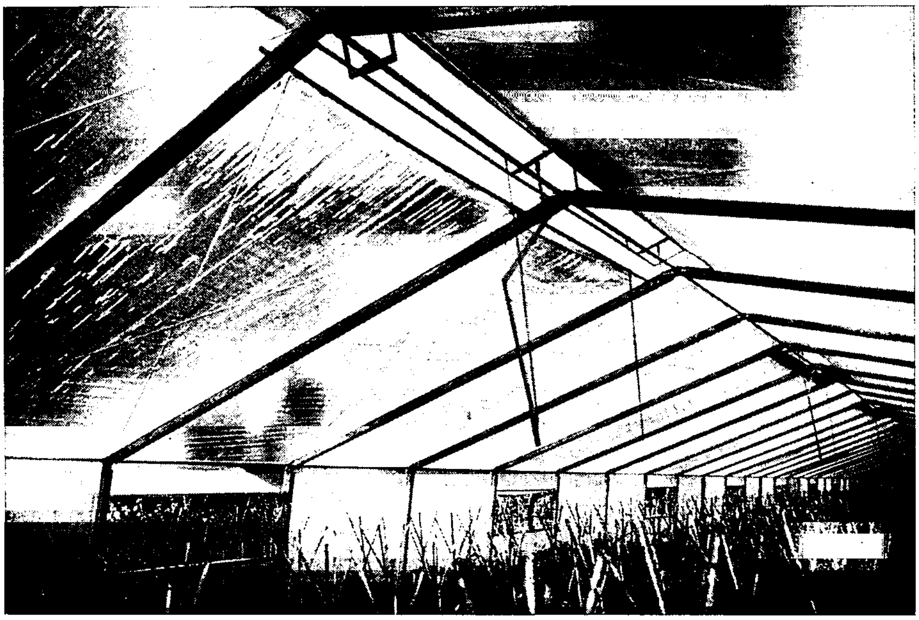


Fig. 2

Olivier CHARRON

Directeur général adjoint des Etablissements Antoine Besson et Lepeu
Paris

The Steel Framework of a Modern Horticultural Glasshouse

(Translated from French)

One result of the rise in living standards is the growth of the sale of cut flowers. The market is expanding and the customers are becoming more discriminating. Flowers have to be perfect and in good condition and produced at a reasonable price all the year round.
It is necessary to use specialized glasshouses for this purpose. They must be carefully designed down to the smallest detail to meet the needs of the intensive grower using a very high standard of equipment.

Basic principles

The framing must be light, weather and load resistant, removable and rotproof. It should provide optimum conditions for the following:
— light transmission,
— water and airtightness,
— thermal insulation,
— ventilation,
— shading,
— management,
— maintenance.

A modern glasshouse

A glasshouse based on these principles has been designed by a French manufacturer in collaboration with the "Serrefrance" association, a group dedicated to the improvement of glasshouse construction techniques. This glasshouse is for the specialist rose grower. Several models with a total floor area of 10,000 m². have been or are being built in the Paris area.

Structural design

The glasshouse is a clear-span glazed structure about 12 m. wide and having a gable roof with a 30° pitch which gives a height of about 6.60 m. to the ridge. Height to eaves is 3 m.

The length can be varied according to the number of bays chosen by the grower, standard bay spacing being 2.94 m., or four of 0.735 m. wide glass panes. A length which works out at a reasonable cost per m². and appears to suit the crop is 2.94 m. × 35 bays = 102.90 m., or 103 m. if we add the thickness of the vertical panes closing the gable ends.

A door is usually provided in the centre of each side wall and in each gable end wall.

Several 12 m. spans may be placed side by side, either in the original plan or in successive phases, all units being interchangeable and demountable.

These dimensions enable high-output machinery to be used, i.e. tractors, powered cultivators, powered trucks, etc. Work is made easier by the height of the side walls and the fact that they are vertical, the plants can grow without constraint and there is more air available.

It is possible to plant 11,000 rose bushes in a 12 × 103 m. glasshouse (1236 m².), and these should produce on average 110,000 top-quality roses per year, sold with a quality mark.

Structural strength

The designer rebelled against the empirical approach to glasshouse design currently favoured in France, where it is still regarded as something of a craft, and calculated the structural strength on the basis of the Snow and Wind regulations (Règles NV 65) NV — Neige et Vents = Snow and Wind. However, he thought it reasonable to disregard the snowloads for climatic extremes and the dynamic effects referred to in paragraphs 1-5 of the Règles NV 65, in view of the modest size of the buildings involved and the limited risk in case of failure This enabled him to determine a minimum but sufficiently strong section for the structural members, giving maximum light transmission at minimum cost.

Special features of the structural framework

In order to combine lightness and strength in the framing, special sections were manufactured by cold forming sendzimir 3 mm. galvanized steel plate. The building is very strong and was specially designed for rapid erection and dismantling, and for ease of replacement of units with a view to subsequent modifications. For example, the chief rafters of the trusses are attached to the posts by a double gusset in 5 mm. Sendzimir plate and are single- or double-faced, according to whether the post supporting the truss is on the outside wall of the glasshouse or in the centre between two spans. Each of the two gusset plates is independent of the other *(Fig. 1)*. They are fixed by threaded nuts to the bolts welded for this purpose to the ends and each side of the posts and rafters to be joined together.

Fig. 1

As soon as one plate is bolted in position the system will hold up; the other can then be fixed without difficulty. If it is desired to add another span to an existing one, all that is neccesary is to replace each single-sided gusset plate in turn by a double-sided plate.
With this system the grower wishing to extend an existing house can dispense with a line of posts and their foundations; what is more, he can remove the existing gusset plates and re-use them on the new outside wall.

Gutters

These are also formed from Sendzimir steel plate into re-usable units, 5.880 m. long with watertight bolted joints. The shape is designed to facilitate run-off of water and melting snow, to collect condensation and any water that has filtered into the house and carry it outside, and to support an expanded metal catwalk which staff can walk round on, while at the same time protecting the lower part of the gutter.
The gutter is symmetrical in section so that it can be used either on the side walls or in the centre of the house. It also replaces one purlin and supports part of the roof.
The gutters are generously designed for easy flow and to avoid overflowing, even in the heaviest storms.

Glazing

The glazing was designed for:
— water and airtightness;

— flexibility, so as to minimize movement due to linear expansion, sundry vibrations, accidental impacts, e.g., hail, gusts of wind, etc ;
— elimination of heat bridges;
— speed of erection.

Horticultural glass 4 mm. thick is used in the standard width of 0.72 m. The glass panes are butted together with no overlap and have a watertight joint flush with the purlins. They are supported by metal glazing bars made of either roller-formed galvanized steel plate or extruded aluminium. Both the steel and the aluminium glazing bars are designed so that the glass pane resting on their upper part and held in place by the pressure of a neoprene joint seal can be inserted or removed with the greatest ease. Should water penetrate or condense inside, it is collected in a runnel provided for this purpose and led out through the eaves into the gutter.

The glazing bars are fixed to the purlins by sliding grips having a threaded stem which engages in the matching hole in the purlin and is covered by a nut. There is no need for any adjustment or tightening later and this is a great saving of time.

The glass in the side walls and gable ends is fixed in the same way. This type of glazing eliminates the heat bridges which occur in conventional designs when metal glazing bars in contact with the atmosphere. Once the glazing is in place, the metal framework is insulated by an envelope of glass and plastic. This has important consequences for heating, ventilation and the battle against condensation.

Ventilators

Running the whole length of both sides of the glasshouse roof either side of the ridge purlin is a portion of roof, about 1.40 m. wide and glazed in the same way as the rest of the house, which opens in one piece. The upper cross-member of the frame of the opening portion carries collar-shaped metal straps turning on the tube which forms the ridge capping. The lower cross-member is attached to the central lifting mechanism by means of a hinged connecting rod *(Fig. 2)*.

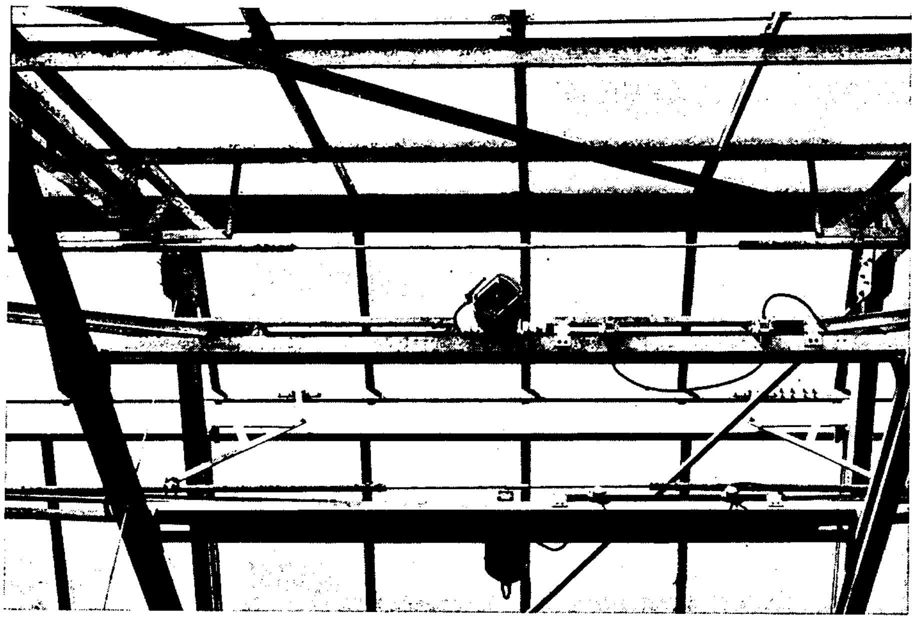


Fig. 2

Each side has its own electric reduction-gear motor and adjustable end stops and fall breakers, and a pull is exerted on a bar suspended below the ridge purlin. As this bar moves forward, it sets in motion a set of connecting rods which open out as they lift the opening ventilator.

The motor is mounted at the required height along the centre line of the house, access being via a catwalk. It is controlled from floor level by push buttons set in a control panel and can operate one or both sides or be automated, as desired.

The frames in the side walls can be made to open either by a manual system which enables one man without difficulty to open a ventilator 2.94 m. wide (the space between the trusses) and running the full height of the side wall, there being automatic stops in various positions, or by an electrically powered central system similar to the one which operates the ridge ventilators.

Shading

The construction of the glasshouse makes it possible to install a shade consisting of a canvas strip rolled round a pole mounted 0.40 m. below the ridge purlin and hung from it. It can be unrolled parallel with the roof pitch and runs on two guides hung about 0.30 m. below the rafters. It can be unrolled to any length desired. This system is simple, quick and efficient and is a great help to the grower who has here an additional aid in improving his produce. It is electrically operated.
Note that in winter this shade can improve heating efficiency by holding a layer of air beneath the roof, giving an appreciable saving in fuel.

Conclusion

In the opinion of professional growers, this glasshouse is one of the best on the market at present. It provides ideal conditions for installing the most modern systems of heating, ventilation and cooling, CO_2 enrichment, sprinkler irrigation, insecticidal treatments, etc.

Olivier CHARRON

Directeur général adjoint des Etablissements Antoine Besson et Lepeu
Paris

(Translated from French)

I shall now try to answer, as far as I can, some of the questions which have been raised. During the Congress, we have heard of the relationship existing between the degree of perfection sought and the required cost price. We feel that a compromise between these two factors should be found, especially as the economies in running costs to be gained from higher quality products are usually forgotten. I would particularly like to emphasize this latter point.
Especially in the case of glasshouses, it will be found that quality pays in the long run. For this reason, an organisation called "Serrefrance" has been set up in France to lay down fixed standards which provide buyers with a guarantee of quality.
One of the best ways to reduce costs is to achieve a highly standardized product. In our case, we only manufacture one type of glasshouse for flower-growing (roses in particular) and this has been designed in conjunction with the growers themselves.
As regards the strength of the materials (another point which has come up), it is worth recalling that in 1957, 70 % of the glasshouses built on the Cote d'Azur collapsed under the weight of the snow. As a result, with the help of the CTICM (Industrial Technical Centre for Metallic Construction), it was decided that some attempt should be made to curb the current hit-or-miss approach to glasshouse construction by taking regulation No. 65 of Metallic Construction 56 in France (wind and snow effects) as a basis, although extremes of climate and dynamic effects were not considered.

As regards corrosion (also considered by the other Working Parties), the buildings are constructed of Sendzimir galvanized sheeting with galvanized bolts. We have never thought of using aluminium, because of its price, heat conduction and expansion which is twice that of steel.

The question of condensation has also been brought up. To prevent condensation, we have eliminated thermal bridges by protecting the frame with glass and elastomer joints.

Finally the structure has been made as air-tight and water-proof as possible so that the air is renewed 6 to 30 times slower (according to wind-speed) in our type of glasshouse than in ordinary houses. This makes it easier to maintain the internal atmosphere at the required temperature and proportions. The saving in fuel consumption especially is 65,000 calories an hour for a house approximately 2,400 metres square.

Lower running costs mean that the slightly higher purchase price, compared to that of an ordinary model, can be quickly recovered. It should also be noted that the design and quality of the structure ensure considerable reduced expenditure on upkeep.

Prof. Ranieri FAVILLI

Direttore dell'Istituto di Agronomia generale e coltivazione erbacee
Università degli studi
Pisa

Technical and Economic Considerations on the Use of Steel in Covered Market Gardening

(Translated from Italian)

Growing demand for out-of-season horticultural produce, both early and late, which has risen noticeably in the last five years, has encouraged Italian growers to extend, rapidly and consistently, the area devoted to covered crops. This expansion has also been boosted by a bigger call for cut flowers and ornamental plants both on the home and foreign markets. This favourable market trend, undoubtedly due, as far as the home market is concerned, to Italy's improved standard of living has brought a wider range of quality horticultural produce. Whereas up to now the tomato has been virtually the only forced or semi-forced garden plant, this method of growing is now widely used for other species, including peppers, cucumbers, melons, egg-plants, beans, lettuces, etc. In the nursery field, the spread of protective methods has made it possible both to extend flower-growing to new areas and to increase the production period of many of the most important species in the traditional, but less climatically favoured, areas. So in the Pescia district, Versilia and the coastal areas of Latium, where the open-air carnation could formerly only be picked in summer, glasshouses have now made it also possible to grow the more valuable winter and spring crops.

Table 1 gives a clearer idea of the spread of covered market garden cultivations over the last few years. This compares the area given over to glass-houses and other forcing or semi-forcing structures (frames, Dutch Lights, tunnels, cloches, etc.) in the various regions of Italy in the year 1960 and again in 1964. This area has again increased considerably in 1965 and 1966, and the total covered area in Italy today can be estimated at around 5,500 hectares.

There is no doubt that the introduction of plastic materials and their rapid progress in this sector of agriculture have contributed greatly to this rapid expansion. These materials, either in the form of rigid sheets or of flexible transparent film, have made it possible to build efficient houses at a considerably lower cost than in the case of the traditional glazed type, and also to use entirely new means of semi-forcing (tunnel houses, tunnel cloches, cloches, etc.) or those for which no other material was suitable.

Table I — Area (in hectares) Occupied by Glasshouses and Semi-forcing Installations in Italy.

Region	Glasshouses		Semi-forcing installations							
			Dutch Lights		Tunnels		Various movable frames		Cloches	
	1960	1964	1960	1964	1960	1964	1960	1964	1960	1964
Piemonte	17.74	12.11	2.44	15.84	—	13.85	—	41.36	—	0.46
Valle d'Aosta	—	—	—	—	—	—	—	—	—	—
Liguria	533.92	1,169.70	9.30	11.10	—	0.90	—	120.00	—	2.00
Lombardia	12.98	27.56	4.87	8.19	—	636.32	—	15.79	—	271.40
Trentino A.A.	1.00	10.30	1.50	2.00	—	—	—	2.50	—	—
Veneto	4.12	8.82	8.94	31.51	—	6.56	—	21.50	—	8.51
Friuli V.G.	3.65	5.48	3.80	2.47	—	9.74	—	10.50	—	3.00
Emilia Romagna	1.80	30.38	6.22	2.15	—	58.45	—	0.87	—	2.61
Marche	1.68	3.03	2.22	13.71	—	0.13	—	—	—	1.10
Toscana	14.96	96,87	9.29	4.90	—	2.73	—	5.75	—	1.75
Umbria	0.98	2.48	0.48	0.07	—	0.60	—	0.45	—	0.15
Lazio	12.04	358.57	3.00	16.59	—	165.20	—	12.50	—	2.80
Campania	3.61	28.07	4.30	0.06	—	1.20	—	17.80	—	2.00
Abruzzi e.M.	1.76	20.98	0.05	0.05	—	0.20	—	—	—	—
Puglie	2.39	16.40	6.20	11.73	—	1.58	—	0.18	—	0.10
Basilicata	0.53	8.94	0.03	—	—	—	—	—	—	—
Calabria	—	23.21	—	0.08	—	0.02	—	0.03	—	0.02
Sicilia	4.66	748.34	0.73	1.10	—	2.02	—	3.50	—	80.50
Sardegna	6.78	26.60	—	0.01	—	0.40	—	0.27	—	0.30
Italia	624.60	2,597.84	63.37	121.56	—	900.08	—	253.00	—	376.70

Data furnished by the author for 1960 and by the Agricultural Technical Office of the Consorzi Agrari for 1964.

The development of the various methods of growing protected crops has thrown up enormous opportunities for the use of steel, and continues to do so. In fact by sticking mainly to this material, the builder can achieve a better planned and more efficient unit and so attain the best technical and economic results.

Houses

For industrial or growing houses—with which we are principally concerned—the supporting structures can be built entirely of various types of wood, metal (steel or aluminium), prestressed reinforced concrete, plastic (polyester resin reinforced with glass-fibre), masonry, or even a combination of these materials (steel and wood, reinforced concrete and steel, timber and masonry, etc.).

In Italy, as we can see from *Table II*, timber houses are the most popular (79.5 %) while those in metal—exclusively steel—constitute a fairly minor proportion (17.3 %). Finally only a very limited area (3.2 %) is occupied by houses of mixed construction and these are nearly all in timber and steel.

The use of aluminium in these structures—which has been widely tried in some countries—appears to offer few economic advantages mainly because of the greater cost of the metal and its higher rate of heat-conduction (The heat-conductibility, expressed in (Kcal./sec.)/(sq.m.) (°C/m.) is: aluminium, 4.9×10^{-2}; steel, 1.1×10^{-2}), resulting in greater loss of heat inside the house.

When steel is used for the supporting structures it is in the form of sections of various kinds (simple or double "T" section, "C", "L" or other special types) or in tubular form, adequately protected from oxidation by galvanizing with zinc, or efficient anti-rust paints. Steel houses built in this way—although more expensive than the timber type—do offer considerable advantages compared with the latter. The internal area is completely free of upright supports—unlike the timber houses—which, apart from hindering the working of the soil or completely preventing the use of machinery, often provide a refuge and breeding-ground for animal and vegetable parasites. Besides, they allow more light to reach the plants, because for obvious reasons they have a structure which is both lighter and better-partitioned.

Table II—Materials used in the Construction of Glasshouses in Italy

District	Steel		Timber		Mixed	
	Hectares	%	Hectares	%	Hectares	%
Piemonte	9.78	80.8	1.05	8.7	1.27	10.5
Valle d'Aosta	—	—	—	—	—	—
Liguria	204.70	17.5	965.00	82.5	—	—
Lombardia	25.08	91.0	0.44	1.6	2.04	7.4
Trentino A.A.	1.12	10.9	0.68	6.6	8.50	82.5
Veneto	5.41	61.4	2.42	27.4	0.99	11.2
Friuli V.G.	4.41	75.5	0.87	15.9	0.47	8.6
Emilia Romagna	9.45	31.1	14.55	47.9	6.38	21.0
Marche	2.60	85.8	0.21	6.9	0.22	7.3
Toscana	27.41	28.3	47.67	49.2	21.79	22.5
Umbria	1.87	75.0	0.60	24.2	0.01	0.8
Lazio	77.45	21.6	270.72	75.5	10.40	2.9
Campania	4.41	15.7	15.10	53.8	8.56	30.5
Abruzzi e.M.	1.13	5.4	19.81	94.4	0.04	0.2
Puglie	6.12	37.3	9.08	55.4	1.20	7.3
Basilicata	8.86	99.0	0.05	0.6	0.03	0.4
Calabria	3.20	13.8	—	—	20.01	—
Sicilia	32.93	4.4	715.41	95.6	—	86.2
Sardegna	24.66	92.7	1.94	7.3	—	—
Italia	449.43	17.3	2,065.28	79.5	83.13	3.2

Data provided by tne Italian Federation of Consorzi Agrari for 1964.

It should be noted, in fact, that in a steel house the total area occupied by the non-transparent material is rarely more than 11-12 % of the total covered area. This percentage is considerably lower than in the case of a timber or reinforced concrete house where in some cases it is as much as 20 %.

The higher rate of heat dispersal which, compared to wood, can occur through conduction in a house made from steel sections, is largely offset—if the house has been properly built—by the improved hermetic sealing which can be obtained permanently with metal components as opposed to wood. As a result the "heat return" (see R. Favilli: Atti del 2° Conv. Nazionale sulle Applicazioni delle Materie Plastiche in Agricoltura, Latina 1964, pp. 32, 43)—which we consider to be the basic measure of the agronomic efficiency of a hot-house—is always, all else being equal, quite a lot higher when the house itself is built in steel.

This improved sealing of the building permits, in cases where artificial heating is used, considerable savings in fuel, and also the use of CO_2 fertilizers, with better technical and economic results.

Although this type of house requires greater capital investment on the part of the grower, unlike timber, it should last for an unlimited period. It also costs far less to maintain the main structure (virtually nothing if the sections have been properly galvanized), than to maintain the cladding, no matter what material has been used for this.

For example, the average life of the main structure of a timber house covered with plastic sheeting, of the type widely used in the province of Latina, varies between 4 and 5 years. The main structure and the framework for the glass panes ("windows") of the mobile house used in the orchard district of Albenga, Savona is reckoned to last approximately 10 years. On the other hand, a steel house—even with variations depending on the characteristics of the material used—can last much longer, even though from an accounting point of view it is usually written off in 20-25 years. In addition to that there is the fairly high annual expenditure required to maintain the structure of a timber house, which varies between 10-12% of the initial value of the structure.

There is also a considerable difference in the yearly upkeep of the cladding. In the case of houses with sound steel framed glazing and with a carefully calculated structure, even allowing for occasional accidents, the number of panes broken—nearly always due to purely accidental factors—is minimal (0.3-0.5% of the entire covered area) while in timber houses the percentage is as high as 2-5%, or even higher in the case of mobile houses.

In the case of those covered in plastic sheeting, the type of structure has an often considerable influence on the life of the cladding. In fact repeated observation has shown that in many cases the damage caused to the sheeting by wind is due to ineffective sealing of the house—a common fault in timber houses. The wind penetrates the inside of the structure and exerts a pressure on the sheeting which, being no longer supported by the entire structure but only at the points of attachment, is easily removed and torn. In other cases the film gets torn because the wooden members are too thin and too rotten to withstand the force of the wind. These problems rarely occur in steel houses, because of the greater air-tightness of the shelter, the more efficient way in which the sheeting can be fixed, and the increased strength of the basic structure. Metal houses are being produced in Italy today which are specially intended for covering with plastic film. In spite of the fact that they include all the necessary requirements, the cost is still extremely low. So from every point of view they are much more economical than the traditional, and often too primitive, wooden houses.

Finally, from the point of view of agricultural economics, steel houses also have the edge because they make it easier to control the internal atmosphere. This mainly because a more efficient, easily operated or even automatic air-conditioning system can be installed in a steel-framed house. Whereas the rudimentary system found in timber houses makes it extremely difficult to regulate the temperature and the relative humidity of the atmosphere inside the building with the same ease and efficiency that can be achieved by correct manipulation of the roof and side windows, with which a properly designed steel-section house is usually well provided.

In the mixed steel and timber houses the steel can either be used for the trusses of the roof or else covered in plastic and made into light frames which are fixed to the wooden structure. The plastic sheeting can then be applied both quickly and effectively.

One special instance of an industrial hot-house which can only be made in steel is the "tunnel" which is already popular in France and is now being used in this country also. This is a house covered only in plastic sheeting, with a semi-circular cross-section. Its supporting beams are made up of light interchangeable sections which can be partly raised to ventilate the house.

Finally for general purpose houses—that is, ones adapted for all possible agricultural uses (cultivation in soil or on benches, seed-raising, forcing, etc.)—steel is the only suitable material which can meet the particular requirements of this kind of hot-house.

Semi-forcing equipment

Here again there are considerable opportunities for steel. Of the so-called tunnels, in fact the most stable and therefore the most efficient, are those constructed by stretching the flexible sheeting over special metallic arches. Compared with other kinds of supports these have the advantage of being easily and solidly fixed in the ground; they do not warp and last for a considerable period of time. The plastic sheeting can also be applied much tighter, which has several advantages, including the fact that the covering can be lifted and replaced, when climatic conditions require, more easily and with the minimum loss of time.

Another semi-forcing device where steel could find some uses is the Dutch Light. The covering can conveniently be made of metal frames glazed with transparent rigid or flexible plastic material. Here it is best to use light sections because these frames have to be moved entirely by hand.

Since the structure of a metal house requires a minimum quantity of section steel of from 5-9 kg per sq.m. if plastic sheeting is being used and a maximum of 12-18 kg. per sq.m. for a glazed house, the total amount of steel used in this sector of agriculture in Italy in 1964, for houses only, can be estimated at around 70,000 tons; to this can be added any quantities used in various means of semi-forcing. But the further notable expansion which has since occurred in covered crops in this country, makes it quite reasonable to put this total figure in the region of 100,000 tons.

Considering how few metal hot-houses there are in Italy at present, there is every indication of considerable room for expansion in the use of steel in the covered market gardening sector in Italy. It is to be hoped that this expansion—which is now backed by a flourishing industrial boom—can get under way as quickly as possible so that the resulting benefit can be transferred as soon as possible to the agricultural economy of the country and of the Common Market to which it belongs.

Dott. Pasquale SCIARRETTA

Ufficio studi Comansider s.p.a.
Roma

The Use of Steel Frames with Glass or Plastic Coverings, in the Economic Development of Hothouse and Shelter Cultivation

(Translated from Italian)

The steady general improvement in the standard of living (and consequently in food), a more discriminating taste and the greater purchasing power of more and more people, are producing a growing demand for fruit and vegetables out of season.
In face of this demand, which exists everywhere in Western Europe, Italy, and more especially the southern coastal areas and the islands, enjoys the advantages of ideal climatic conditions and of a highly skilled labour force with long experience in the cultivation of fruit and vegetables. These favourable conditions ensure a high degree of success for the hothouse cultivation of early and late crops of excellent quality at prices which are competitive by general European standards.
Obviously, however, to obtain satisfactory technical and financial results it is essential to have suitable growing facilities. There is no doubt that hothouses built with steel frames are the best buildings for the purpose and answer the numerous and varied requirements of the industry.
As far as the framework of the building is concerned, it is now accepted that the use of modern galvanized cold-rolled sections, made from strip, has solved the main problems of design.
The most important developments have been in connection with
— cold-rolled sections with fittings for the glass;
— protection of the metal from corrosion.
For some years, the use of cold-rolled sections for hothouses has been noticeably increasing. On a weight basis, their use per hothouse has increased from about 30% in 1957 to over 75% today in some types.
In steel-framed buildings where cold-rolled sections made from galvanized strip are used, the percentage use decreases sharply as the internal span of the building increases. Thus as against an average of 80% cold-rolled and 20% hot-rolled sections in shelters with a span up to about 8-10 m., we get an average of 40% cold-rolled sections in shelters with a span of 20 metres or more.
Then again, cold-rolled sections are also widely used in hothouses for the framework of pillars, doorways and longitudinal connecting members, and in many cases predominate in the structure and are used for the glass fittings.
The following are some of the advantages which cold-rolled sections offer as compared with hot-rolled sections:
— a lighter structure as a whole;
— greater elasticity and resistance to overloading;
— greater strength, due in part to the use of high-grade material;
— possibility of using special sections in the design which are accurately made and economical to assemble;
— ability to give such sections a full protection such as galvanizing, at a lower cost than hot-rolled sections. The former can be made from galvanized sheet or strip, whereas to protect hot-rolled sections they have to be dipped in a zinc bath after the other manufacturing processes have been carried out.
Steel-framed hothouses are best covered with sheets of glass which provide translucent material with superior properties of transparence and air-sealing.
Very large dimensions are possible, with spans of 20 metres or more. Suitably designed to resist wind and external pressure, these structures give an absolute assurance of great strength and very long life. These characteristics also contribute to the reduction of the cost of maintenance.
A further advantage of hot-houses built of steel and glass is the reduced obstruction of the interior by structural members *(Fig. 1)*. This results in better lighting (the total area occupied by such opaque material

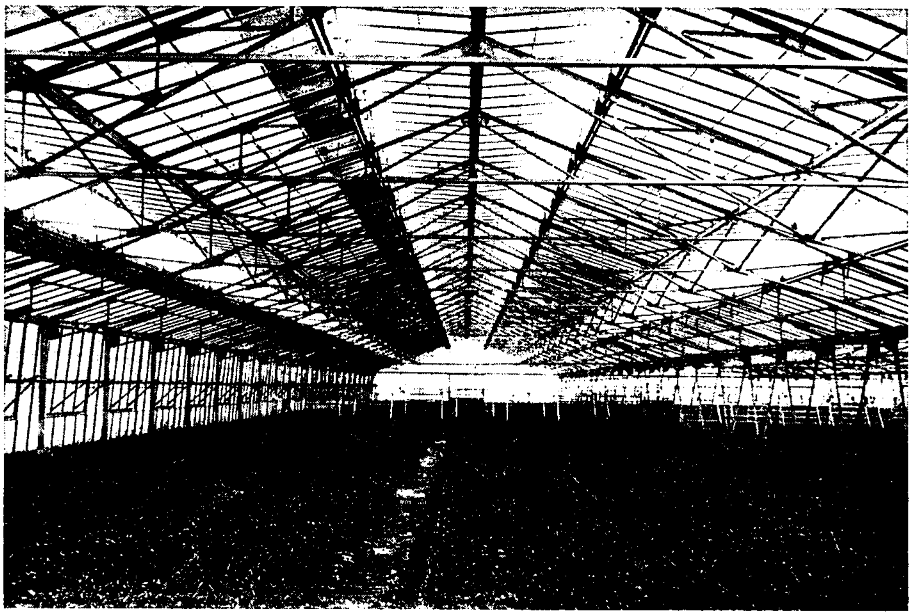


Fig. 1

is barely 10 to 11%) and in making it possible to bring in machines for mechanizing the various cultivation operations.

Efficiently-designed hothouses are, as already mentioned, excellently sealed; this increases the hot atmosphere, and results in lower heating costs and faster ripening of the produce. At the same time, the ventilation is good because the amount of surface that can be opened (with special operating devices) is up to 50-60% of the total surface area.

To sum up: steel-framed hothouses with glass covering ensure the greatest productivity and are the most suitable modern buildings for successful hothouse cultivation.

However, in my country, in addition to true hothouse cultivation we use methods which are half-way between, or rather a stage of development between, outdoor cultivation and hothouse cultivation. Such are the many temporary and partial protective measures used for some outdoor crops during a greater or lesser period of their growth. This type of protection was given a considerable fillip by the development of reasonably inexpensive types of thin plastic film, which are now being more and more used.

The advance which this represents is being very much favoured by the efficient steel structures of today. It would not be too much to say that the increasing success of cultivation under plastics is really due to the manifold advantages of steel structures. To understand more clearly the changes that are taking place, it should be remembered that the first structures—and indeed most of those in existence today—had timber frames. These buildings, which are cheap but by modern standards amateurish, have faults and disadvantages such as the high degree of internal obstruction due to the number of supporting posts—resulting in poorer lighting, and impracticability of employing mechanical means for the cultivation operations—high maintenance costs (about 20 to 25% of the annual cost of running the installation), low resistance to wind and accidental overloading, greater susceptibility of wooden parts to animal and vegetable pests, poorer sealing (a characteristic which is particularly disadvantageous when the building is heated), and finally, the inevitable warping of the timber.

A further serious defect of timber-framed structures is the impossibility of attaching the plastic without using nails or screws which result in damage to the plastic covering by the wind. In contrast with the limited efficiency and the disadvantages of timber-framed structures (the cheapness of which is illusory in view of the heavy maintenance costs), it is now possible, as we have said, to use plastic-covered metal structures which are light, strong, and have a practically unlimited life and are therefore genuinely economical as well as being practical *(Fig. 2)*. For such structures, as with hothouses, the use of modern cold-rolled galvanized sections made from strip has enabled fundamental design problems to be solved.

Another advantage which the use of steel offers as compared with timber is the decreased internal obstruction

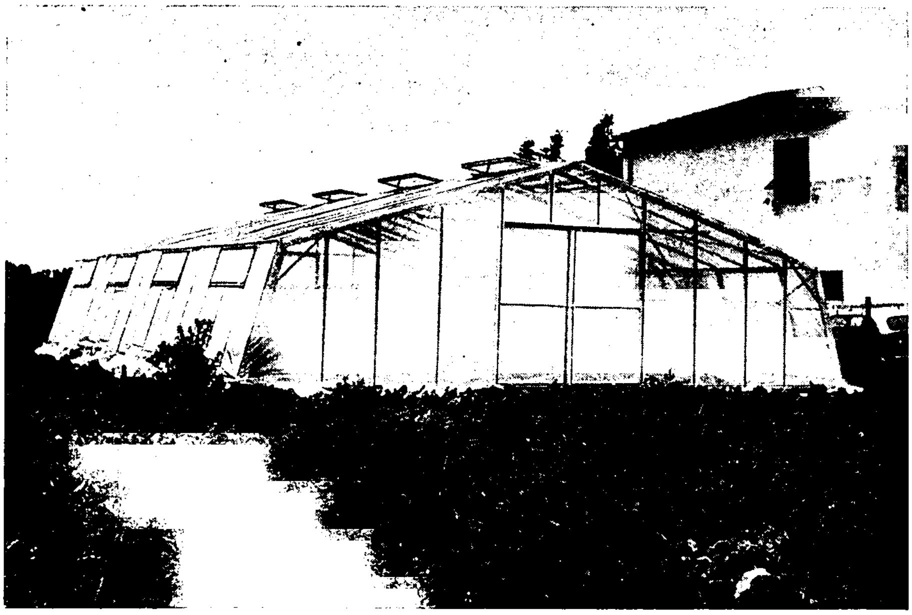


Fig. 2

(as already mentioned in the case of hothouses of glass and steel construction). At the same time, the metal structure ensures better sealing.
Steel structures can also be easily shifted to another position, which solves the problem of the soil becoming worked out through repeated growing of the same type of crop, lessens the danger of accumulations of toxic substances in the soil due to repeated treatment with pesticides, and eliminates infestation of the plants by pests and thus reduces the need for such treatment. Furthermore, the stronger structures of this type,

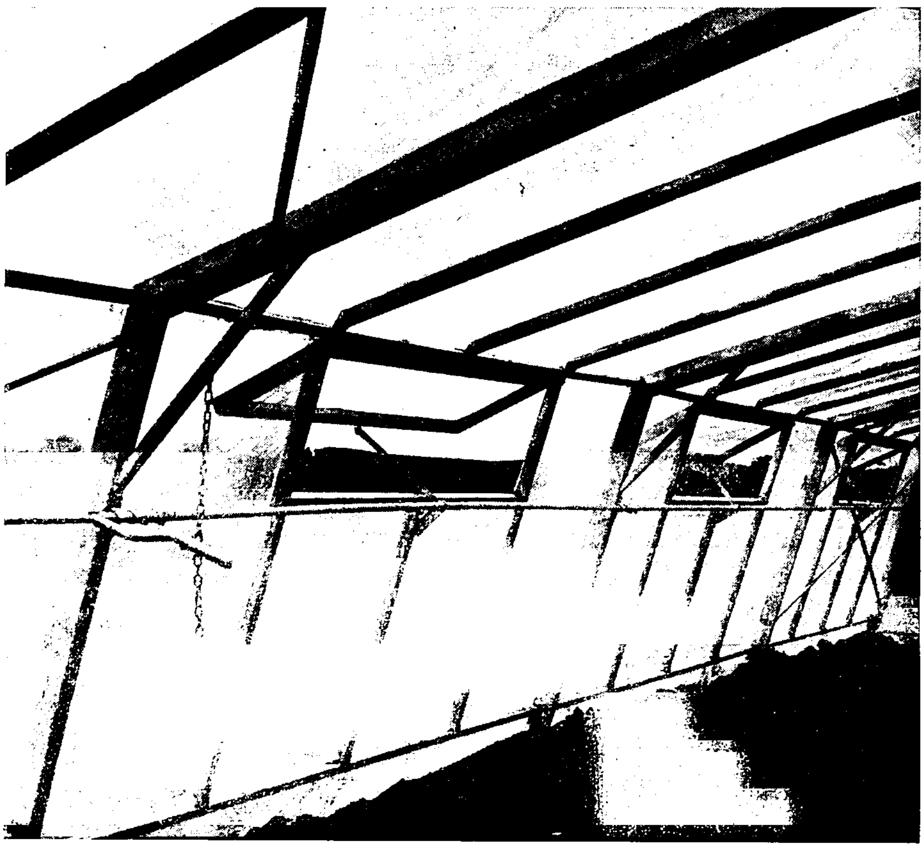


Fig. 3

now being made for covering with flexible plastic, can, if necessary, be easily modified for use with rigid plastic laminates.

As regards cost, it should be pointed out that development in design techniques (resulting in a reduction in the weight of steel frames without loss of strength) has permitted significant reductions in the prices of these new types of structure.

When the size and value of the crops that can be produced with these buildings is considered, it will be seen that their cost is favourable and that rapid amortization can be achieved.

Thus, by using the latest types of metal structures, the following practical and very important advantages are obtained:

— the plastic film can be stretched as required more easily and efficiently, and can be replaced, wholly or in part, much more readily;
— No special devices (such as reinforced edges and the like) are required in the fixing of the material to a steel structure, so that any type of plastic can be used, and tearing and other damage is avoided; *(Fig. 3)*
— the film touches the frame at all points.

In conclusion, it should be emphasized that hothouse cultivation requires very special know-how. To get technical and financial results it is therefore necessary to specialize.

The partial-protection techniques mentioned earlier can afford a valuable contribution to the training of anyone wishing to go in for hothouse cultivation. They are a step towards cultivation in efficiently-equipped hothouses, that is, in glass-covered steel-frame buildings.

Methods of protection consisting of steel structures covered with plastic constitute therefore an incentive to, and a means of training for, top-efficiency hothouse cultivation in steel and glass buildings, which offer the best opportunities and ensure the best results.

Dott. Domizio CAVAZZA

Ufficio technico Comansider s.p.a.
Roma

The Use of Wind-breaks

(Translated from Italian)

In coastal areas it is often necessary to protect crops from wind damage. In general this is achieved by a series of shelterbelts composed mainly of evergreens. But in the case of more delicate crops like citrus fruit and many flower crops, solid wind-breaks are more often used. These are usually made from trelliswork; the most familiar type of this is the one used in the orange-growing area of the Sorrento peninsula.

Of course there are many different types according to the area and the intensity of cropping, and it is always difficult to give an overall solution. Another difficulty common to all wind-break systems is the problem of establishing them in the first place, especially in shelter-belts directly next to the sea, where, in addition to the action of the wind there is the caustic effect of the salt sea-air, which only a very few plants, such as the tamerisk (tamerix gallica), can withstand.

The use of an artificial wind-barrier is therefore indispensable, especially in the belt nearest to the sea, and also in succeeding belts, where efficient protection is required with the minimum of shade and the minimum use of ground.

We do not consider that artificial wind-breaks can completely do away with natural wind-breaks, but they are a valuable auxiliary measure for the most exposed areas and for the more delicate crops.

The main requirements are as follows:
— costs should be reasonable and lower than those of modern trellis-work.
— they should last longer.
— the materials should be able to be salvaged.
— they should be stronger and more efficient.
— it should be possible to regulate their effect as needed.

Having carefully examined all the various solutions possible, we concentrated on a type of wind-break made from galvanized steel posts between which steel wires are stretched supporting a net of plastic material with a convenient sized mesh *(Fig. 1)*.

The essential constructional elements can be seen from the attached diagram *(fig. 2)*: the posts and wires of steel; the prefabricated concrete foundation; the supporting wires anchored by helicoidal screw stakes like those currently used in vineyards.

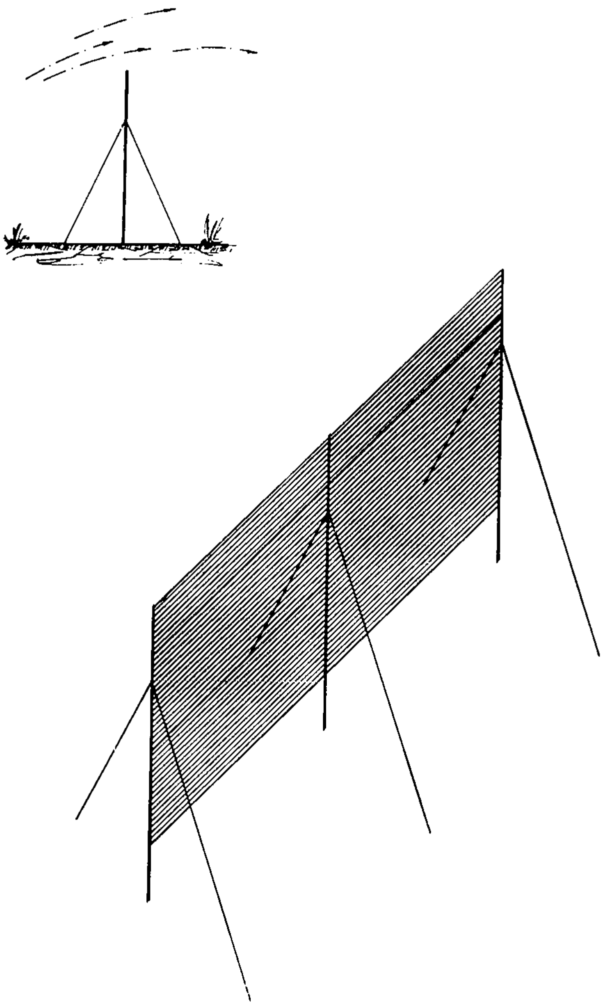


Fig. 1

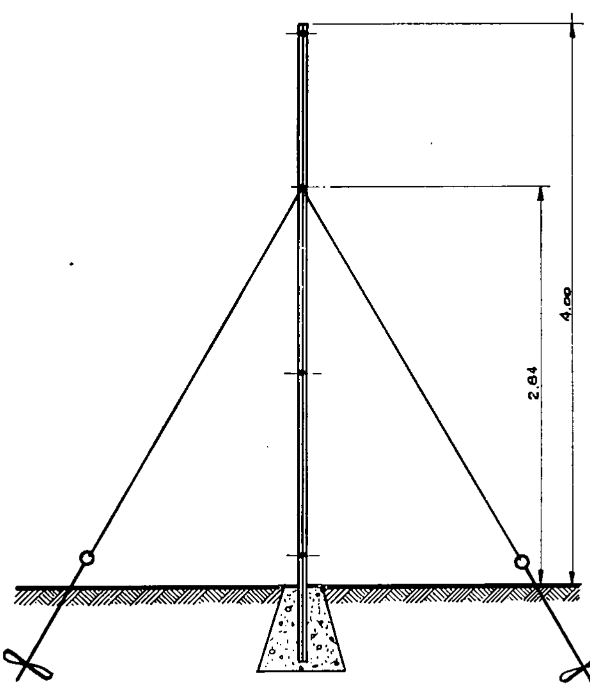


Fig. 2

An essential characteristic of the wind-break is that light and air should be allowed to pass through while reducing the kinetic energy of the wind to a comfortable percentage, not over 50%.

It is obvious that a completely impermeable barrier, such as a wall, appears at first sight highly efficient, but in reality it protects only a relatively small area. The wind hitting the wall creates a vacuum on the other side and this draws the air currents from above downwards and so at a distance of 1.5 to 2 times the height of the wall the protection is practically nil.

On the other hand, a barrier with 50% impermeability causes only a fairly slight down-draught and so the area efficiently protected extends to at least 5-6 times the height of the barrier.

The action of the wind-break should be to cut down the effect of strong winds to a level where they cannot harm crops, without interfering with the circulation of air vital to the life of the plants.

Scale of the problem

Although wind-breaks made from plastic nettings and steel posts cost rather less than the traditional trellissed type, it is obvious that the high cost per hectare protected can only be justifiable in the case of highly valuable crops such as flowers and fruit.
Furthermore, Italy alone has a coastline of more than 3,000 km. and so there are a great many areas in which this problem is acutely felt. At a conservative estimate the area of Italy affected by this problem is at least 200,000 hectares.
If we then look at the Mediterranean basin as a whole, which has largely similar weather conditions, we can see what an enormous problem it is; a problem, too, requiring careful study, because the value of the work to be done deserves highly accurate study and research.

Specifications and Estimates

The wind-break must be constructed on the basis of carefully-prepared calculations if it is to be capable of resisting unexpectedly strong winds.
With reasonable caution, our prototypes have been based on a 120 km./p.h. wind and therefore for a dynamic thrust of

$$T = \frac{V^2}{16} = \frac{33.3^2}{16} \approx 70 \text{ kg. per sq.m.}$$

Given a permeability of 50% of the kinetic energy, the real thrust can be taken as 35 kg. per sq. m., this is the primary calculation factor.
The protective barrier can be taken to be effective for a distance equal to six times its own height. Between two successive barriers the effectiveness can be taken at 8 times the height because of the "lift" effect on the current of air due to pressure on the frontal face of the wind-breaks.
Assuming that in general wind direction varies but wind strength does not, the barriers should face (perpendicularly) into the prevailing wind and be sub-divided by other sections at right angles at distances three to four times that between the first.
In our early attempts it was thought that the cost of the barriers would be substantially reduced by raising the barrier to a considerable height, and the intention was also to use posts curving in the direction of the prevailing wind. This solution only holds good if the wind comes from a constant direction, but in coastal areas as often as not the wind reverses direction (land and sea breezes), so that the curved shape no longer makes any difference.
For our current experiments we are using rectilinear posts erected vertically, and to make the structure more economical we have chosen a double vineyard stake with a maximum height of 4.5 metres above ground guyed on both sides at a height at which lateral movement is reduced to a minimum.
With these specifications the wind-break should not cost more than Lire 500-600 per sq. m. This works out at around Lire 600,000 to 750,000 per hectare protected. These figures relate to prototypes and so would be considerably lower for mass-produced types.
This enables us to say that the cost per hectare of an artificial barrier is about half or one-third that of the traditional trellissed wind-break, with the additional advantages of greater and more accurately calculated physical strength, and the possibility of salvaging most of the material used.
This factor is particularly relevant to artificial barriers intended to protect the early growth of natural wind-breaks in coastal areas immediately next to the sea.
After three or four years, when the natural wind-break has become sufficiently strong, the artificial barrier can be removed and transferred to another area where protection is required.

Joachim LOUIS

Technischer Direktor Mannesmann-Landtechnik GmbH
Düsseldorf-Gerresheim

Sprinkler Irrigation

(Translated from German)

The use of irrigation

In the dry areas of the world, an adequate supply of water is a prerequisite for any intensive cultivation of plants; but even in those areas of Europe with a high precipitation, an organized water supply is still essential to economic cropping particularly at specific times in the vegetative period. Modern agriculture can no longer afford crop losses caused by temporary lack of water.
The development of irrigation has already progressed considerably. Systems of ditches were originally used, from which water was distributed over the fields. Today more and more use is being made of sprinkler irrigation, which is the nearest thing to natural rainfall. By the use of modern sprinklers the quantity of water supplied can be precisely adjusted to the needs of the plant. It is also significant that these use about 40 per cent less water than the original systems of ditches and irrigation channels. This saving of water is largely the result of much smaller losses from evaporation during transportation to the plant and complete absence of losses by seepage from earth ditches. Furthermore, the intensity of irrigation can be so exactly regulated that only so much water need be supplied as the ground is capable of retaining. All these advantages are the practical results of the use of piped systems.
The basic uses of irrigation are as follows:

—To supply additional moisture to the soil

In these cases the principal object is to make up for any deficiencies in rainfall and to ensure steady yields and efficient management.
This is particularly applicable to lighter soils not capable of holding very much water.

—To prevent dehydration

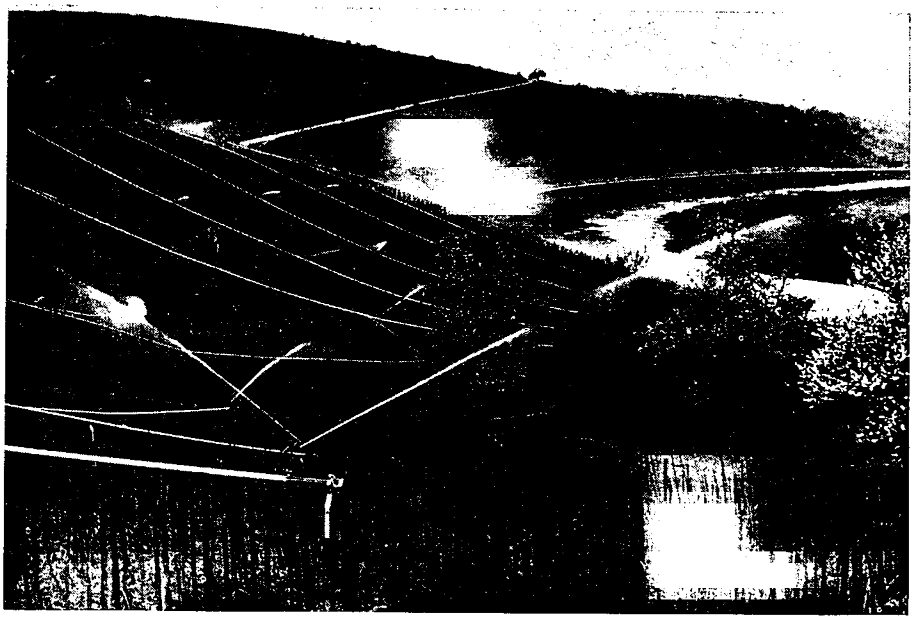
The use of sprinkler irrigation to cope with drought takes the form of extra watering, as and where necessary; in Europe this is done mostly only in very exceptional weather.

—For protection against frost

High-value specialist crops such as wine *(Fig. 1)*, tobacco, fruit, hops and vegetables can suffer considerable damage from late frosts in the spring or early frosts in the autumn. If these crops are sprayed during the period of frost, they receive solidification heat as the water freezes, which is particularly valuable in protecting young shoots from frost.

—For purposes of pest control

In recent years sprinklers have been increasingly used for spraying pesticides on to fruit-trees and vines. The pesticides are introduced into the pipe system by injectors and sprayed on with the irrigation water.



—To obtain colour

Sprinkling is also employed to touch up the colour of growing fruit, as an additional means of making it particularly attractive for market. In practice it is only economic to do this where the sprinklers are already installed.

—To apply fertilizers

Like pesticides fertilizers can now be applied by spraying. Those used are soluble fertilizers which are also suitable for top dressings. Other products sprayed for this purpose include semi-liquid manure and ordinary town sewage.

Sprinkler systems

The available sources of water and the requirements of the crop condition the extent and performance of sprinkler system. Systems should be planned and laid out in conformity with these requirements and in accordance with the prevailing weather.
Basically, a sprinkler system consists of a pump unit, pipes, with the necessary angles and connectors, sprays with their attachments and stand pipes.
Depending on the prevailing conditions, pumps can be driven by electric, diesel or petrol motors. The pump units can be fixed or mobile. For smaller installations tractor-driven pumps can be used.
The pipework consists basically of so-called quick-release coupling pipes. The lap or butt welded strip-steel pipes have a wall thickness of between 0.8 and 1.5 mm. and a diameter of between 50 and 218 mm., and for rapid connection are supplied with snap or lever couplings. These pipes are generally hot-dip-galvanized. In addition there are standard-shaped units such as T-pieces, bends, pipe carriers, etc. It is thus possible to construct a pipe layout with quick-release couplings to meet all requirements of the lie of the land and the quantity of water.
If a permanent pipe system is required in larger installations, bitumized steel pipes are used with appropriate hydrant outlets. Recently, plastics have been increasingly used for permanent pipe layouts. The various requirements of individual crops and sites can be met by the use of appropriate sprays. Types available include low-volume sprays, with nozzle sizes of 3-7 mm., medium-volume sprays with nozzle sizes of

8-12 mm., and heavy-duty sprays with nozzle sizes of 14-18 mm. According to the type of crop, these can be mounted on stand pipes or on high stands of up to 4 metres.

Sprinklers may also be mobile, semi-mobile or permanent.

The following are the approximate quantities of pipes required per hectare:

- fully mobile installations, approx. 40 to 50 metres per hectare
- semi-mobile installations, approx. 60 to 70 metres per hectare
- permanent installations, approx. 450 to 500 metres per hectare

Sprinkling has the greatest economic effect when it is used for crops with a high market value such as fruit vegetables, sugar beet, early potatoes, rich forage maize and garden plants. Sprinkling of cereals is not very helpful in Europe.

Maurice PIGNEDE
Ingénieur

Directeur de la Société Lorba
Maisons-Laffitte

The Development of Spray-irrigation Techniques; Permanent Grids

(Translated from French)

Over the last fifteen years, in Europe and especially in France, a technique formerly only used in kitchen- and flower-gardens has been worked up for agricultural use. This is spray irrigation, employed to make good any seasonal rainfall shortage.

The practice has developed rapidly (and to a large extent parallel with the expansion in maize-growing), but still has a long way to go.

Its popularity with farmers can mainly be attributed to

- the many ways in which it is better than other irrigation methods, more especially in that
  - it is suitable for most types of land, irrespective of the topographical features of the terrain, the shape of the plots and the physical and chemical composition of the soil,
  - the amount of water used is controlled, and savings can thus be made, quite apart from the elimination of erosion and "washing-away,"
  - the fine spray produced, in its delivery from the apparatus to the ground, absorbs oxygen which serves to aerate the soil,
  - the equipment used can be handled by unskilled labour, which is the type most often available to farmers;
- the continual improvements being made
  - to pipes and methods of assembly,
  - to sprinklers, in order to ensure more even spraying rates and working pressures.

Piping

In order to meet farmers' requirements, a variety of types of piping had to be offered. A number of these, mostly large-diameter pipes placed underground in large installations, posed no particular problems: it was really only a matter of getting water from one place to another. When demand began to grow for semi-permanent or even mobile systems, however, the industry was compelled to provide new types of pipes and connections.

—Movable pipes

Until quite recently, farmers mainly wanted light, easily-moved and corrosion-resistant pipes that would at the same time be cheap. The point of their being light was to enable them to be moved one, two or three times a day on the same plot of ground or to another plot. Standard bores were 50, 70, 89, 108, and, less frequently, 133 and 159 mm.

The first people to tackle this problem successfully were the steel-tube manufacturers. Thanks to advanced production methods, particularly in welding, it soon became possible to produce tubes of 0.8 and even 0.7 mm. wall thickness on an industrial scale. After the couplings were welded on, there followed the difficult task of hot-dip galvanization.

Further technical developments, such as the Schoop metalspraying process (protection by a special zinc paint applied by spray-gun), have made it possible to produce some pipes by a continuous process, using galvanized strip. Couplings are attached by a new adhesive bonding process.

At the same time as steel tubes appeared on the market, aluminium ones became available: these could be seamless (extruded) or welded, and were soon followed by both flexible and rigid plastic tubing.

In this way there has grown up a healthy and proper spirit of competition between the various materials which has benefited not only the farmers, but also the consumer, as a result, basically, of steadily increasing operating efficiency.

—Fixed pipes

In industrialized regions such as Western Europe, labour is inevitably moving from farm to town in pursuit of jobs in industry (in France at the rate of 100,000 people a year), and the shortage of labour resulting from this flight from the land has led in turn to a demand for fixed installations to replace the movable ones. The trend so often seen in industry in countries with a high standard of living—increasing capital- and diminishing labour-intensiveness—is developing more and more in agriculture also.

In high-yield areas such as Beauce, farmers are preferring to spend three times as much per hectare (about FF 3,000 instead of FF 1,000) and start the season with a permanent network of smallbore pipes (about 30 mm.) covering the whole area to be irrigated. As we shall see later on, the tube-makers have succeeded here in meeting these new requirements with a whole new range of products.

As far as arbor culturalists are concerned, the solution is sometimes even more fundamental, namely a fixed grid, buried or mounted on standards above the trees, costing anything from FF 6,000 to FF 10,000 per hectare.

This brief outline shows that the designers and tubemakers, whether dealing with fixed or movable, buried or surface installations, are having to adapt their methods to suit an ever-changing situation.

Couplings

—Victaulic type mounting

A special type of coupling is useful for the semi-permanent type of system, which in theory should only need to be moved once a year: in general, the pipes are fairly large, usually between 100 and 300 mm.

This coupling makes a perfect seal against either suction or pressure. The seal is achieved by fixing rims and gripping collars to the ends of the pipes: the collars protect the joints, prevent deformation, and locate and retain the pipes.

—Swivel-joint mounting

This is one of the finest examples of instant-seal, spherical-type assemblies, which were designed for farmers, but are now also used in civil engineering, mining, etc. (for water, compressed air, hydrocarbons, etc.).

The coupling is absolutely secure, again perfectly sealed, but allowing 30° movement in all directions. The seal is ensured by an encased annular joint, which is used to attach the collars of the swivel assemblies to either end of the pipes.

—A sturdier type of assembly

While the swivel joint is almost foolproof, its cost is comparatively high, and so recently there has appeared another range of mountings, the socket type, which costs less, but which is only sealed against pressure. The seal here consists of a flange joint, which gives 20° of angular movement.

Permanent grids

As I mentioned, irrigation methods have been changing rapidly in recent years.
The permanent-grid system represents the latest stage in this development, combining savings in labour with high-efficiency spraying.
With this system, a rectangular pattern of small-bore tubes is laid down at the beginning of each season, and is not taken up again until the season ends. All the piping is fixed, and only the sprinklers themselves are moved from one place to another, an obvious saving in labour.
In addition the system offers the following advantages:
— it can be fully tailored to irregular plots;
— the main delivery pipes can be smaller in diameter, as the flow rate is on a diminishing scale, again with resulting reductions in costs;
— a much less powerful pumping station is required (usually 12 to 15% less for the same sprinkler output);
— the T valves which connect the permanent grid with the water mains enable pressures to be regulated in the permanent grid itself, thus giving a more even rate of spraying, and make it possible to use much longer grids, of up to 700 metres in length.
In brief, the layout comprises
— a pumping station;
— a distribution network, fixed or semi-fixed according to the nature of the ground;
— a rectangular pattern of pipes, usually of plastic or aluminium of about 30 mm. diameter, with either one or two movable sprinklers per pipe;
— sprinklers mounted on tripods which are connected with the permanent grid by a T-shaped cock fitted with a non-return valve.
In conclusion, we may safely say that the tube and pipe industries will have much to contribute to the solution of what is undoubtedly one of the greatest problems of this century; how to feed a world population of 6,000 million in the year 2000, compared with 2,000 million in 1900.

Dott. Domizio CAVAZZA

Ufficio tecnico Comansider s.p.a.
Roma

The Use of Steel in Irrigation

(Translated from Italian)

In the last few decades there has been an increasing tendency to change from traditional irrigation using open channels to newer systems in which water is distributed and piped in under pressure.

The underlying reasons for this development are partly technical but mainly economic, especially because of the need to reduce agricultural manpower. Some operations like levelling are now possible at fairly low cost thanks to new earth-moving machinery. But these installations need constant upkeep, using manual labour, and for this reason they are considered too much of a liability.

It can be seen, then, that developed areas looking for new irrigation methods tend to go for the system of distribution using sprinklers which requires far less regulation than other systems.

Between 1946 and 1954 the area irrigated by sprinklers in the USA increased 12 times to over 3 million acres. In Israel 90% of the 250,000 acres of irrigated land are served by sprinkler systems.

The sprinkler irrigated area of Italy has at least doubled in the last ten years and has now reached 500,000 hectares at least.

In the competitive battle between channels and pipes the tide is turning very much in favour of the latter, which are now being produced in larger and larger dimensions and with much advanced technical specifications.

The economics of irrigation require costs to be kept within strict limits.

So the use of steel piping is limited by other types of tubular products, which, at the moment, are proving more attractive in certain sizes and for certain soil conditions.

Where steel has made a decisive break-through is in the construction of the mobile branches.

In fact in this field it has taken over completely in Europe. In Italy, although other competing materials do occupy a marginal position their significance is absolutely minimal.

In the USA, for reasons of weight, a light-alloy tubing is mainly used for the mobile branches. However, steel is beginning to make considerable ground in cases where the equipment is hauled by mechanical transport, which causes considerable wear in the materials used.

Current production of mobile branches in Italy can be put at around 4 million metres a year, weighing around 10,000 metric tons.

Due to improvements in the quality of cold-strip steel there is a general tendency towards making thinner piping and thereby reducing the weight.

Fixed Pipes

At the moment, however, steel does not rank very high in the construction of fixed pipes.

Here the question of costs is more critical and the use of steel is generally limited to certain conditions: high pressures, mountainous terrain, subsiding land, etc.

Another notable field of application is in frost protection equipment which requires very small-bore pipes with comparatively high pressures. Here steel has long been the most popular material.

Large Diameter Pipes

The greatest possibilities for steel lie in the large diameter sector.

If we look at the trend of comparative costs for steel pipes and asbestos cement pipes, it transpires that, at a certain point, the price levels meet and after that steel costs less than the cement fibre pipe.

We can also see how a similar trend in prices existed a few years ago if we compare unwelded steel piping with asbestos cement class C piping. Recent production of welded piping allows a considerable reduction in the thickness and the number of pieces which cuts down both the diameter and the cost at the same time. Under present market conditions we can safely say that the minimum level for carrying out a feasible economic appraisal is from a diameter of 400 mm. upwards.

In this sector there are ample opportunities for steel because of the future development of irrigation should occur mainly in the big co-operative holdings in which the channel system has mainly been used up to now.

Problems to be faced

There are undoubtedly ample opportunities for steel in irrigation but the general public and many technologists have not yet grasped certain basic principles, which show its real field of application.

First of all there are the psychological problems arising from the widespread tradition that steel is almost a precious metal, to be used only for special applications, where cost is not a prime consideration.
In fact however, the enormous progress made by our national steel industry has made it possible to put a material with excellent physical qualities on the market at an increasingly competitive price compared with other available materials.
So in many cases an acurate economic appraisal is enough to show the superiority of steel.
Another psychological problem which must be overcome is the prejudice which has existed for years against the use of welded pipe.
It is quite true that at one time there were fundamental differences between these two materials and even today in certain cases the only suitable material is the highly-reputable unwelded steel pipe.
But in reality modern production techniques for welded pipe can reduce, if not eliminate, the difference in quality between these materials. So for less rigorous uses, such as most types of irrigation, the use of welded pipe could even be an advantage.
It is in fact possible to make very thin pipes with high levels of strength and safety.
Therefore it is important to inform the general public of recent progress in this field and demonstrate the various uses of the materials.
Finally, it is essential to draw up and distribute precise standards for assembly, means of protection and defense against corrosion, physical and hydraulic characteristics, in order to give planners a variety of practical answers and so provide the groundwork for devising the solutions to be employed.

Pierre FAUCONNET

Président de la Fédération départementale des agriculteurs
Saint-Hilaire sous Romilly

An experiment in Irrigation of Maize

(Translated from French)

Maize growing in the area concerned

The farm to which I shall be referring is in the portion of the Department of Aube known as the Nogentais, an intermediate district between the chalk region of Champagne and eastern Brie. The soil is clayey and often stony, with a chalky subsoil; the latter is permeable and in a dry spell of any length the crops quickly suffer.
Maize growing has been taken up in the area on an increasing scale in the last dozen years or so—over 1000 hectares are now devoted to it, as against only about 20 in 1952—but a restricting factor is the very considerable difference in yield from one year to another. For the 200 or so hectares under maize which are farmed by members of our Farm Management Centre, we have recorded annual averages ranging from 14 quintals per hectare in 1959 to 56 in 1963. A study of the rainfall figures over ten years shows that in only two of those years was the water level about adequate, while in four there were passing shortages harmful to the crop, and in the remaining four the total water shortfall was 150-200 mm. or more.
Maize absolutely must have sufficient water at certain stages of its growth, usually, in this part of the world in July. And, obviously, if it receives adequate supplies from the start of its growth and during the crucial period following florescence, these supplies will have to be maintained.
Generally speaking, then, the potential maize yield can be put at 60 quintals a hectare, thanks to the technological improvements of the last few years (French hybrid strains and chemical weedkillers), but the

average long-term yield is barely 40 quintals. One of the most serious implications of this state of affairs is that the farmer cannot really afford to turn over much of his acreage to maize without the risk of badly unbalancing his finances, since he cannot know at the start whether the crop will show a profit or a substantial loss.

Position of the farm studied

This was a particular problem in the case of the farm with which we are concerned, which is a single continuous block of 150 hectares, with no livestock. The soil is too stony to grow sugar beet; rape cannot be used on as large a scale as the first crop because of its uncertainty and the difficulty of keeping the ground clean, while such crops as sunflowers, poppies or linseed are too chancy altogether. In view of the risks attached to maize, the farmer used until the last year or two to grow only 20-25 hectares of it, whereas in fact the first crop should always cover 50-60 hectares at least, and if possible more, in order to have a large enough break for wheat.

However, irrigation has enabled the maize crop to be extended to cover 40 hectares in 1965, 50 in 1966, and no doubt more in later years. The crop rotation is thus nicely balanced between maize, a moderate acreage of rape and a large break of wheat (quite a worthwhile crop on this soil), with little in the way of minor cereals such as spring or winter barley, which never yield much in these parts. The advantages of such an arrangement, comprising only a few crops and keeping the risks to these to a minimum, are obvious.

The farm employs three skilled hands. It is in the neighbourhood of a small industrial town, so that labour is both scarce and costly throughout the area. The production system I have described requires three men to 150 hectares, but inevitably there is not much time for moving the pipes every day at harvest time, which is exactly when irrigation is required; consequently there can be no question of going over on any scale to an unduly time-consuming system of moving the main grid, which is in any case a heavy job.

The farm is situated on the slope and plateau overlooking the Seine valley. At the bottom end of the property, in the valley, there is a six-metre well by which ample water can be brought up from the phreatic sheet of the river.

The installation

Tests conducted during the 1964 season with the aid of the steel tube manufacturers' federation produced the following findings. Firstly, the practice of irrigating the maize was clearly a paying proposition, since for 1964 the yield of the irrigated maize was 67 quintals a hectare as compared with only 45 for the unirrigated (incidentally, some local thunderstorms caused the maize here to flourish very much better than anywhere else in the area, where the average yield was barely 30 quintals a hectare, and in some localities only 12).

On the other hand, the daily movement of the pipes took six man-hours per hectare, plus 20 man-hours for a move from one field to another, even though a space two rows wide was left unplanted every 24 metres for a tractor and trailer to pass through—a substantial loss in yield of 5-6%. In all, then, eight hours per hectare per watering operation, amounting to 320 hours for the full 40 hectares. It is practically impossible to spare 320 man-hours from the time of the available personnel during this particular fortnight.

The following year, as a basis for deciding whether to go ahead, the very latest irrigation techniques were used in order to reduce the time spent in moving the apparatus to a minimum. The principle of total coverage, by 30 mm. pipes connected direct to the main supply pipe, was retained, although this meant installing tertiary grids up to 750 metres in length in some fields.

Capital expenditure

For an acreage of 40 hectares, this represents a capital expenditure of FF 2,700 per hectare more than the gross yearly proceeds of the crop. Given the length of the main supply pipes (which are of steel, with 133 mm. diameter) and the pressure required for a steel change level of 60 metres, the cost per hectare for 60 hectares would work out rather lower, at F 2,400 per hectare. According to the initial estimate the motor-pump unit and the main conduit would account for 40% of the total.

The most economical of the simpler arrangements, with no permanent basic grid and hence involving shifting the grid twice a day, would cost FF 1,600 per hectare (over 40 hectares); the intermediate arrangement, with tertiary grids of flexible tubing enabling the secondary grid to be moved only after five applications, would cost FF 1,900 per hectare.

Operation

The apparatus consists of a network of 30 mm. plastic pipes connected direct to the main conduit every 18 metres and installed throughout the summer alongside all the maize to be watered. It has thus to be put in place at the beginning of the season, when the maize is beginning to shoot, and removed in September before harvesting starts. This takes about 200 man-hours in each case, with the aid of a tractor and trailer; the operations raise no particular problem as regards job organization, however, as they can both be phased over a month or so and timed in between work peaks.

Each tertiary grid has an automatic valve every 18 metres, connected to a sprinkler which has to be moved twice in the 24 hours to distribute in all, i.e. 2 1/2 hours per hectare, as compared with the earlier eight. In addition, it is a purely "machine-minding" job, unskilled and requiring no great physical effort.

It should be noted, however, that the sprinkler has to be moved through very wet maize, which necessitates a special appliance, especially as it is preferable to move the sprinkler without turning off the water in order to check for any leaks in the piping.

Operating costs and profitability

The largest item is the repayment of the principal and interest. Redemption is over nine years, and works out at FF 435 per hectare irrigated. The power, at the summer rate of FF 3.27 per kWh at night and FF 5.46 per kWh in the daytime, costs FF 53 per hectare irrigated, including fixed charges. Labour costs are also not high, amounting, inclusive of the cost of tractor and trailer, to FF 69 per hectare irrigated, for two applications in the summer.

In all, then, the cost per hectare irrigated in 1965 was FF 557, given redemption over nine years. FF 557 per hectare is equivalent to 14 quintals per hectare of extra costs; the estimated average gain is at least 20 quintals per hectare.

Conclusion

There is thus a net gain of approximately FF 250 per hectare, or 15% of the average gross proceeds of the unirrigated maize—quite a substantial figure, since it represents a net margin of 10% on the capital invested, a level seldom reached in the agricultural sector.

Then again, the system offers the possibility of a really well balanced organization of production based on a worth-while crop—a boon, therefore, to the farm as a whole—thanks to judicious water control. It is in fact the control of natural processes that forms the basis of modern agriculture, and the object of all present-day techniques.

Lastly, it brings a much-valued element of stability into the farm's finances: as a result it is now possible to make financial and not merely economic estimates well ahead.

Werner OCKER

Heizungsingenieur
Pfungstadt

Heating and Hot Water Installations in Agriculture

(Translated from German)

With every justification, the rural population is claiming a share in rising living standards and in the increasing demand for comfort and easier working conditions. A very real contribution can be made by central heating and hot water installations in the farmhouse, conveniences which are already regarded as indispensable in town houses.

To have only one heating apparatus to look after for the whole house also makes housework easier.

In West Germany at the present moment there are about 1.2 million farms, of which 700,000 are over 5 hectares. At the present time 150,000 farms have a central heating installation and in most cases also a central hot water system. From experience of past years it can be calculated that about 200,000 new installations are added each year.

In addition to a choice of a suitable fuel, careful attention must be paid to the planning and installation of the heating or hot water system in farms, which frequently have widely differing requirements for heat and hot water at various times of day and times of year, in comparison to town houses. Requirements include

— heat for occupied rooms in winter and in the autumn and spring;
— adequate hot water both for the house and for the farm;
— heat for grain drying in summer;
— power or heat for the preparation of the daily meals.

The differences must be recognized and attention must be paid to them when the heating system or the hot water system is being planned.

The choice of a suitable heating system is dependent upon the type of construction of the farm and that of the hot water system on the anticipated requirements for hot water. Differentiation can be based on

— type of heating appliance;
— type of pipework;
— type of radiator.

It should be assumed from the start that the hot water installation will basically be operated in conjunction with the central heating system. The only differentiation here is as between

— hot water storage tanks with or without electric elements;
— other means of heating;
— flow apparatus with or without electric elements;
— compound apparatus with or without electric elements.

Heating Appliance

Apart from differences as to the type of fuel used, two types of appliance are suitable for farms: the boiler proper, usually installed in the cellar, and the stove, which is usually in the kitchen, in the working area and under the control of the housewife. The boiler is ordinarily cast iron or steel; the stove has a built-in back-boiler *(fig. 1 and 2)*.

Where boilers are made from steel individual designs can be adopted and extensive use made of heating know-how while keeping dimensions small.

To illustrate the relationship between numbers of boilers and stoves another quotation may be taken from AID Information of September 1964. In 1963, 19,879 central heating installations were put into farm dwelling houses: of these 64% were stove and 22% boiler systems, the remainder being otherwise organized.

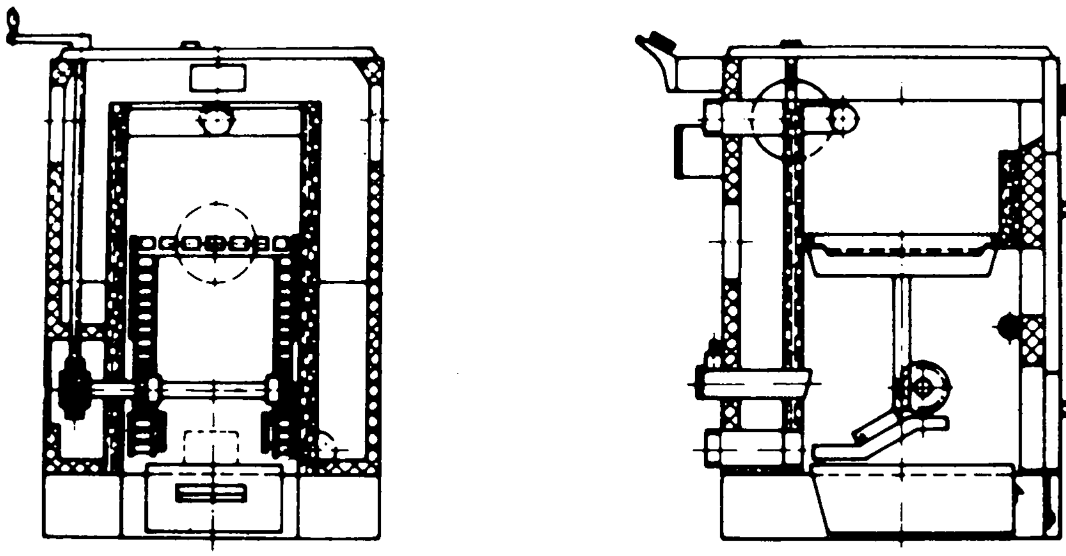


Fig. 1

These figures clearly show that the stove is the most suitable type of heating appliance for a farmhouse. It makes a considerable contribution to the rationalization of farm domestic economy; it is a real multi-purpose appliance and fulfils a variety of necessary functions every day.

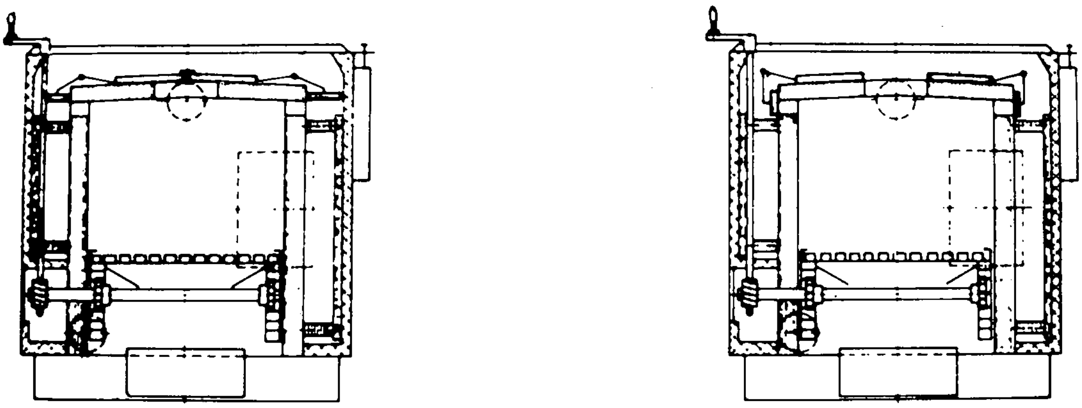


Fig. 2

Thus the large hotplates are suitable for quick cooking, slow cooking and keeping food warm. The built-in steel back-boiler supplies all living rooms and bedrooms, as well as the bath and kitchen, with adequate warmth. Hot water is available whenever it is required from the water heater incorporated in the stove. Further advantages of this appliance are

— automatic temperature control for all types of appliance and all fuels;
— silent and odourless operation with oil and gas burners;
— easy maintenance;
— absence of heat in the cellar;
— no special room required to house the heating appliance;
— high efficiency for lower fuel costs;
— high efficiency for a low initial expenditure.

Pipework

—Bottom Distribution

The flow and return pipes are fitted on the ceiling of the cellar or in the floor. The radiators are attached to risers. This type of pipework is preferred with heating by a boiler.

Disadvantage: The cellar is rendered unsuitable for some kinds of storage, and one potential store-room has to be given up to house the heating installation.

—Top distribution

The flow pipes are fitted on the floor of the loft or in the ceiling of the upper storey and are connected to downcorners. The return pipe is fitted in the floor or in the cellar. This type of pipework is preferred for stoves and back-boilers.
Disadvantage: Losses of heat through the flow pipes in the attic.
Advantage: Cellar remains cool. Instead of both flow and return pipes, only the return pipe is installed in the cellar, carrying water which has been already cooled. In certain circumstances a cellar can be dispensed with' resulting in lower building costs.

—Single-pipe heating

Instead of a flow and return system to which each radiator must be attached, it is now possible to connect each radiator to only one pipe, the so-called ring system. The advantage of this system is that this piping can be of smaller bore than in the flow and return system and is therefore easier and quicker to install. It is impossible to say which of these systems has the best performance and which should be given preference. They have all performed well and as a rule the choice will depend largely on the design of the actual building. One considerable difference between the first two systems and the third is that, in the third, if the circulating pump fails the supply of warmth also fails. But, as against this, the system is particularly suitable for installation in existing houses, since there is no need to pierce the floors and the walls can be pierced with drilling machines. The ring main can of course well be made of steel, as owing to high raw material costs copper piping is often not considered today. A further difficulty with copper is the high degree of longitudinal expansion of copper pipes, caused by the different temperatures of the heating water throughout the system, and this must be taken into account during installation.
The advantage of the circulation pump is common to all systems. Small-bore piping results in a lower content of water in the heating system and thus easier regulation and more economic operation.
The initial cost and maintenance of the circulation pump bear no relation to the advantages which it brings to the heating system, irrespective of the type of pipework used.

Radiators

Cast-iron or steel radiators are commonest. Convectors have not met with much success in Germany and skirting heating is only satisfactory where all the furniture stands on feet. As a rule skirting heating has to be fitted to the internal walls in order to give the necessary amount of heat. The advantage of convectors and skirting heating is the very small water content and thus the improved control of the system. Steel radiators are generally preferred because of their technical qualities and also because of their price.
In more recent times air-conditioners have often been preferred to radiators; in winter they fulfil the function of a radiator in distributing heat, and in the summer they can be used to cool rooms by the use of their cooling equipment. Air conditioners in the rooms most occupied (living and bedrooms) are not so expensive as the air-conditioning of a whole house and meet the wishes of many customers.
Before we can discuss the hot water systems some general introduction is necessary. The appliances which are described below are part and parcel of the heating installation and as such are supplied with heat from the heating appliance. Hot water (from the heating system) warms cold water (from the mains supply). It is thus indirect heating of the mains water.
In some hot water systems additional heating elements are provided (electric immersion heaters or grate-heating appliances) which heat the mains water directly in storage systems and indirectly in flow and compound systems.

Storage hot water appliances

In these types of appliance mains water is present in considerable quantities according to the size of the appliance. The water is heated in a steel container whose inner or outer heating surface is connected to the central heating system. Storage containers are usually galvanized, provided the water contains no harmful properties requiring an enamelled or plastic-lined container.

The great advantage of a well-insulated storage system is that warm water can be drawn off for some considerable period after the heating element has been turned off.

In spring, summer and autumn stove-type or back-boiler appliances can be used intermittently as water-heaters, though of course not all the time as they are needed at some hours of the day for cooking. (This point should definitely be borne in mind when choosing a heating appliance). Hot water tanks can also be used which are heated in spring or autumn direct by grate-spring or by electric elements. The industry can supply both types of mass-produced appliance.

Flow type water heaters

In heating water on the flow system the mains water is only heated immediately before it is drawn off. The heater needs to be in pretty regular use at a high and even water temperature. The mains water usually flows through a copper heat-exchanger, which is surrounded by the heating water and located either in the source of heat itself or in a separate container. This type of hot-water system has not proved so popular for farms as that described under storage hot water appliances. Flow hot water systems can of course be operated with electric immersion heaters outside the heating period, provided the heat-exchanger is not built in to the heating apparatus itself.

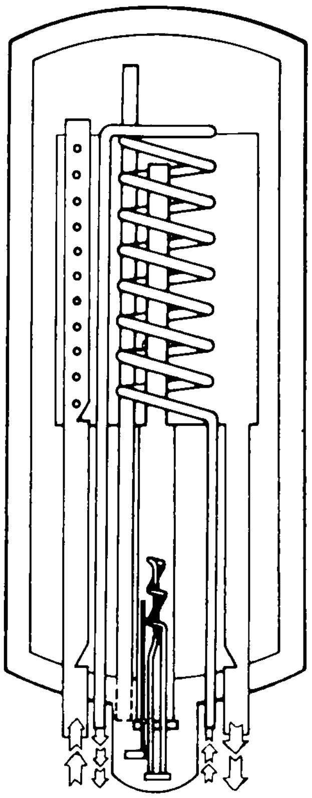


Fig. 3

Compound appliances

This type of hot-water appliance is one which combines the advantages of both the systems described above. In this system a large quantity of heated water is stored and the hot water is drawn off via a heat-exchanger located in the heating water. This permits hot water to be drawn off even when the appliance is switched off. This system provides better all-the-year-round heating than either of the others. It can also be fitted with additional electric heating *(Fig. 3)*. In conclusion it may be said that certain heating systems should preferably be installed on the basis of advice and recommendation.

Every new farmhouse today should be fitted with a central heating installation in connection with a hot water system. As there are still well over 500,000 farms with no central heating, further funds should be provided for the installation of such appliances. Such expenditure would certainly help to make life easier and pleasanter not only for the members of the family themselves, but also for all those working on the farm.

Dipl.-Ing. MANN

Neuhoffnungshutte

(Translated from German)

Having regard to the fact that there is a large demand for hot water on farms, both for domestic and farm uses, and mostly occurring in marked peaks, and that this can only be supplied by storage hot water systems, there should be increased demand for steel hot water boilers with storage capacity over the next few years. In West Germany installations of this kind for farm houses are grant

aided under the scheme for the improvement of domestic economy on farms. In 1965 such installations totalled 11,500 hot water systems and 20,500 hot water central heating systems, of which 75 per cent were equipped with provisions for hot water supplies and were in operation throughout the year.
With the use of combine harvesters and mechanical harvesting of green crops, drying of both grain crops and fodder crops has considerably increased in importance and this can also be done by hot water heating. At the moment the dual purpose boiler holds the field. These boilers are so constructed that they can be heated by solid fuel or by oil or gas.
The hot water heater in the upper part of the boiler is supplied with warmth from the heat source via the water in the rest of the boiler.
The heat of the water at the tap in a continuous flow water heater is equal to the maximum performance of the boiler and also depends on the volume of flow, but in the case of a storage boiler the temperature at the tap is, for short time, far higher than the boiler performance. Storage boilers are far the most suitable to meet the requirements occurring in agriculture.
From a technical point of view there are no serious problems in the manufacture of a steel boiler. The individual parts of the boiler can be joined perfectly reliably by the use of well-known and well-tried modern welding techniques.
The steel heating unit, in the form of a radiator in accordance with German standard DIN 4722, gives off 60 to 70 per cent of its heat by convection and 30 to 40 per cent by radiation. Assuming that the heater is located in the correct place in the area to be heated (against an outer wall or under a window) these two forms of giving off heat will provide a comfortable atmosphere.
In addition to its functional advantages the radiator also has advantages from the point of view of economic manufacture. Fully automatic fabrication is possible owing to the ease with which the steel plate can be formed into the radiator half shells (a radiator unit is made from two half shells) and the reliability with which they can be welded.

W. JAKSCHE
H. KOOB
Ingenieure

Thyssen Industrie GmbH
Düsseldorf

New Steel Components for Farm Building

(Translated from German)

In farming, just as in industry, efforts are being increasingly directed towards simplifying the methods used. A progressive farmer trained at an agricultural college will therefore no longer speak of sheds but of production premises.
By 1965, the number of new farmsteads built in West Germany was 17,000 representing building investments amounting to approximately DM 3,400 million. In addition, it has been estimated that about 75% of existing farm buildings are in need of conversion. Even more farm buildings will have to be put up over the next few years if we are to be able to match up to our task in the future. The reason why this need is so great is that, besides the general trend towards rationalization which renders it necessary for old farms to be adapted to make them suitable for modern farming methods, many farmers are now moving out of rural communities and setting up dwelling and service accommodation right in the middle of their fields, thus forming a real self-contained productive enterprise.

The difficult market situation brought about in part by the introduction of the Common Market provides a stimulus for rationalization and specialization. Hence nowadays we are familiar with specialized dairy farms, pig farms, poultry farms and other similar enterprises.
Existing buildings are in many cases no longer adequate for this kind of specialized output and must therefore be supplemented by the conversion of some buildings and the erection of annexes, but thorough and effective rationalization can really only be achieved by new buildings based on an analysis of the economically most efficient methods of running a farm.
Enterprises which have already succeeded in setting up a series of farms are encouraged by the optimistic forecasts of agricultural experts and associations.
The contribution of steel to industrialized building for the farming industry lies in the very nature of the material. Steel construction has always been synonymous with industrialized building. Steel buildings were prefabricated before the word prefabrication was ever heard of.
Apart from industrialized buildings made from steel components, there have for some years been available on the market hot-dip galvanized sheet steel elements for roofing and wall cladding. These elements are at present mainly used for factory buildings. The widths of cold-formed profiled sheets have been standardized and adapted to the most usual structural steel frame dimensions. There are a number of cross-sectional dimensions (height and width of the corrugations) and length of sheets available. The Sendzimir galvanized elements with a 25 micron zinc coating on each side are normally supplied in lengths of up to 12 m. and in special cases up to 15 m.
These components are provided with a plastic coating on one or both sides depending upon customers' requirements and the purpose for which they are to be used. The thickness of the coating is also governed by how the components are to be used and a wide range of colour offers the designer considerable scope.
The question as to whether the roof of a farm building should be lined or unlined depends upon the type of building involved and its purpose. Barns for storing feed and equipment do not need a heat-insulated roof and may be roofed easily and quickly using large-surface steel decking components. An unlined roof does not require any special treatment and provides reliable, long-term protection.
Trusses may be spaced as much as 6 metres apart owing to the great bearing strength of the purlins. The high strength and low weight of the roofing elements also result in a lighter supporting structure, reduced foundation costs owing to the reduced load, a greater spacing between bolts and shorter assembly times.
For production premises requiring a heat-insulated roof, the trapezoidally corrugated sheet serves to support further elements and also to check condensation as long as joints and overlaps are well sealed. Roof decking elements are first given a bituminous coating and are then covered with an insulating layer of glass wool, cork slab or other material which is in turn covered with several layers of bitumen felt. Apertures for saucer domes, ventilators, etc., are generally cut out after the decking elements have been laid. The shaped components and sections required for this purpose and for ridges and guttering, together with barge boards and other elements are all included in the production programme.
There is also a wide range of wall cladding components to suit customers' requirements. Single panel, unlined wall cladding elements are used particularly in buildings in which an air conditioning system is not required. In buildings which need heat sound insulation the Senzimir galvanized elements are produced with single or double insulation.
Standardized insulating panels with surface coating or hard-board coverings are most suitable for single-layer internal insulation.
The principle upon which this arrangement is based is the provision of ventilation behind the outer shell, that is to say, there is continuous ventilation between the heat-insulating panel and the steel sheet through the spaces in the profiled sheets.
The large-surface, trapezoidally corrugated sheets may be mounted on any type of supporting structure and used in any climate. In the case of steel supporting structure, the roof elements are secured by means of screws, rivets or pistol-fired studs. Where the supporting structure is of concrete the components may be assembled using screws and dowel rails embedded in the concrete, by means of tap bolts or by firing studs into flat steel bars set in concrete.
The longitudinal overlaps of the sheets are further made weather-tight by the insertion of permanently plastic sealing strips. Sheets are joined together with self-tapping screws or rivets.

An example

The *figures 1-4* show one of the most modern self-contained farms in Hesse which was built in a short time using Sendzimir galvanized industrialized building components.
The farm as a whole comprises a dwelling-house, separate living accomodation (the old farm building), service buildings, barns, tower silos and machinery storage sheds.

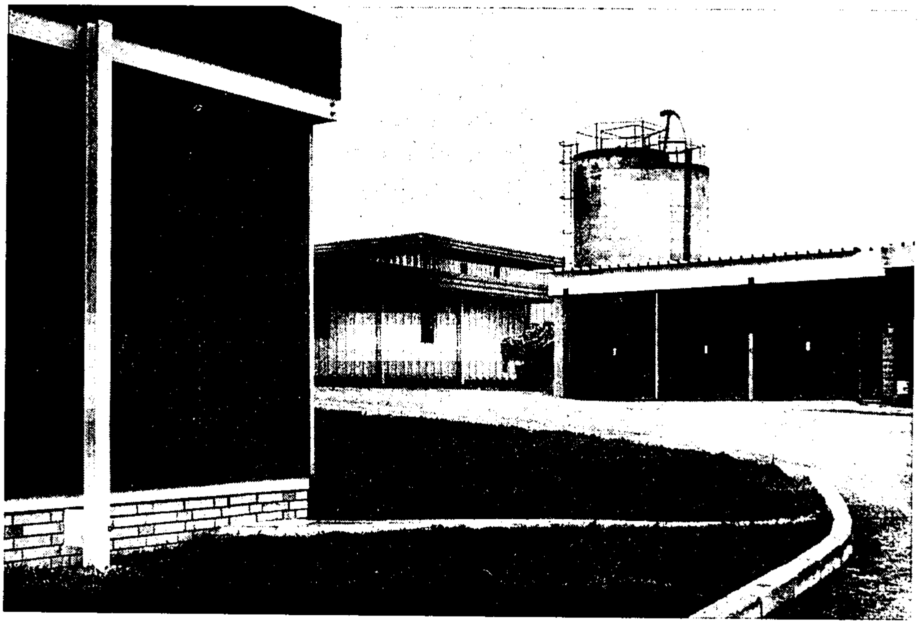
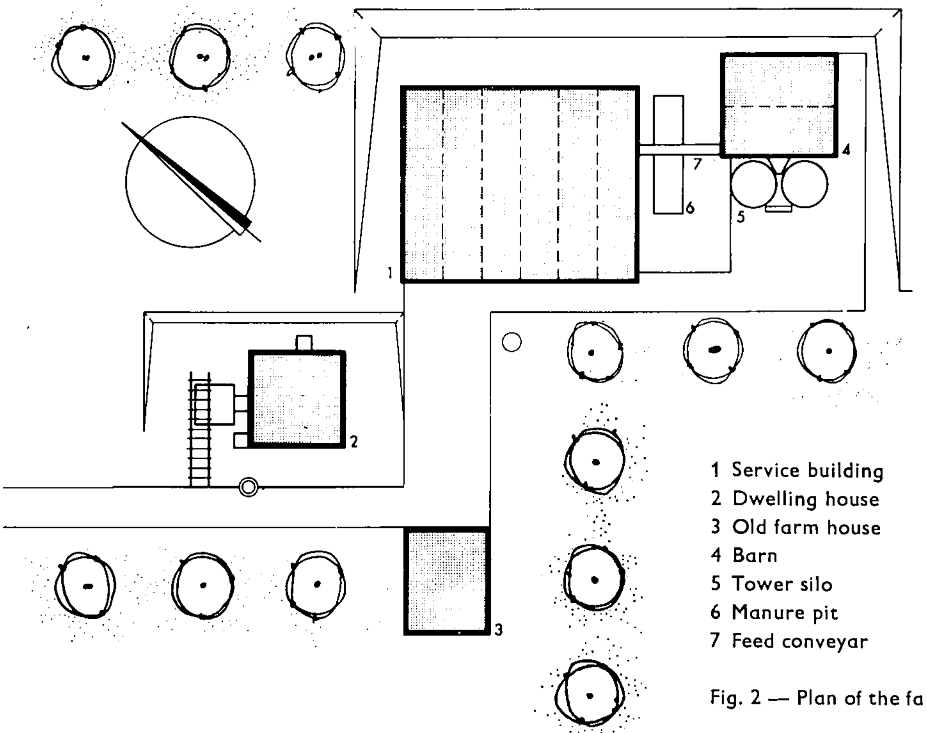


Fig. 1

The main activity is dairy farming.
The buildings are constructed on the basis of a 1 metre grid frame which enabled a considerable amount of prefabrication to be achieved together with flexibility. The supporting elements are protected against corrosion and transmit the loads proportionately through girders and columns to the various portious of the foundations.

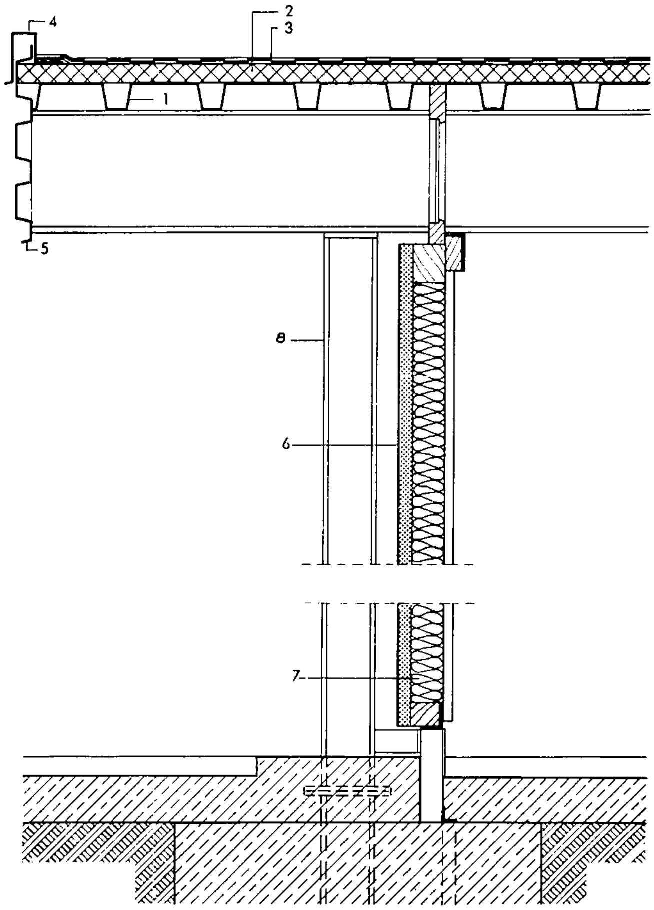


1 Service building
2 Dwelling house
3 Old farm house
4 Barn
5 Tower silo
6 Manure pit
7 Feed conveyar

Fig. 2 — Plan of the farm

The decking and wall cladding elements were of trapezoidally corrugated sheets of Sendzimir-galvanized steel. The favourable load-bearing characteristics of the components meant that large spans could be allowed between uprights in spite of low unit weight.

Fig. 3



1 Roof section
2 Insulation
3 Decking layer
4 Verge
5 Eave
6 Wall section
7 Insulation
8 Steel uprights

Fig. 4: Section through roof and wall

Trusses were spaced 5 m. apart, and it was not found necessary to provide intermediate supports.
The thickness of the insulating panels was determined by calculating thermal insulating properties, taking into account local conditions, the difference between room and outside temperature, relative air humidity and the heat-conducting properties of the insulating material.

This calculation resulted in the use of an insulating panel 6 cm. thick bonded to the outside surface of the steel sections to produce a lined roof. The usual type of roofing felt was used for the top roof covering. The trapezoidal roof supporting sections constitute the lower roofing layer within the building. Although the surface of the roof was kept under continual observation, no condensation was noted.
The view of the interior of one of the buildings *(fig. 3)* is an impressive example of the effect achieved using galvanized roofing components in combination with saucer domes.
Industrialized building components will be and will have to be used more and more in future. Since farm building accounts for what is by no means a negligible proportion of all building projects, and in view of the trend towards rationalization, more attention than hitherto should be devoted to the prefabrication of farm buildings and accurate competitive analyses should be effected.
Steel is the most suitable material for all types of industrialized buildings.

Jean GOUËBAULT

Centre d'information de la tôle d'acier galvanisée
Paris

Applications of Galvanized Steel Sheeting

(Translated from French)

The expansion in light construction is leading to the increasing use of thin-walled members, i.e. sheeting, in constructional steelwork. Such sheeting must therefore be considered as raw material which has to be shaped into a structural material and protected against both atmospheric corrosion and corrosion resulting from contact with certain materials commonly used in the building industry.
Galvanized steel sheet meets both these requirements regarding corrosion resistance; modern methods for the continuous galvanizing of coils provide an absolutely regular zinc coating which adheres perfectly and the sheet can be bent, seamed, profiled and drawn with no risk of the zinc coating flaking off.
New applications, especially in building, have been developed as a result of the easy working property of galvanized steel sheet. Structural members can be shaped to transverse sections best suited to withstand the required stress, making allowance for the correct choice of thickness and for the properties of such sheeting, i.e. lightness, mechanical strength, dimensional stability and low cost. Hence in addition to the best known applications such as roofing and cladding galvanized steel sheet is also used for curtainwalling, metal joinery, fastenings, door frames, floors, ceilings, partitions, ducting, etc.
In the construction of farm buildings, roofing and cladding are the main uses for galvanized steel sheet. There are various roofing processes, the most common being upright and cleated joint systems, flat roofs and roofing in corrugated or ribbed sheets. However, it is the corrugated and ribbed sheets or "self-supporting pantiles" which account for the largest tonnage.
The latter are gradually gaining ground because of their mechanical qualities and attractive appearance. They are suitable for all types of roofing whatever the type of building and climatic conditions. Large constructional steelwork companies often use them as a basic material in industrialized building programmes for sheds, open-sided stalls and stockbreeding premises. Very low pitch roofs which are perfectly watertight are obtained by using sheets of the same length as the roof slope. Such corrugated sheeting is designed to be economically adaptable to all types of framework as it reduces the number of purlins to a minimum and is fixed by simple and rapid fastenings not requiring skilled labour. The use of very long bent sheets

allows the distance between supports to be greatly increased up to about 8 to 10 metres. There are also new roofing processes which permit spans of up to 15/20 metres.

These roofs have a high safety coefficient and also the advantages of mechanical strength capable of withstanding high concentrated excess loads such as snow and wind pressures, often extremely high, and of insensitivity to temperature fluctuations and dimensional variations of the main fabric of the building.

Shed roofs are generally designed without any attempt to resolve problems of thermal insulation and condensation. Often efficient ventilation is adequate since ventilation helps to reduce the flow of heat entering the building and also prevents condensation. Ventilation should be provided by two series of openings arranged in two opposite parts of the roof or at the gutter and the ridge. The cross section of each of the two series of openings must be equal to 1/500th of the roofed area.

In building stockbreeding premises particular attention must be paid to thermal insulation for the walls and the problems of heavy condensation.

Thermal insulation for galvanized steel sheet roofing can be provided by two different techniques:

a) The traditional method is to use rigid slabs or mats of insulating materials with a very low conductivity coefficient in the region of 0.03 kcal./h.m.°C, such as expanded polystyrene, glass wool, rock wool, polyurethane, etc. The insulating material is fitted under the roof with a ventilated air gap or may also be laid above a ceiling or false ceiling with roof ventilation.
   The thickness of the insulation is determined on the basis of the thermal transmittance coefficient required, which is generally close to one; it is obtained by the methods set out in the Rules for the calculation of heat losses in buildings.
b) The other method is the use of corrugated or ribbed galvanized steel sheet with one face coated in the factory with a layer of polyurethane foam about 2 cm. thick. To provide an attractive appearance or to meet special corrosion requirements, the other face may be painted in the factory. These sheets are supplied on site ready for assembly and obviate the need for all the additional supports and fastenings required in the technique described above, at the same time eliminating the problem of heat flow paths. This economical process has already been used in the construction of stockbreeding premises. It may be applied to the roofing of sheds and various other buildings either to provide thermal insulation or to avoid condensation. In the latter case the thickness of the polyurethane coating is greatly reduced, generally being from 3 to 5 mm.

Galvanized steel sheet has a very high power of reflection and a very low emissive power. Tests in the laboratory have shown that all the metal materials generally used in building have similar coefficients. Galvanized steel sheet thus provides a heat screen against the rays of the sun.

Other tests on an actual roof have shown that all roofing materials assembled by the self-supporting pantile technique have a very similar and extremely low thermal inertia.

Roofing with inadequate thermal insulation suffers from condensation on the underside. Condensation occurs when the temperature falls below the dew point because the temperature on the underside of the roof is too low.

Condensation can be avoided or minimized in most cases by the provision of a ventilating system designed to suit the purpose of the building. This problem is in practice the same for all roofing materials and static or induced ventilation is selected depending on circumstances. In special conditions when the air is saturated with moisture the ventilation should be supplemented by a vapour barrier.

Cladding in galvanized steel sheet is particularly suitable for farm buildings since it forms light, watertight partitions resistant to impact, attractive to the eye, and easy and quick to assemble.

Single skin cladding has evolved towards curtain-walling techniques. Sandwich-type cladding, also known as industrial curtain-walling, is composed of two partitions of ribbed sheet with an insulating material between them. This type of cladding of about 4 to 6 cm. thick provides efficient thermal insulation (with K less than one) and a high degree of soundproofing.

With single skin cladding, thermal insulation and soundproofing can be improved by spraying on products with a glass fibre, rock fibre or asbestos fibre base bonded with a special binder and applied on site after assembly or by rigid materials or fibre mats fixed to the cladding.

Ribbed elements coated in the factory with polyurethane foam can also be used for cladding.

Roofing and cladding may be painted to make them more attractive by varying the colours or to provide additional protection when galvanized steel sheet is used in particularly corrosive atmospheres.

The paint, whether applied in the factory or on site, must comply with certain specifications. Numerous tests in the laboratory and in the open air have shown the efficiency of steel plus zinc plus paint combination. Tests have shown the tremendous advantage of zinc as an undercoat as it eliminates the risk of the steel being attacked by rust under the coating. The findings in this connection speak for themselves: when paint is tested by the "Industrial Building" cycle, 25 cycles is taken as a quality standard, but not until the two hundredth cycle, a figure rarely achieved in paint tests, did the first occasional traces of paint destroyed by rust appear. Out of curiosity the tests were continued to 350 cycles, 14 times the quality standard, and about half the painted test pieces still showed no trace of rust.

As building techniques are closely bound up with assembly methods, large scale test programmes have been carried out on welding problems: bronze welding, arc welding and spot resistance welding.

Although roofing and cladding are the main outlets for galvanized steel sheet in farm buildings, mention should also be made of the recent development of parts such as metal joinery, floors, ceilings and ducting. Windows made from galvanized steel sheet are extremely light; the shape of their contact surfaces makes them properly watertight, they are not affected by heat and are easy to transport. All types of window can be designed: casement, horizontally or vertically pivoted, Italian, sash and sliding windows. The parts of the windows may be opened or closed. Galvanizing provides efficient protection of inaccessible surfaces or those in contact with the main walls.

Floors of galvanized steel sheeting were mainly developed in the USA. In France metal flooring techniques have only recently been applied but there are some excellent examples in office and industrial buildings. Some processes meet the requirements for farm buildings and should gradually gain ground in this field. The increasing use of sheeting for industrial ceilings should also be stressed. These processes should also gain ground in some farm buildings where the ceilings have to support insulating materials or absorb sound.

Mass production of round ducting, generally with seamed joints, has promoted the use of such ducts, whose diameters are commonly between 0.20 and 1 m. They are chiefly used for ventilation, heating, dust removal, cable conduits and pipes.

Other large scale applications are available to galvanized steel sheet in agriculture, for example the construction of grain silos of all sizes made chiefly of bent corrugated sheet, but also of flat or ribbed sheet, silos for silage with walls of ribbed sheet. The majority of the different types of grain driers made in France are of galvanized steel sheet.

Mention should also be made of the recent increase of the use of this material in the production of elevators, gratings, vats and tanks, bins, parts of agricultural machinery, etc.

The galvanized steel sheet industry plays a vital role in farm buildings and its use is likely to expand still more with the emergence of new processes and the development of allied techniques such as painting and welding. France has become the primary European producer of galvanized steel sheet. She also occupies third place amongst world producers.

K. LEWUS
Oberingenieur

Gemeinschaftsausschuß Verzinken e.V.
Düsseldorf

The Protection of Steel against Corrosion in Agriculture

(Translated from German)

By far the majority of all agricultural machinery, implements, and the various installations for livestock and fodder storage, hot houses, irrigation equipment, electrical equipment, fencing and many other things is made from steel. Its high strength, wide variety of design and service properties, excellent machinability and above all low price have made steel an ideal material. However, one considerable disadvantage of steel is its susceptibility to corrosion, which in most cases makes a protective surface coating essential.

For cheap mass-produced articles with a short life a coat of lacquer or a very thin metal coating, generally applied by electrolysis, frequently represents adequate surface protection where the steel parts are not burnished or merely greased. In addition to short-term rust protection this lacquer or metal coating often has to provide a more attractive appearance in order to promote sales. One example of this is the brightly painted agricultural machinery leaving the factory.

Coloured paint alone is of no use in protecting steel against corrosion. The first and most important condition for a durable corrosion-resistant coating is that the steel surface be thoroughly cleaned of rust and scale. Manual work with scaling hammer and steel brush is not adequate—blasting with steel shot, corundum or sand is necessary. Another important condition during painting is that no harmful substances land on the coat of paint or the freshly blasted steel surface. This means that the first coat must be applied immediately after blasting and that when the paint is applied the permissible limits for temperature and relative humidity must be observed so that the coat dries quickly and does does not have harmful effects.

Experience in Holland *(see table 1)* shows that the average life of four properly applied coats of paint after blasting is 12 years in a rural atmosphere while with manual rust removal and 3 coats of paint it is only half as long. The cheaper paint application may be sufficient in many cases where the life of a vehicle or machine is about 6 years to scrapping. In the majority of cases assets such as stalls, fodder silos or hot houses have to last much longer. As there is a shortage of labour and no time available for maintenance the demand for durable and reliable protection against corrosion is becoming more and more insistent. Hence a durable

Table 1 — Annual costs in fl/sq.m. for rustproofing thin steel parts in a rural atmosphere

Type of protection	Average life in years	Average production costs in Fl./sq. m.	Annual costs in Fl./sq. m. after a life of			
			5 years	10 years	20 years	35 years
Manual rust removal with steel brush 2 base coats of red lead 1 top coat, all on oil base Repair after 6 years by manual rust removal and 1-2 coats	6	6.00	1.20	1.00	1.15	0.90
Blasting off rust by hand 2 alkyd resin/red lead base coats 2 alkyd resin top coats Repair after 12 years by manual rust removal and at least 2 coats	12	10.70	2.14	1.07	0.80	0.80
Hot galvanizing Weight of Zinc coating about 450 g./sq.m.	40	7.00	1.40	0.70	0.35	0.20

rust-proof coating intended to last the average life of the article concerned is often applied to the products in the factory.

This also provides more economic and better corrosion resistance. Since wages account for about 75% of the cost of manual painting and frequently the necessary supervision cannot be provided during the work to ensure that uniformly good quality is achieved, with the constantly increasing wages to-day, a farsighted man will sensibly invest his money on durable and reliable protection of his property threatened by corrosion.

The figures in *table 1* show that the annual costs of corrosion protection fall as the years pass. Whereas the annual cost per sq.m. for manual rust removal and three coats of paint including restoration of the steel averages Fl. 1.— it falls to Fl. 0.80 in the case of a high-quality coat from the start. Hot galvanizing proves to be particularly economical with an annual cost of only Fl. 0.20 For this reason alone hot galvanizing is becoming very popular in the wide field of corrosion protection.

Another particularly important advantage of hot galvanizing is the sacrificial protection afforded by the zinc which reliably protects the steel beneath, even if deep scratches or other damage expose the bare steel surface. This electrochemical protective effect prevents steel from rusting underneath a hot-dip galvanized coating, as it may do when painted, etc. Only when the zinc coating gradually becomes weathered away in the course of the years can the steel start to corrode. Unlike coats of paint which once cracked start to flake off quite quickly, the life of the protection afforded by zinc coatings can easily be determined in advance since their durability is in direct proportion to the weight per unit area of the zinc coatings. *Figure 1* is a diagram showing this protection life in a rural atmosphere. This shows that with a zinc coating

Flächengewicht der Zinkauflage in g/m^2—Weight per unit area of zinc deposit in g./sq.m.
Streubereich-Scatter
Schutzdauer in Jahren (bis mind. 95% des Zinküberzugs noch intakt ist—Length of protection in years (until at least 95% of the zinc coating is still intact)

Fig. 1—Length of protection of the zinc coat of hot-galvanized parts in a rural atmosphere

weight of 450 g./sq.m., a minimum in the hot-galvanizing of finished parts, an average life of 40 years may be expected. Allowing for the scatter of atmospheric action depending on locality, the protective life of this zinc coating is between 30 and 55 years. One might perhaps be tempted to question this exceptionally long life of hot-galvanizing, but proof can be provided in many cases in which objects are still in use, for example, the Dutch hothouse shown in *figure 2*. Despite the corrosive atmosphere in a greenhouse, no rust spots have been noted on the hot-galvanized steel sections for almost 50 years. Equally long useful lives are known for galvanized watering cans, gratings and steel beams. Precise information on the life of galvanized products can be obtained by plotting the values given in *table 2* for ordinary zinc coating weights on the graph in *figure 1*.

Table 2 — Reference values for ordinary zinc coating weights

Finished products	
Gratings	450— 500 g./m.²
Steel structures	500—1000 g./m.²
Boilers and pressure vessels of light plate	450— 650 g./m.²
Containers and structures of heavy plate	500— 800 g./m.²
Castings	500—1000 g./m.²
Screws, nails and small parts	300— 500 g./m.²
Semis	
Tubes, galvanized, commercial grade to DIN 2444	400— 500 g./m.²
Wire, 1-4 mm. dia., to DIN 1548	
galvanized, commercial grade	30— 120 g./m.²
galvanized, heavy grade	120— 275 g./m.²
Sheet and wide strip	150— 200 g./m.²

Semis, as can be seen, have a lower weight of zinc coating than finished products. This is because semis, which still have to be worked, must have a thin and ductile zinc coating. The galvanizer provides this material with optimum properties as regards corrosion resistance and workability. The comparatively thin zinc coat on semis is increasingly being used as a base coat for subsequent painting or plastic-coating. It gives better, more economic and more reliable protection than any other material against rusting of the steel under the paint or plastic coating. The durability of these films is considerably increased in this way and provides unprecedented resistance combined with great economy. As a result it is quite feasible to provide

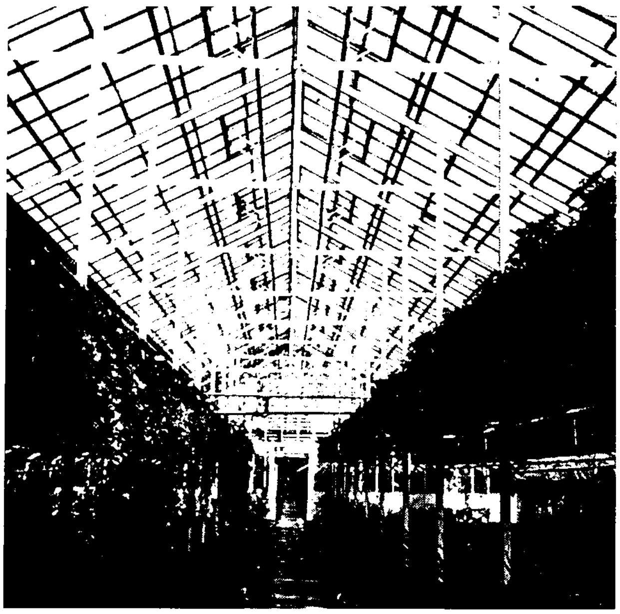


Fig. 2

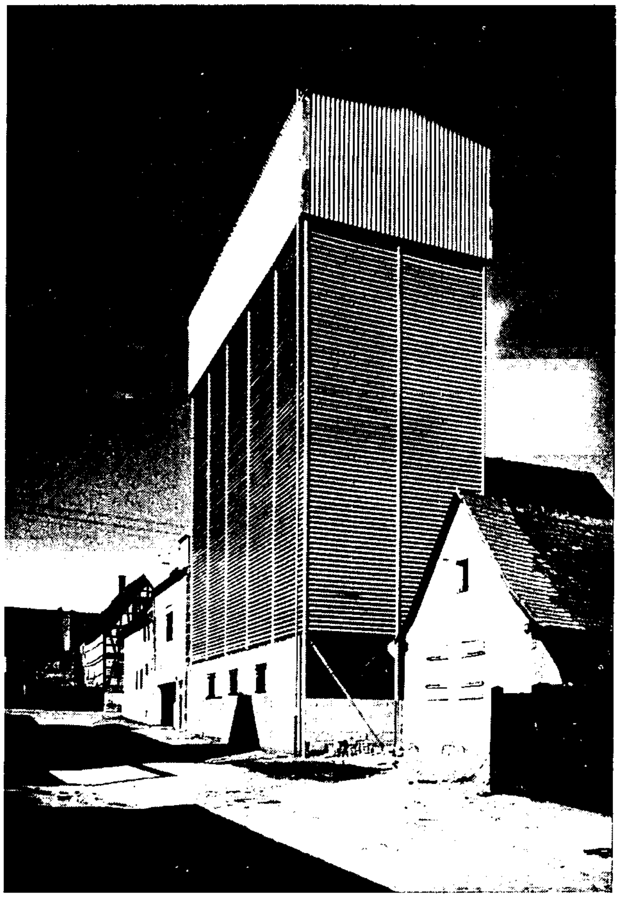


Fig. 3

an additional plastic coating only on the surface most severely threatened by corrosion, e.g. on the outside of pipes to be laid in corrosive earth. Excellent experience has also been gained with grain and fodder silos of hot-galvanized steel sheet with the inside coated with stoved plastics *(Fig. 3)*. Parts of galvanized hot houses in contact with acid humus or stalls likely to rust from the action of liquid manure or dung are also

reliably and durably protected by a combined system of hot galvanizing plus painting. If the paint or plastic coating needs renovation because of exceptionally severe chemical action or mechanical abrasion it can be re-applied quite easily and at low cost because the zinc coating only needs to be brushed down and the expenditure on removing rust from ungalvanized steel is saved.
The exceptional advantages of the combined system are being increasingly recognized so that for example fences are frequently made of galvanized and plastic-coated wire netting. Roofs of stalls, barns and farm buildings are made of sectioned galvanized sheet covered with an additional coat of stoved lacquer. In this way wire netting and roofs can be obtained in a colour toning with their surroundings. Roofs of this steel sheet are comparatively light and do not require the heavy roof structure necessary for tiles and in addition they can be walked on and are safer if struck by lightning. For many years now the advantages of lower weight, lower transport costs and easier assembly have opened up additional markets for hot-galvanized sheet in American, Canadian and Australian agriculture. Europe and Africa will follow this example. In the USA alone about 6-7 millions tons of galvanized sheet is produced annually from wide strip and most of it is used in agriculture. Complete installations for pig and cattle breeding, chicken farms, silos for fodder and foodstuffs including sheds with their internal equipment such as ventilation, heating and drying plant, cattle boxes and automatic transport and feeding equipment are already currently produced from hot-galvanized sheet in an extremely economic method of construction.

Dipl.-Ing. F.W. KOHL

Deutscher Verzinkerei-Verband E.V.
Düsseldorf

New Uses for Hot-dip Galvanized Steel Sheet

(Translated from German)

The use of hot-dip galvanized steel sheet for various purposes in agriculture is increasing. The examples of uses given will show the course of this development.
Many years ago, and even still to-day abroad, flower containers were made of zinc or galvanized sheet steel and displayed flowers particularly well. In the last few years window boxes, balcony plant pots, plant containers for use in the garden and other containers for plants have been manufactured from other materials. Since there is renewed interest to-day in plant containers—one calls to mind the separation of areas in open-plan offices, so-called "office landscaping," and the design of large paved areas—it is natural that these containers should again be made of galvanized sheet steel. Fabrication is extremely simple, the containers being formed, moulded or drawn. These containers are light, unbreakable and can be coloured as desired for any particular scheme. Any local metal working shop is in a position to make them. It is therefore surprising that such readily manufactured and economical containers have not been generally more popular for a long time.
The answer is simple and applies to other products of mass production from sheet steel. To-day's requirements are not confined to such qualities as utility and cheapness, but also include, to an increasing degree the demand for suitable forms. For instance a bucket, designed decades ago and not in accordance with to-day's taste, can easily be manufactured, but will prove difficult to sell; it is no longer suitable for a kitchen of modern design. But the form is not inherent in the material and incapable of being altered, but is the result of changing ideas on design, having regard to the characteristics of the material.

Another example is paving plates in galvanized sheet steel, which are light, simple and easily moved. They are fixed to the ground by triangular spikes. If these paving plates are laid in grass, for example, the holes in them allow the plants to grow through. This holds the plate firm and, if they are painted a suitable colour they are practically invisible in the vegetation, but still fulfill their function of providing firm paths or trackways. The grass can still be mown without difficulty. No special foundation is required. These plates are particularly suitable for gardens in places where temporary pathways are required for the passage of barrows. This temporary firm pathway is very practical in places where the ground is composed of loose material, since it is thus not disturbed and the spread of dirt is avoided. Other uses can be suggested, such as trackways at the entrance to garages.

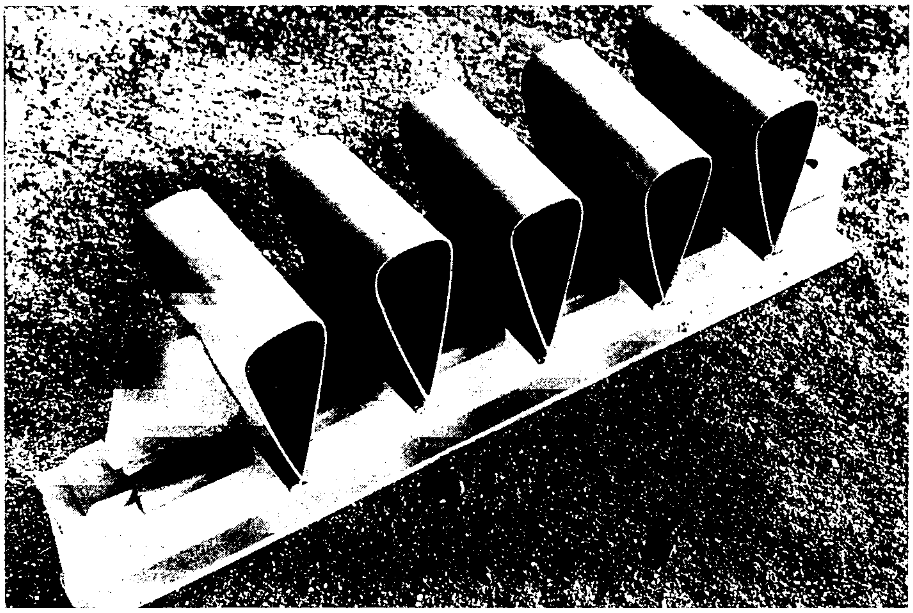


Fig. 1

Another important use for this material arises from the application of industrial mass production techniques. Fence posts have been made from a wide range of materials and steel posts have been known for a long time. Technical progress, inventiveness and knowledge of the material have now produced a new method of manufacture, by which posts of various dimensions can be formed direct from hot-dip galvanized strip by mechanical methods. These posts are given a double protective coating with plastic material and for additional protection high-grade tar is applied at the point where the post comes into contact with the concrete anchorage or with the earth. It is obvious that fence posts of this type will have a long life. These triangular posts are suitable, owing to their shape, for a wide range of other uses. For the construction of windbreaks, for fixing traffic notices and for covering ditches or drains in place of steel gratings.

These posts are especially suitable for use wherever agriculture requires gratings to cover manure drains. They are easy to move, available in a wide range of lengths, and distance pieces can be used to provide the required gaps between them of 2.5 cm. for pigs, 3.5 cm. for young cattle and 4.5 cm. for adult beef cattle. The heat loss to animals lying on them is small. A further advantage is that the posts can easily be removed for cleaning the drains or ditches *(See Figs. 1 and 2)*.

Silos

Silos for fermenting material are to-day indispensible in the economic rearing of beef cattle. Fabricated silos, which are easily erected, particularly airtight and produce perfect silage are now being made both in Germany and abroad from galvanized sheet steel. Three firms have been producing silos of this type in Germany for more than 30 years and they have proved reliable in use. It is a testimony to the galvanized material that silos of this kind are still in use to-day. Naturally they must be suitably painted inside, or given a coating of some plastic material. These silos are labour-saving, since they can be filled by a conveyor through a loading shaft. There is a wide range of unloading equipment, either top or bottom, available.

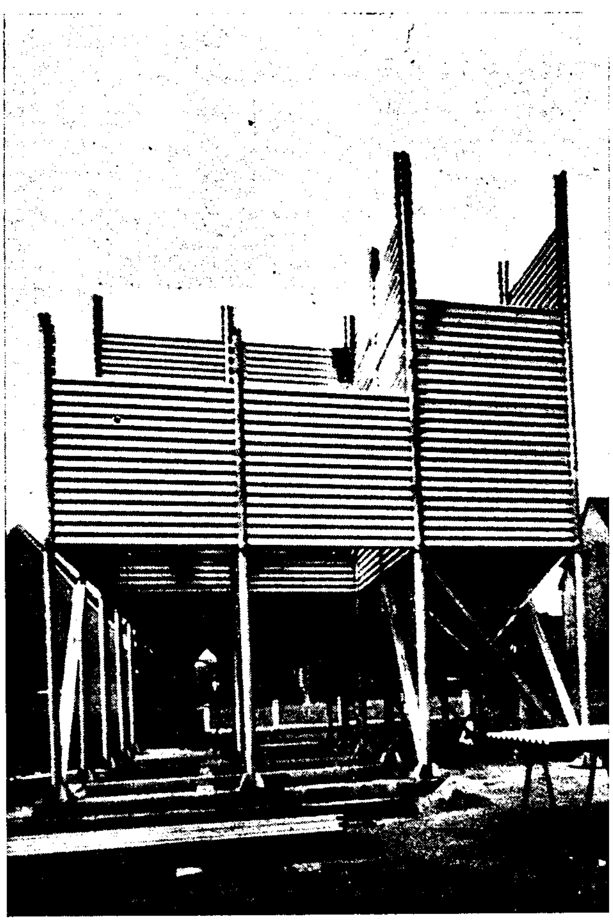


Fig. 2

As everywhere abroad, there is to-day increasing use in Germany of grain storage silos of curved galvanized corrugated sheet. Erection is simple, the sheets merely being bolted together to form a self-supporting circular container, and can be done by unskilled personnel. In other types of silos the sheets are fitted vertically and bolted together along their sides. The internal pressure is taken up by reinforcing bands fixed on the outside.

Rectangular silos from pre-fabricated sheets, which can be extended in any direction at will, are also finding increasing favour because the use of space is more economical in some circumstances. Silos of this type can be expanded into large units, in fact into buildings.

Similar considerations apply to storage bins for concentrates which are becoming increasing important as efforts are made to get away from packaging in paper. Expensive load bearing areas for the storage of feedingstuffs can thus be dispensed with and the feedstuffs themselves are cheaper if delivered in bulk.

Marcel TOLLET
Licencié en sciences commerciales et financières

Services commerciaux de la S.A. Phénix Works
Flémalle-Haute

Precoated Sheet

(Translated from French)

It is a feature of the world economy today that the products marketed are more and more highly worked and finished and more and more tailored to the customer's wishes and requirements. A great deal of both technical and market research is involved in this process.

The idea that the iron and steel industry is the basic heavy industry is altering too: the clearest example is perhaps the emergence in Europe of the coil coating industry, which grew up years ago in the United States.

What is coil coating?

A sheet or strip of cold-reduced or galvanized steel or of aluminium is continuously double-coated at the works, after careful surface preparation.

—Plant

The strip is uncoiled and hooked to the strip ahead of it before going into a looping pit. It then undergoes a series of dips for the various pretreatments, following which the surface is passivated.
Next, both sides of the strip are given a ground coat by a first coating machine. The solvents are evaporated by passing it through a furnace; on leaving this it is cooled and then goes into the second coating machine, which adds the finishing coat on one or both sides. After that it is polymerized in a second furnace.
Finally it is cooled once more, and the finish may be supplemented by graining or printing.
Multiple-roller coating ensures that the coat is evenly distributed, and enables the thickness to be kept under constant control.
Continuous coating is most valuable, moreover, since the metal needs to be coated as quickly as possible after pretreatment, to avoid loss of adhesion.

—Types of coat

The coats applied to the metal strip vary widely. It is not easy to classify them, so I propose merely to give you a brief description of the different kinds.

1. Acrylic finishes: These polymerize rapidly, give a soft and flexible surface and are highly colour-fast; they are also very resistant to hot alkaline solutions, and largely stainproof.
   The acrylic copolymers are highly resistant to ultra-violet ray deterioration, and stand up excellently to atmospheric corrosion.
2. Vinyl finishes: These are of two kinds, the vinyl solutions and the organosols and plastisols.
   - Vinyl solutions: They consist of polyvinyl chloride suspended in a solvent. Their main advantage is first-class formability; their resistance to atmospheric corrosion is good, but not quite as good as that of the acrylic finishes.
   - Organosols and plastisols: Polyvinyl chloride, though an excellent polymer for coating, is soluble only in a few very special solvents.
     To apply the organosols and plastisols to a metal strip, it is necessary to disperse the former in low-boiling and the latter in high-boiling fluids for which they have affinities at higher temperatures. These coats offer excellent resistance to abrasion and injury, high formability and a wide variety of decorative possibilities. They will take embossing owing to their thickness.
3. Polyvinyl fluoride: This is available in several forms. They are the very latest types of coat; though expensive, they have altogether exceptional properties as regards both formability and resistance to atmospheric corrosion (anything up to 20 years) and to the effects of the main acids and bases.

Sketch of past developments

Here are a few introductory figures.
American sales of precoated metal 1962-65, with extrapolation to 1975 are given in the table on p. 175.
— Plants in production in the United States in 1964, over 200.
— New plants planned or building in the United States in 1965, 10.
The process dates from about 1936, when Joe Hunter brought into operation the first continuous coating line, handling narrow strips of cold-reduced steel for the manufacture of venetian blinds. In 1945 the process began to be applied to aluminium, and precoated aluminium sheet has since come to be used more and more for wall panels (cladding in general). From 1958-59 firms have been increasingly installing lines for coating wide strips, which are afterwards slit into narrower sizes and cut into sheets.

The steep rise in demand for precoated products, in sheet or coil form and in all sorts of sizes, thicknesses, colours and so on, has obliged the industry to work under constant pressure, while at the same time striving to make improvements in the base metals, coats, treatment chemicals and plant used. This has particularly benefited the steel industry, and the coatings concerned are unquestionably admirable.
Following the American lead, there has been a big push in the same direction in Japan, Australia, Mexico and of course in Europe; several firms are now building or have recently brought into production ultra-wide continuous coating lines.

Year	Aluminium			Steel			Total		
	A	B	C	A	B	C	A	B	C
1962	165	—	115	260	—	47	425	—	162
1963	183	111	127	395	152	72	578	136	199
1964	210	115	146	515	130	93	725	125	239
1965	229	109	160	599	116	108	828	114	268
1966	250	109	174	680	114	123	930	112	297
1967	272	109	190	755	111	136	1027	110	326
1968	297	109	206	823	109	149	1120	109	355
1969	320	108	225	885	108	160	1205	108	383
1970	343	107	239	946	107	171	1289	107	410
1975	408	119	284	1134	120	204	1542	120	488

A '000 tons.
B Index of increase.
C '000,000 sq. m.

Reasons for using precoated sheet

The main reasons for precoated the sheet at the works is of course the elimination of the subsequent finishing operations and improving the quality of the end product. Accordingly, a large number of different types of coat have been developed, each with an eye to a particular purpose, such as forming, exposure to weather, resistance to heat or to a given acid or base, and so on. As a result, precoated metal is coming to be employed for a great many widely different uses: to mention only a few, they include roofing and roofboarding of all kinds (flat, corrugated, semi-corrugated and shaped), roofing and cladding of industrial and agricultural buildings, wall panels and partitions, prefabrication, farm installations (tanks, indoor bins and silos, etc.), motor cars, aircraft, ships, locomotives and rolling stock, metal furniture, electrical fittings and household equipment, and so on and so forth.

Uses for farm buildings

Recently an American coating firm arranged to sell from stock precoated corrugated galvanized sheet in four colours and in several sizes and thicknesses, which it advertized in its sales promotion campaign as "farm roofing and siding." The experiment proved highly successful, and demonstrated still more clearly the value of metal equipment to agriculture.
On the building site, steel is traditionally favored because of its happy combination of lightness, strength and cheapness. A drawback was always the rust factor. A Japanese view on the subject is that "painted galvanized sheet is generally reckoned to be three times as corrosion-resistant as the ordinary kind; others put it at 160% of the sum of the respective lives of a galvanized sheet and a coated black sheet."
In the United States some cladding has now been exposed for over 10 years to reasonably normal atmospheric conditions without the slightest peeling or cracking of the surface. The colour too has altered only very little (owing to slight powdering), and even that has been uniformly distributed over the whole surface. All that has been required to achieve this result is that the metal should be washed down regularly with an ordinary hose.
There is a further special reason for this durability: after the pretreatment it is usual to apply the finish to one side of the sheet, though the other is protected by a ground coat.

Compared with the outstanding advantages of precoating, on-site coating raises certain problems. For instance, rain falling on a surface not yet properly dry may spoil it sometimes to the extent of making it necessary to scrape off the whole coat applied and start again. Or the sun may evaporate the solvents too quickly, causing the paint to crack.

With galvanized sheet being used more and more, precoating is a real boon, since

(a) the public authorities are insisting on having buildings coloured,
(b) customers are increasingly preferring more highly-finished products, now that pleasing design and attractive appearance are becoming so much a part of everyday life, and
(c) the general trend nowadays is to have everything prefabricated as far as possible—dwelling-houses, schools and farm buildings alike (the latter including such structures as refrigerated sheds for storing foodstuff).

As regards (b), the choice is falling more and more on pastel shades in preference to bright colours, the idea being that the structure should blend with the surrounding countryside. The sheet is even more popular if, as is now increasingly the case, it is shaped instead of corrugated. Apropos of shaping, and processing generally, the fact that the coat is self-lubricating enables the production machinery to continue longer in service, since there is less strain upon it in forming.

Other agricultural uses

There is undoubtedly plenty of scope for the use of precoated sheet. It is impossible to mention all the possibilities but here are a few:

- silos;
- containers (more especially for grain);
- agricultural machinery and implements (combine harvesters, combined side-delivery rakes and tedders, milk coolers, presses, pick-up balers, manure spreaders, dryers, blowers);
- refrigerators;
- ventilation plant;
- tractors (incidentally, more than 45 motor-car parts are made from precoated sheet, including oil filters, horns, internal fittings, dashboards, radiator grills, speedometer dials, etc.).

Especially form equipment manufacturers should go into the potential uses of this new product, and arrange with the steelmakers to get the type of coating just right for the particular purpose concerned.

Conclusion

The European market for precoated sheet is only just opening up, but it has got off to a most promising start, irrespective of the particular use to which the product is to be put.

Raymond THIBAUDEAU

Vice-président de la Confédération nationale des artisans ruraux
La-Roche-sur-Yon

Steel and the Craftsmen in the Service of Agriculture

(Translated from French)

In this paper I propose to define the position of the rural craftsman in our country between his two main partners, the steel industry as his supplier and agriculture as his customer.

There are many rural craftsmen who have tried to keep up with the radical changes in the farming world resulting from technical progress and who have converted their businesses to meet new demands:

— mechanics, general mechanical engineering, for the maintenance of modern equipment;

— steel construction: for frameworks of farm buildings, open stall systems, silos, crops under cover;

— builders of farm vehicles and body-builders, often starting with the conversion of old carts.

Finally, the needs of the family and the improvement in rural life which has been encouraged and developed have given rise to new requirements which craftsmen have taken on as their main or secondary activities, such as heating and plumbing installations, water supply, hardware, iron working and metal joinery.

Rural craftsmen must once again follow in the wake of their customers; although the traditional versatility of the craftsmen remains his trump card as far as services are concerned, improved profit-earning capacity can only be obtained by specialization. Whatever the form or nature of the activities towards which craftsmen are turning, they will have one point in common: the use of iron and steel products.

The craftsman needs the products and assistance of the steel industry. He is generally very ill-informed about this great supplier, whom he knows only through the many materials he uses and the merchants who supply them. The steel industry, that huge and powerful complex of scattered companies producing vast quantities of very varied products, does not appreciate this customer at the far end of the distribution system. And yet he deserves consideration both because of the quantities he uses and the stability of the market he represents.

We may estimate today that rural craftsmen use an annual average of 2,000 kg. of iron and steel products per productive man (wage-earner or owner) which for the whole of France amounts to 360,000 tons. This figure does not include special steels or finished products such as horseshoes, parts of farm machinery, corrugated sheet, wire netting, wire, etc. but only ordinary steel semis, merchant bars, heavy and light plate and sheet, special sections for metal joinery and tubes of all types. It is no exaggeration to estimate that craftsmen represent a market of 500,000 tons of miscellaneous products from the steel industry. Apart from the heavy industries, what industrial groups provide such an outlet in France? The steel industry itself must answer this by examining the range of its customers.

The craftsman is not a metallurgist, he uses steel as well as his training and tooling permit. At the technical level, he has been helped to adjust and to obtain further training by the very useful activities of certain "Chambres de Métiers" or trade associations. Some large sectors of industry have also provided assistance by publishing extension literature and practical drawings and plans. Other technical centres organize in the provinces days for meetings with rural craftsmen during which they provide them with information and advice and in return obtain valuable reactions and comments from the craftsmen and benefit from an appreciable increase in the use of their products. Amongst the bodies initiating such activities are the "Office technique pour l'utilisation de l'acier" and the "Chambre Syndicale des Fabricants de tubes d'acier," whose work is an example and a model.

But because of their versatility rural craftsmen have a great variety of requirements and hence a wide need for information.

If contacts and co-operation are to bear fruit there must be a central clearing house with sufficient facilities to collect and compile a large amount of technical information and distribute it judiciously and as widely as possible to meet these very varied needs.

The most urgent duties to be undertaken by this "clearing house" might be defined as follows:

— To prepare basic documents containing:
  — as complete as possible a list of iron and steel products and materials with their technical specifications, methods of identification, conditions of use and recommended applications;
  — easily assimilated information in the form of tables or charts for design calculations for single members or assemblies and for designing water or heating installations.
— To prepare the publication of standard drawings and plans accompanied by dimensions. These would be designed to meet the current requirements and ambitions of the farming world and the usual demands regarding metal joinery, steel construction and hardware. They would be of great help for the submission of estimates and preparation of accounts.
— To organize a permanent advisory service to answer craftsmen's questions and help them to use steel products as well as possible in their customer's projects.
— To organize regional technical information meetings with lectures, film showings, and practical demonstrations. To promote refresher and advanced training courses particularly for young craftsmen and to arrange conducted tours to show young craftsmen something of the steel industry, unfamiliar to most of them.
— To collect the reactions, comments and suggestions of craftsmen regarding the use, quality, appearance and distribution of the products they use and thus to become a source of valuable information for the steel industry as a whole.

This "clearing house", this "central design office" for craftsmen need not be a Utopian idea; putting it into effect depends on the understanding of all concerned. For some ten years rural craftsmen have been struggling to keep going and their failure would swell the exodus from our countryside and endanger the economic balance which has so far been preserved. Rural businesses must be supported and helped to survive not only by local and regional action but by a nation-wide project of this type which would be available to rural craftsmen all over the country.

If, as I hope, such a body is formed, it should be very widely publicized. I am convinced that the wide circulation potential of the technical press specializing in the rural trades, which has always been very attentive to anything likely to help to instruct and inform its readers, will ensure that this venture gets the publicity it deserves.

In this paper it was my intention merely to outline the special problem of the rural craftsmen as an increasing user of steel products in the service of agriculture and to put forward a possible solution. It is now up to all those involved, at whatever level or in whatever way, to give the subject due consideration, and we sincerely hope that it will not be necessary to put an irrevocable full stop to the venture.

Jean MOUZAY

Confédération nationale des artisans ruraux
Paris

(Translated from French)

The representatives of the rural craftsmen enterprises would like to call the Congress's attention to some of their particular problems. May we mention the following desiderata.

1. It is by now generally agreed that more needs to be done to keep farmers informed concerning the uses of steel, but this also applies with regard to the rural craftsmen businesses, which are after all a natural link between industry and agriculture. They too should be supplied with the information they require

to act as advisers and organizers, and so play their part in promoting the dissemination of modern knowledge in the agricultural sector.

2. In particular, a regular classification should be kept of auxiliary and small equipment needed on farms which could be competently made by country craftsmen.
3. The relevant particulars should be circulated to craftsmen, with all supporting material (instructions, sketches, advice, etc.), to enable them to do the job properly.
4. Due account should be taken of the action craftsmen are now taking to replan and rationalize their activities, so as to equip themselves to make a comeback as an accepted, normal and economic link in the distribution chain.

Centre international d'information et de documentation des producteurs de phosphate thomas
Bruxelles

Basic Bessemer Slag

(Translated from French)

The introduction of the basic Bessemer (Thomas) steelmaking process about 1880 was an important development not only for the steel industry but also for agriculture, since as time went on very considerable use was to be made of basic slag as a fertilizer. The new source of phosphoric acid thus opened up came, as more and more steel plants took up the process, to cover a substantial proportion of the agricultural sector's requirements in many countries.

At the same time, the recovery of the phosphorus content from their production of phosphorous pig-iron had obvious economic advantages for the basic Bessemer plants too, inasmuch as a by-product hitherto of practically no use to anyone thereby gained a definite market value and assured sales prospects. Not surprisingly, therefore, the output of basic Bessemer slag increased rapidly: the total for the ECSC countries in 1965 was 7,294,000 tons, broken down as follows:

— Germany (FR)	2,825,000 tons
— Belgium	1,327,000 tons
— France	2,306,000 tons
— Luxembourg	836,000 tons

Incidentally, the expansion will not be affected by the adoption of the new oxygen steelmaking processes (L/D, etc.) provided the pig-iron used has been made from phosphorous ores: where this is so the phosphorus occurring in the pig-iron will necessarily also be found in the slag.

Consumption has risen over the years at pretty much the same rate (though in some countries, such as France, it is restricted by the fact that the output is smaller than the farmer's demand).

It is worth noting that in the four ECSC producer countries phosphoric acid from basic Bessemer slag accounts for a large proportion of the tonnage of phosphate fertilizers used in each.

Basic Bessemer slag assays 14-22% of total phosphoric acid, insoluble in water but dissolving almost completely in weak acids, such as 2% nitric acid, and in the solutions circulating in the soil. Upon dissolving in the latter, the phosphoric acid is held by absorbent power which prevents it from being washed away by rain-water or drainage, and so keeps it available for use by the plants as and when required.

In addition, as the slag contains an average 50 kg. total lime (including 40 kg. neutralizing lime) per 100 kg., it is a notable contributor to the coverage of the soil's calcium requirements, being the source of quite a

Consumption of basic slag as a fertilizer

ECSC countries of which:		6,522,000 t
Germany (FR)	3,113,000 t	
Belgium	352,000 t	
France	2,718,000 t	
Italy	59,000 t	
Luxembourg	37,000 t	
Netherlands	243,000 t	
Third countries of which:		857,000 t
Austria	329,000 t	
Switzerland	196,000 t	
Eire	148,000 t	
East Germany Britain Denmark Yugoslavia African countries Latin America New Zealand	184,000 t	
	Total consumption	7,379,000 t

large proportion of the various types of calcareous soil conditioners used in all the producer countries. Slag further provides the soil with quite a number of secondary elements (magnesia, silica, etc.) and oligo-elements (manganese, molybdenum, copper, cobalt, vanadium, etc), all of which are highly important for plants and animals.

Over and above its consumer appeal as a combined fertilizer and conditioner of proven excellence, slag has the advantage of being cheaper than most other phosphates of comparable efficiency. Consequently it is regarded as very much a paying proposition by the farmers.

Working Party II

Steel

in Agricultural Machinery

Chairman	*Prof. Dr.-Ing. W. Baader*
Rapporteur	*J. Leclerc*
Introductory Papers by	*S. S. DeForest*
	A. Horowitz

S. S. DeFOREST

Manager
Agricultural Equipment Marketing—United States Steel Corporation
Pittsburgh (USA)

Requirements for the Mechanization of Agricultural Production

The subject assigned to me, as a participant in the Steel Congress 1966, is important for two reasons. First, the requirements for the mechanization of agricultural production must be foremost in the mind of a steel marketing man if he is to do his job successfully in helping to market more of the steel products produced by his company in the agricultural equipment industry. Of equal importance is the contribution steel makes in the economy of growing, processing, and distributing food and fiber in ever greater volumes at lower cost.

To better describe this, I think it best to mention some of the problems we face in the United States in marketing steel to the agricultural equipment industry. These are:

1. steel already is used as a major manufacturing material;
2. our company brand identification is lost during the manufacturing process; and
3. competition from our domestic and foreign competitors is intense.

One might ask, "How does this affect the requirements for the mechanization of agricultural production?" Only by understanding such requirements and knowing how steel products may be applied to them can a steel marketing man appeal to agricultural equipment designers and engineers, the men who are influential in specifying components and materials to be used in the equipment they design. While it is true that satisfactory "function" of the tractor or implement is the primary objective of the agricultural equipment designer, sooner or later he will be concerned with and be interested in the best, most economical way to use materials in his design. And steel, because of its inherent qualities (which are well known to all of you), is the material which he will use most. The point is, however, that by knowing something about the requirements for the mechanization of agricultural production, a steel marketing man can obtain and deserve the attention of the agricultural equipment designer.

I have given you a quick review of the background philosophy we use in our work in marketing steel products to the agricultural equipment industry in the United States. This is important because I do not expect in this paper to develop the requirements for the mechanization of agricultural production using examples already well known in the agricultural equipment industry. It is the purpose of this paper to look beyond current engineering practices and examine;

1. newer equipment concepts;
2. the application of newer steel products to the concepts;
3. the application of these newer concepts to agricultural equipment needs.

It is appropriate now to look at the role steel marketing has had in the agricultural equipment industry in the United States.

About 30 years ago the need for bulk handling of milk was identified in the dairy industry. Fortunately a desire for knowledge of the advantages of stainless steel arose and an American steel concern organized and sponsored co-operative research work in several areas including important work with the University of Wisconsin. You may be aware of the success and importance of stainless steel equipment for the bulk handling of milk in the United States. It was largely a result of this co-operative program.

Similar marketing work brought into focus other agricultural industry needs and highlighted the economic advantages of using current or new steels which can perform for the mutual benefit of the industry and our agricultural community. The use of galvanized steel for grain storage bins, farm buildings and roofs; the use of coated steel in silos and the use of steel to replace wood in most farm implements are well-known examples. Recent marketing activities have resulted in wider use of a family of high-strength steels such as USS Ex-Ten, Man-Ten, and Cor-Ten brands in frames and structural members of farm equipment. We also see wider usage of the atmospheric corrosion resistance of high-strength Cor-Ten steel in manure spreaders and the use of USS stainless steel in tanks for agricultural chemical applicators. More use is being made of the strength, wear, and impact resistance properties of United States Steel's heat treated alloy steels in gears and shafts for tractor and combine transmissions; blades for rotary cutter; shafts and axles for implements; and hammers for hammer mills.

Of course United States Steel marketing men continue to follow and further develop these current markets. But what about the future? What do our agricultural observers believe are the market and industry trends? What new engineering and manufacturing innovations do our engineers anticipate? And more importantly, what are some of the new steel research results and development innovations that may find engineering applications in agricultural tractors and implements? Let's consider some of these.

Fabricated Panel Construction

The agricultural haulage equipment market has been one of the last markets to change over from wood to steel in the United States. During the last 10-20 years, we have seen largely a direct substitution of steel for wood. In some cases, this has not taken full advantage of all that steel could offer.

Construction with wood traditionally confines the design to rectangular and square shapes.

When steel is used in the design of these implements, advantage can and should be taken of its unique fabrication and performance capabilities. It is possible to use round, triangular, hexagonal, or elliptical construction if desired in designing the sides and floors of these wagons or spreaders. The auger self-unloading wagon is a good example of taking advantage of steel's ability to make the bottom round.

Further, steel offers the opportunity to economically produce fabricated steel sections that can provide structures of increased strength and rigidity. Such panel construction also opens the door to the use of different steels in combination, such as the use of mild carbon steel where it is adequate and high-strength or corrosion resistant steel for the inner sheet where these special properties are needed.

The design concepts which follow suggest ways in which some of these unique advantages of steel may be employed to a high degree. They are merely illustrations of what might be designed for the future and are intended to stimulate imagination. Those who care to use them will understand that United States Steel makes no representations or warranties with regard to their suitability for the illustrated purposes.

Flat Bed Wagon

Figure 1 shows a 1/4 scale model that has been made of a typical flat bed wagon used on many farms for general hauling use. This design uses steel throughout its construction and features suggested use of a flat corrosion resistant USS Cor-Ten steel top sheet welded to a corrugated transversely stiffened undersheet for the main bed construction. The Cor-Ten steel top sheet is wrapped around the sides and ends of the bed to extend the corrosion resistant and high-strength properties of this material to the sides and ends. This should facilitate provision for stake pockets and attachments for the wagon sides. An interesting variation of this design can be considered. Everyone is aware of the slippery wagon floor that can result with painted flat sheet steel. Because of the excellent atmospheric corrosion resistance of Cor-Ten steel, it will give satisfactory life unpainted. This should provide a floor that would be less slippery than painted steel, particularly when wet.

The traditional wood wagon joists are replaced by built up rod-and-angle bar joists now in common use in the building industry. This flat wagon bed could fit any farm running gear common in the United States.

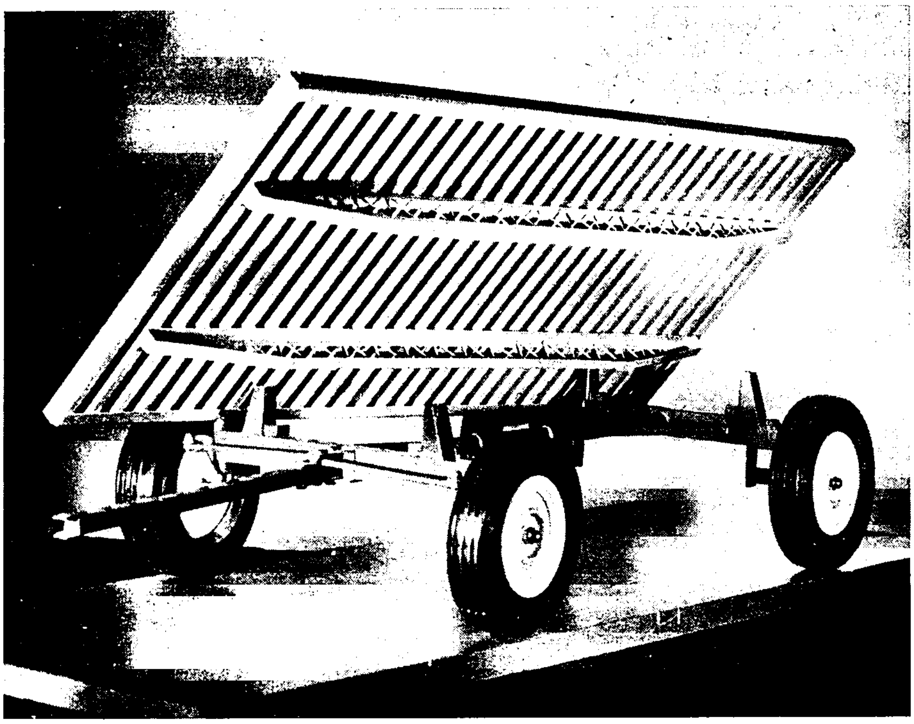


Fig. 1

Manure Spreader

Figure 2 depicts a manure spreader using steel panel construction techniques. This implement employs the same basic platform construction as described previously for the flat bed wagon, except that the built-up floor joist is not used. The spreader body is a frameless, unitized construction and achieves rigidity and

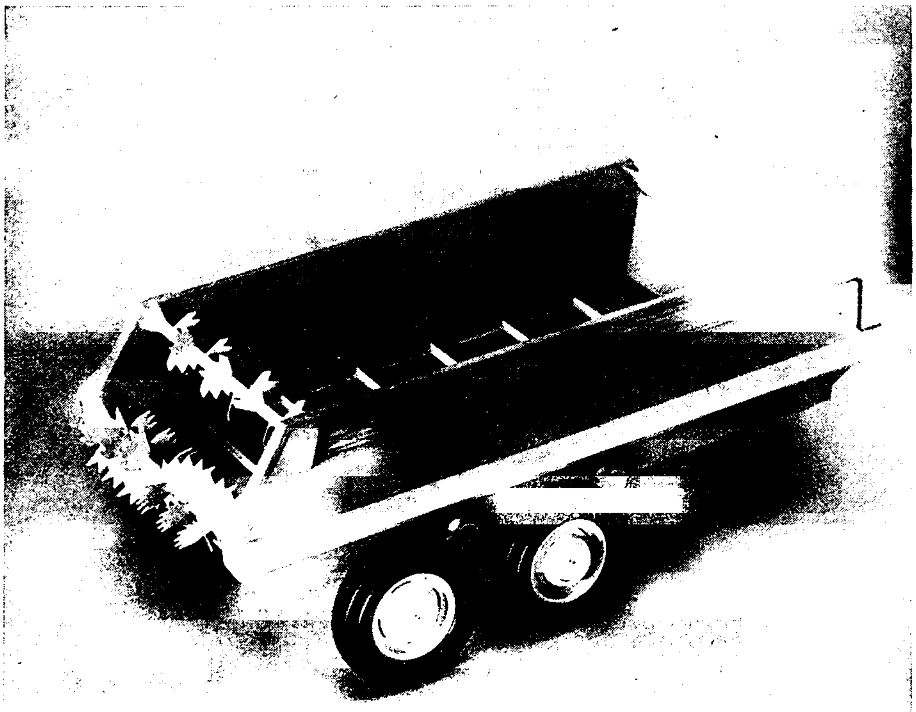


Fig. 2

strength through the fabricated panel side assemblies. These side assemblies consist of a corrosion resistant Cor-Ten steel inner wall supported by triangulated construction carbon steel outer wall. The cross section visualized for this construction is shown by *Figure 3*. This panel side assembly provides excellent strength and rigidity when resisting both beam and torsional loads. Further, it provides means of concealing and protecting the drive shafts and chains needed to power the drag chains and beaters that are serviceable through access doors. The use of auxiliary safety shields is unnecessary, and one can note that the design is simple, clean, and attractive. This provides an opportunity for aesthetic styling and allows for a new higher level of implement safety and cleanliness.

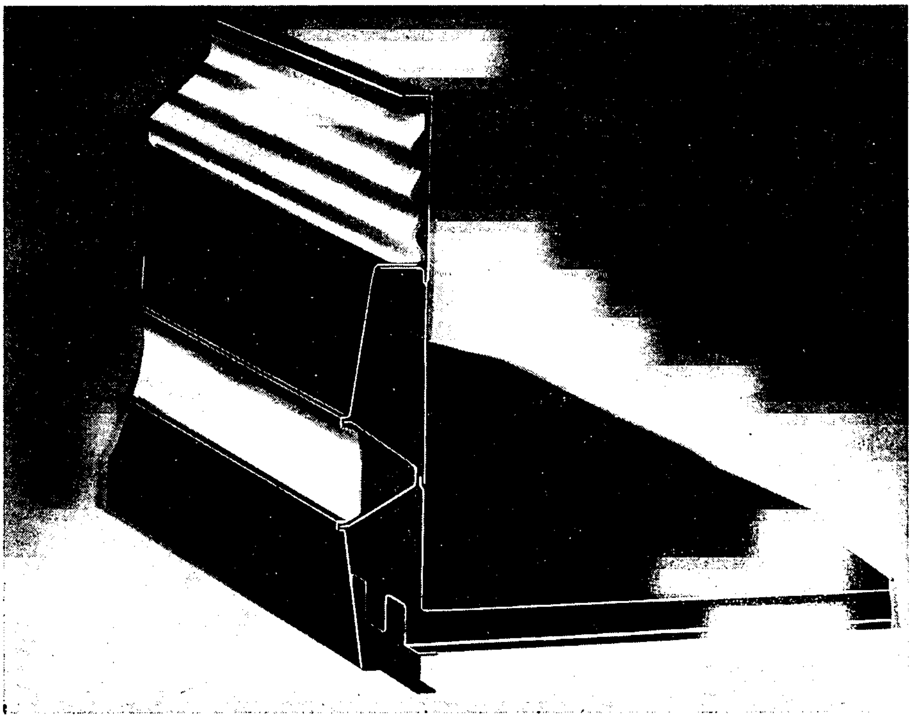


Fig. 3

The hitch frame is made of rectangular tubing. The manure spreader design also incorporates suggested use of 4-wheel independent suspension that is supported on transverse torsion rods concealed in the corrugated floor section. This suspension should reduce shock loads on the spreader when transporting over rough ground at high speeds thus permitting lower cost construction.
Further, use of torsion rod suspension springs provides a convenient means of raising and lowering the implement. An outside mechanical or hydraulic power source could easily lower the spreader bed close to the ground for improved rapid transport on roads or in the field. The vehicle could be raised when operating in the field or around the buildings and have the further advantage of giving a variety in the manure distribution pattern in the field.
This design allows for hydraulic wheel brakes that can be actuated by the tractor's hydraulic system or from a cylinder in a telescoping tongue.

Forage Wagon

In *figure 4* we see a new design concept for a forage wagon using many of the design and construction features of the manure spreader. It should be possible to make the lower half of the panel side assemblies and the floor assembly interchangeable on the two implements. Use of independent torsion spring suspension wheels offers a lower center of gravity for this implement. A forward elevator flight is included to achieve a relatively high discharge level for the material being hauled. Of course, there are other acceptable ways of achieving this function. This forage wagon design also allows for rear discharge of the forage into bunker silos. A reversing mechanism reverses the bed flights and the rear tailgate hinges open for discharge.When intended exclusively as a rear discharge wagon, the forward elevator beater and auger section could be replaced by a plain end.

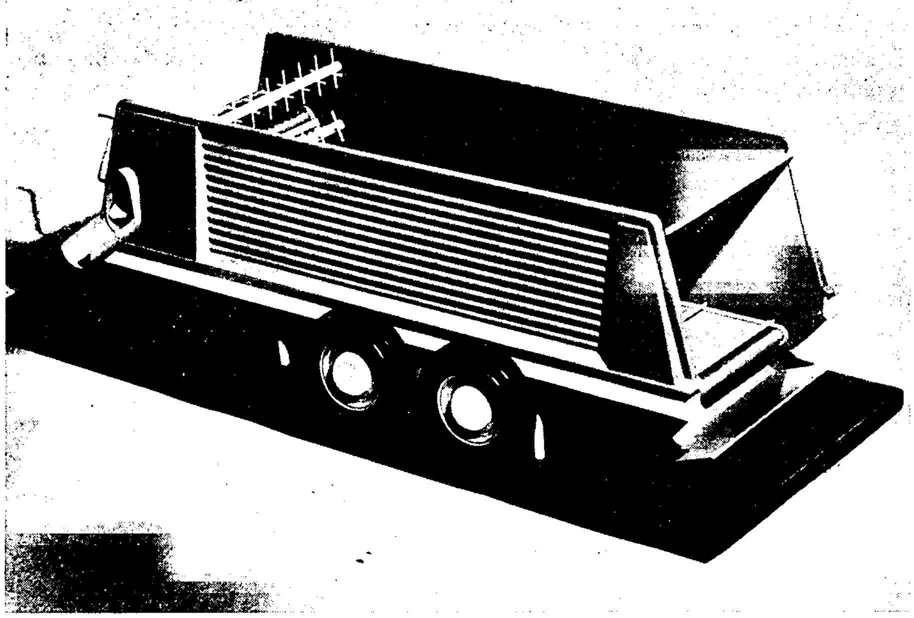


Fig. 4

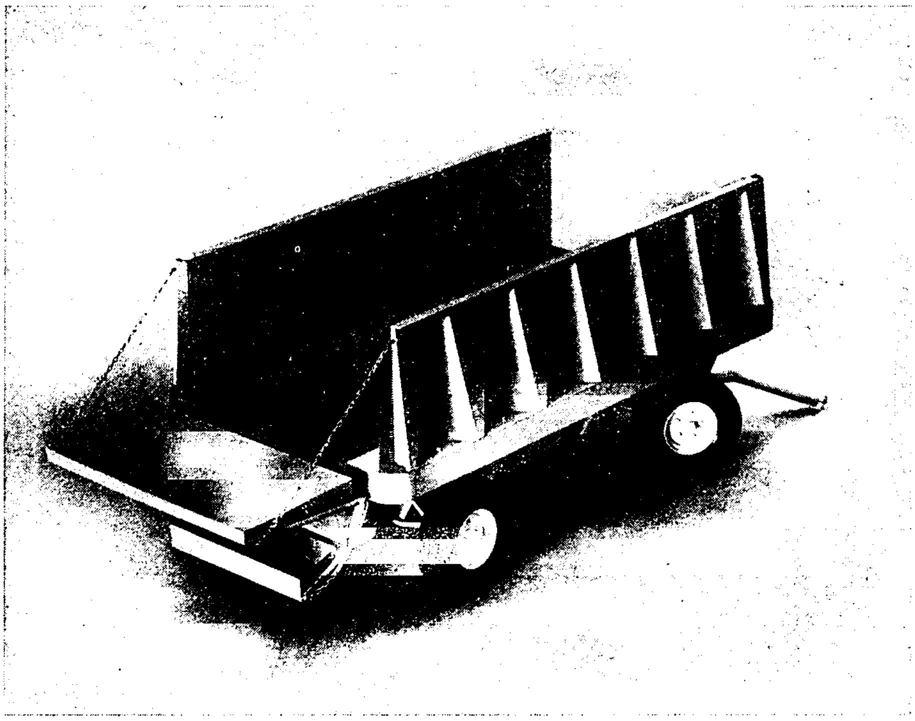


Fig. 5

Unitized Body Farm Wagon

Another concept using panel construction is shown in *Figure 5* in the unitized body farm wagon. This design from United States Steel's Applied Research Laboratory consists of a base body made up by two longitudinal reinforced box beams and a formed pan with a single interior cover sheet. The removable side panels are made of integrally formed post and side sheet sections. The formed post sheet is made by progressively bending a flat rectangular sheet. The sheets can be assembled by welding or adhesive bonding. The unit body pan permits an approximate 25 per cent increase in volume over a flat-bottomed wagon of conventional construction and also results in a low center of gravity. Conventional axles are not required as the body is strong enough to receive the wheels directly, yet it is flexible enough to follow uneven ground. For additional versatility the unit body can be designed to permit removal of the sides and installation of a flat bed for use as a conventional flat bed wagon.

The four models described above were conceived with a view to holding tooling costs to a minimum. Use of die-formed parts was avoided where at all possible. Virtually, all of the sheet metal parts are designed so that ordinary press brake bending would be adequate for their manufacture. Use of the high-strength low-alloy atmospheric corrosion resistant USS Cor-Ten steel for the inner panels should be economical since the thickness of these sheets could probably be as light as 20 or 22 gage. The material in the outer of the side assemblies could be USS Ex-Ten or Tri-Ten high-strength low-alloy steel; or regular galvanized steel could be used. These models are prepared on the basis that these composite materials side assemblies would be arc or spot welded together. However, mechanical lock seam, bolted, riveted, or adhesive bonding might also be economical methods of assembly.

Triangular Panel Construction

The previous four fabricated panel design studies have shown some of the opportunities to improve the strength, rigidity, corrosion resistance, and appearance of certain agricultural implements at a minimum cost and with weight held to a minimum. They involved examples in which implements of rather conventional shape were illustrated. Let's now examine the opportunities that unfold when we use triangular shaped panels in the construction of agricultural haulage implements.

Most engineers recognize that the basic triangular shape is inherently strong and results in economical use of materials. The four design concepts that follow are generalized examinations of the possibilities of the triangular shape in panel construction. Lateral rigidity of any individual panel is achieved from the adjacent intersecting panel.

Auger Self-Unloading Wagon

Figure 6 illustrates a 4-wheel auger self-unloading wagon using frameless triangular panel body construction. The parts for this wagon can be manufactured by press brake equipment and require a minimum of tooling.

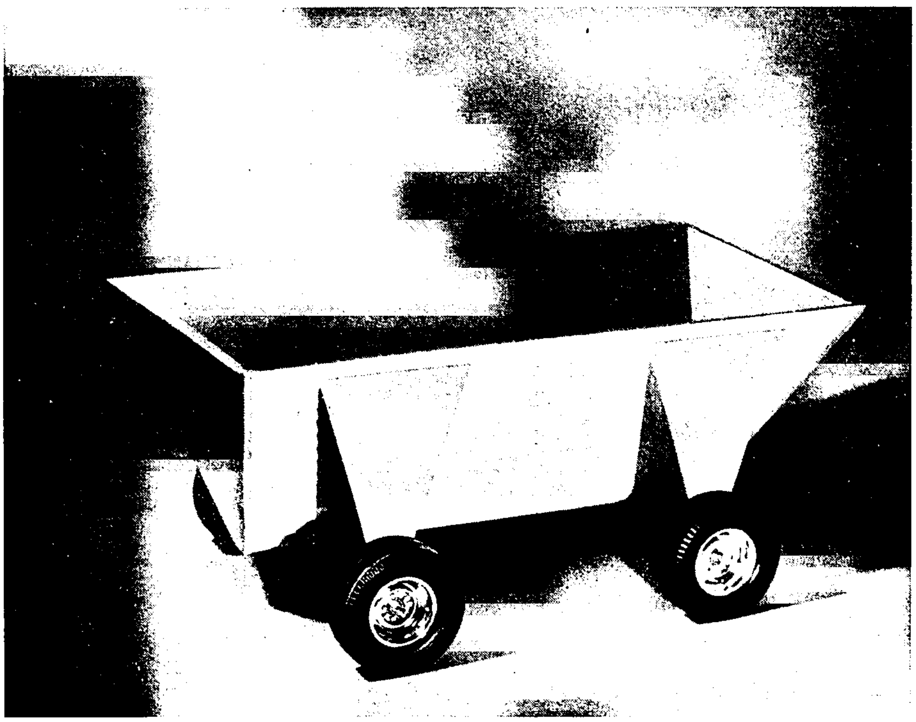


Fig. 6

Corrugated steel sheets are bonded to flat USS Cor-Ten steel sheets to provide rigid, strong, light-weight wagon body side panels. Ends of the corrugated sheets could be either filled with sealant or left fully exposed for drainage to minimize corrosion. It should be economical to secure an adequate structure by use of present-day commercial adhesives. Rectangular tubing is used for the wagon axles.

General Purpose Two-wheel Trailer

Figure 7 is a variation of the triangular panel construction described above for the auger self-unloading wagon. The floor of this two-wheel general purpose trailer is 6 sided. The triangular shaped side panel from the axle to each end panel constitutes a very strong structural assembly. This trailer suggests just one of the design possibilities that can emerge when the engineer is willing to depart from the traditional rectangular shape of these implements.

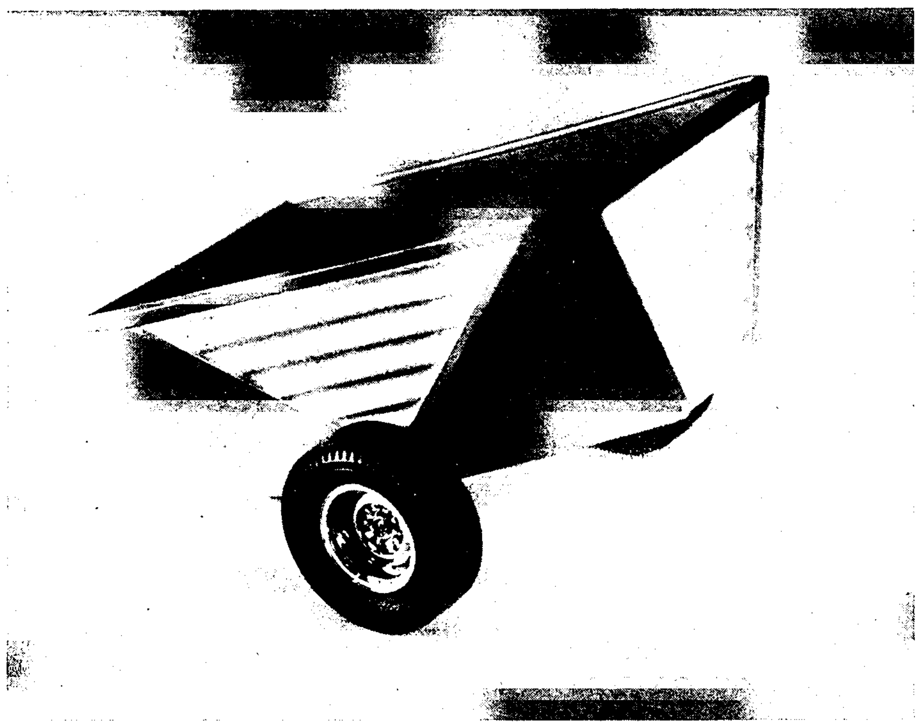


Fig. 7

General Purpose Four-wheel Trailer

Another variation of trailer design using panel construction in which the traditional rectangular floor of the trailer is maintained is shown in *Figure 8*. This variation is achieved by using long side panels with diamond-shaped corner panels in each of the 4 corners of the trailer. The side and end panels are bent in the middle on a longitudinal axis to provide mutual stiffening to the upper and lower halves of these sides. Additional strength is imparted to these large panels by bonding corrugated sheets to them with commercial adhesives. All parts for this trailer body can be formed on conventional press brake equipment.

Sprayer Tank

Figure 9 illustrates a low-cost tooling possibility in preparation of an agricultural chemical sprayer tank design when departure from round shape is considered. The main sheet of the sprayer tank is formed on press break equipment and has 8 flat sides. The end sheet has a wedge-shaped portion removed so that when this split is rejoined by welding, the end has a conical shape to provide required strength characteristics. The 8 flat sides of the tank are given additional support by bonding corrugated panels to them.

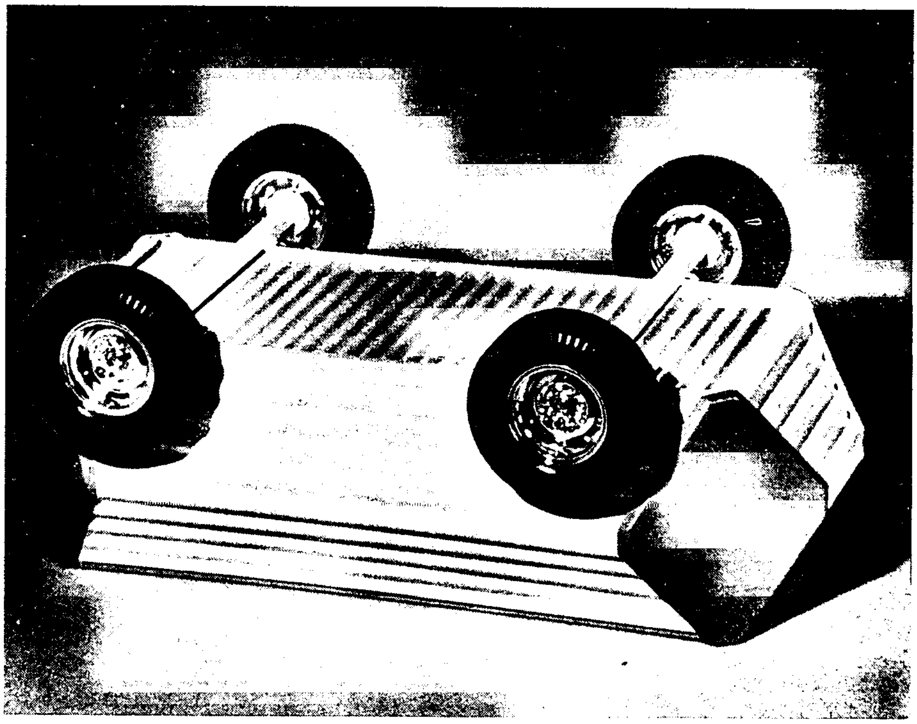


Fig. 8

This design should offer a manufacturer the opportunity to make agricultural chemical tanks with a minimum investment in tooling. Further, the steel in contact with the corrosive chemicals can be thin gage stainless steel with additional structural support provided by the bonded corrugated outer steel sheet of galvanized steel or painted carbon steel.

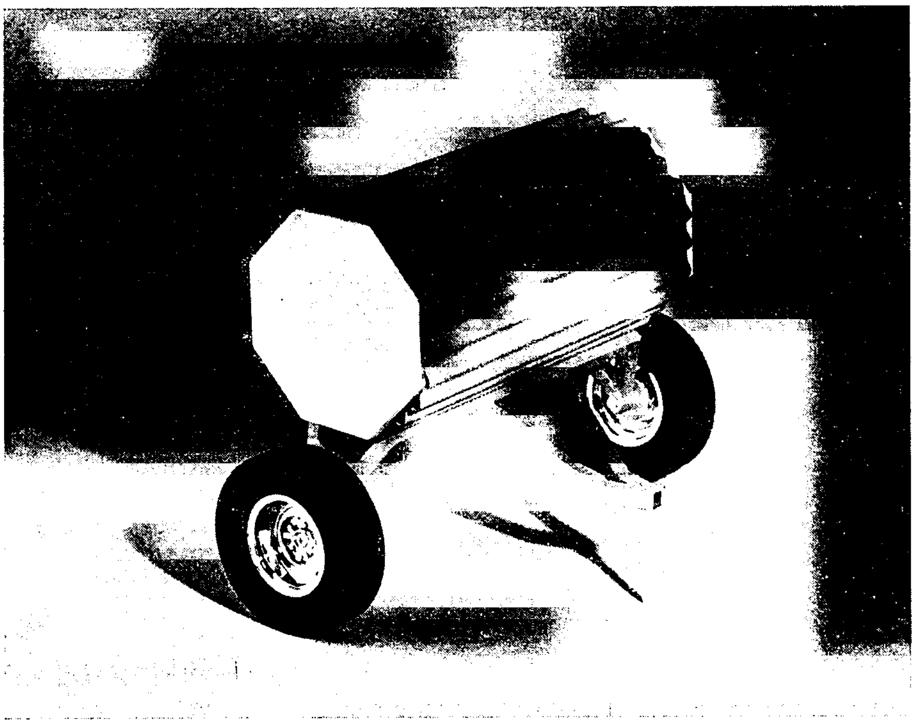


Fig. 9

Cabs, Reel Slats, and Shields

Another important design activity in tractors and self-propelled equipment exists in the area of cabs and operator comfort. Let's explore some engineering innovations with steel for tractor cabs and seats.

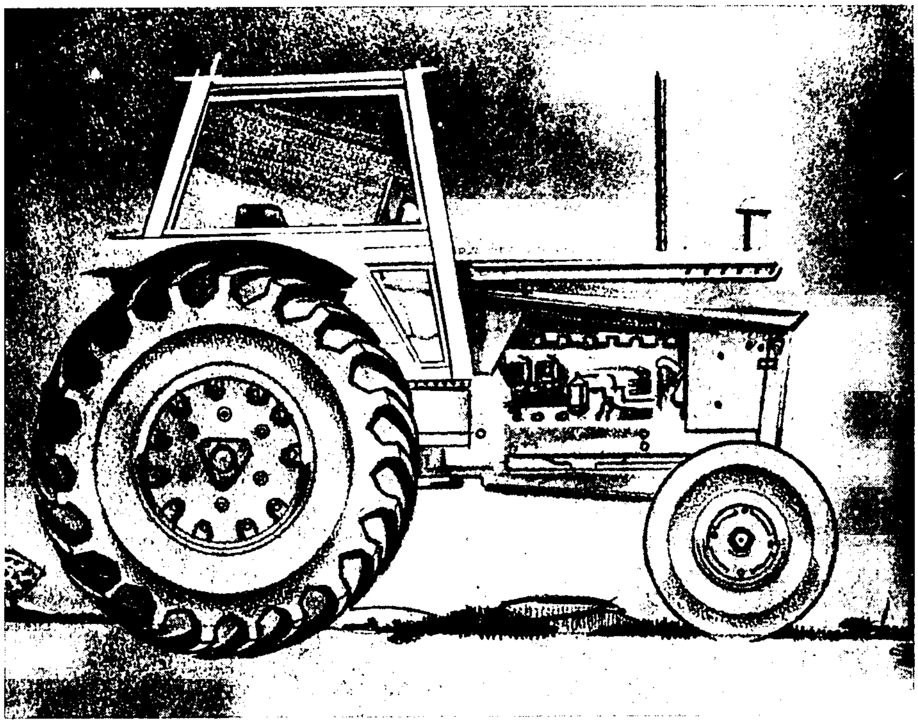


Fig. 10

We see in *Figure 10* a picture of a conventional tractor with a cab design that blends with its design. *Figure 11* is the same general cab design added to a concept of a futuristic agricultural tractor.

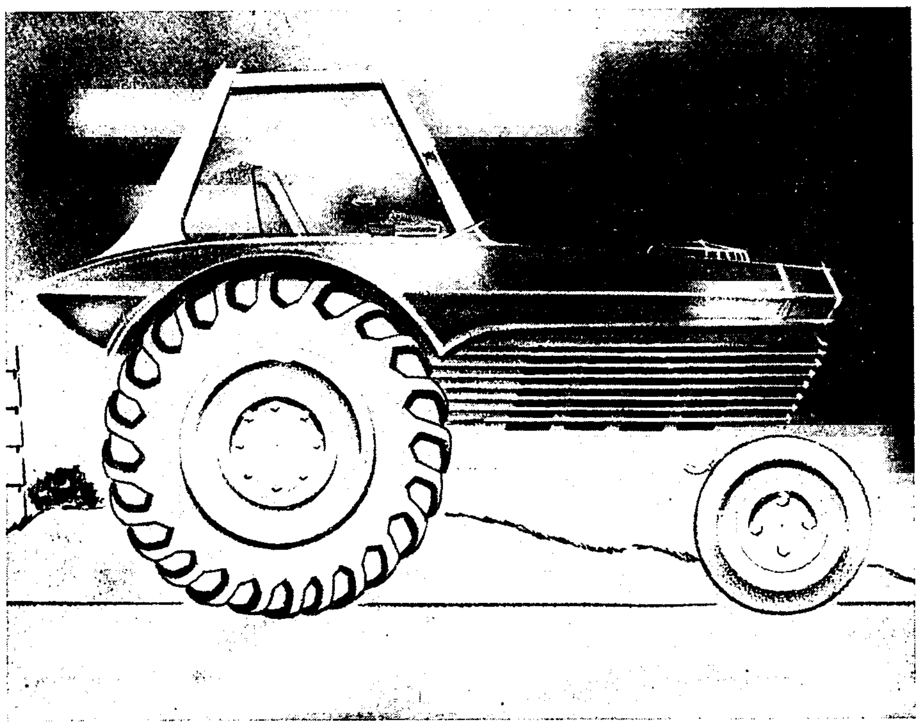


Fig. 11

Figure 12 and *13* illustrate this same cab configuration adapted to a concept of a current and futuristic self-propelled combine. It is significant to note that the same general cab configuration can be adapted to current and futuristic concepts of tractors and self-propelled combines.

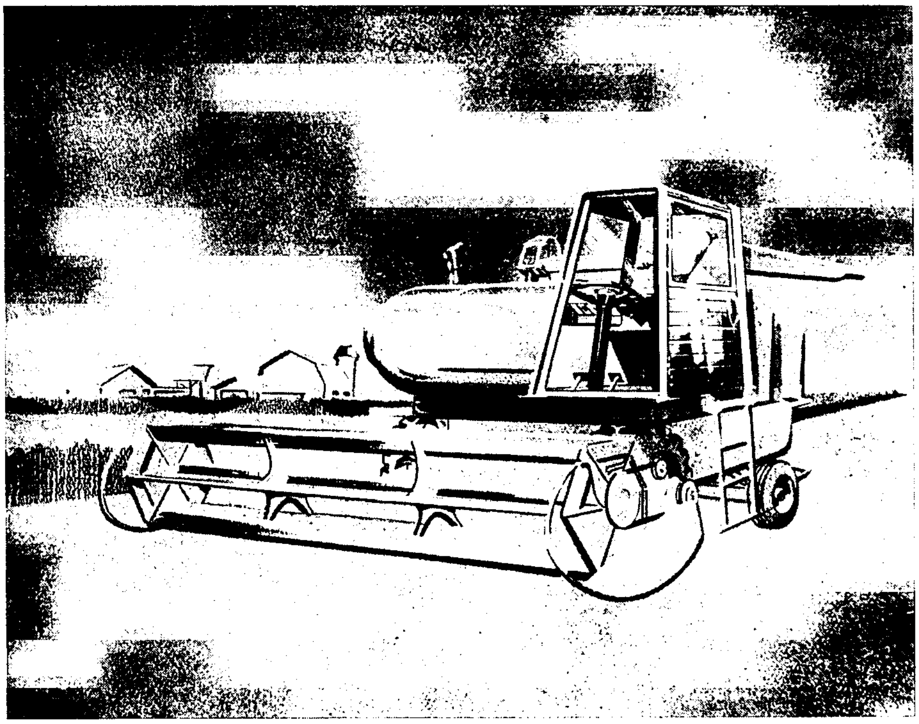


Fig. 12

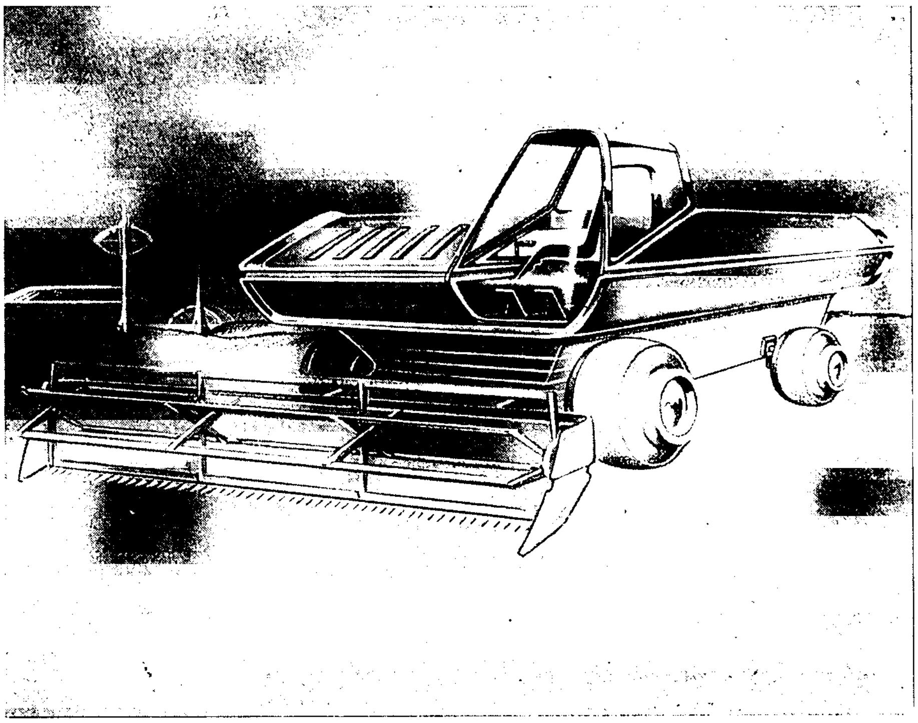


Fig. 13

Let us examine closer a general cab design. *(Fig. 14)* This cab should be adaptable to any of the four machines previously mentioned. *Figure 15* is an exploded view of what it would take to make this suggested all-purpose cab. The main frame members, front and rear, are made from a special rolled steel section. These frame members should be strong enough to protect the operator in the event of accidental upset of the tractor or self-propelled implement. The side, rear, front, and floor panels of the cab are suggested to be made from steel sandwich panels. Steel sandwich panels provide very strong, rigid construction with low weight. They further assist in heat and sound insulation of the operator from the machine. The sheet steel roof has a foamed plastic inner liner to provide noise absorbing and heat insulating qualities. It will also be soft to the operator's head if accidentally bumped. The window frames for both of the doors as well as front and rear windows can be made from special rolled steel sections or steel extrusions.

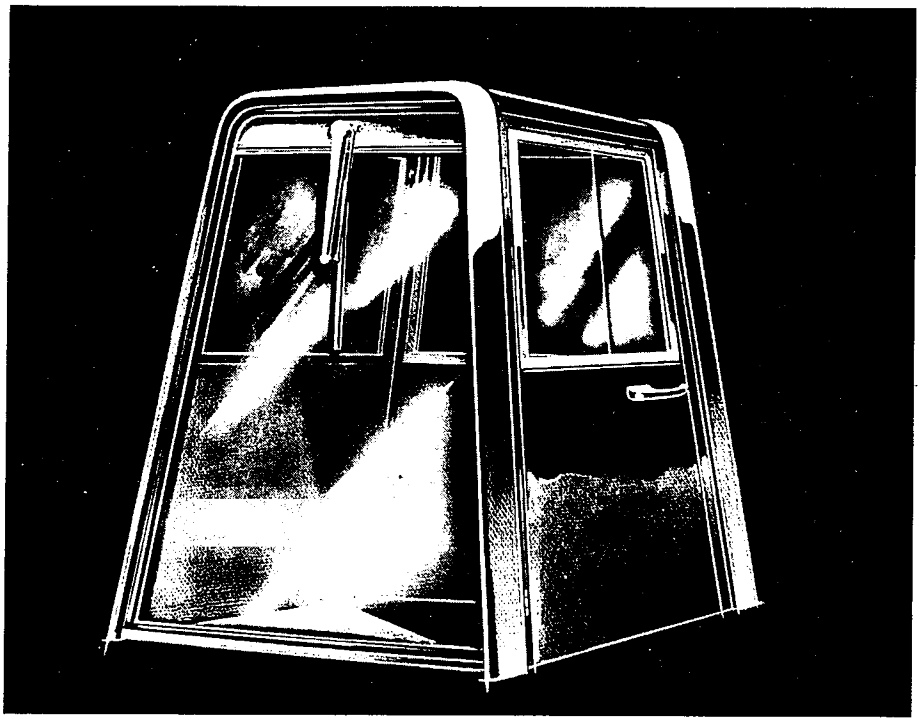


Fig. 14

Thus far we have examined a rather conventional cab configuration adaptable to either current or futuristic tractors and combines. Let us look at even more futuristic cab designs.
The two following futuristic cabs give recognition to the current trend in agriculture toward larger farms in the United States. These larger farms mean that the operator will have to travel farther distances from his farm home to his crop fields and will frequently be gone from the house from morning until evening. This requires that he must have food and beverage conveniences with him in the cab.

Fig. 15

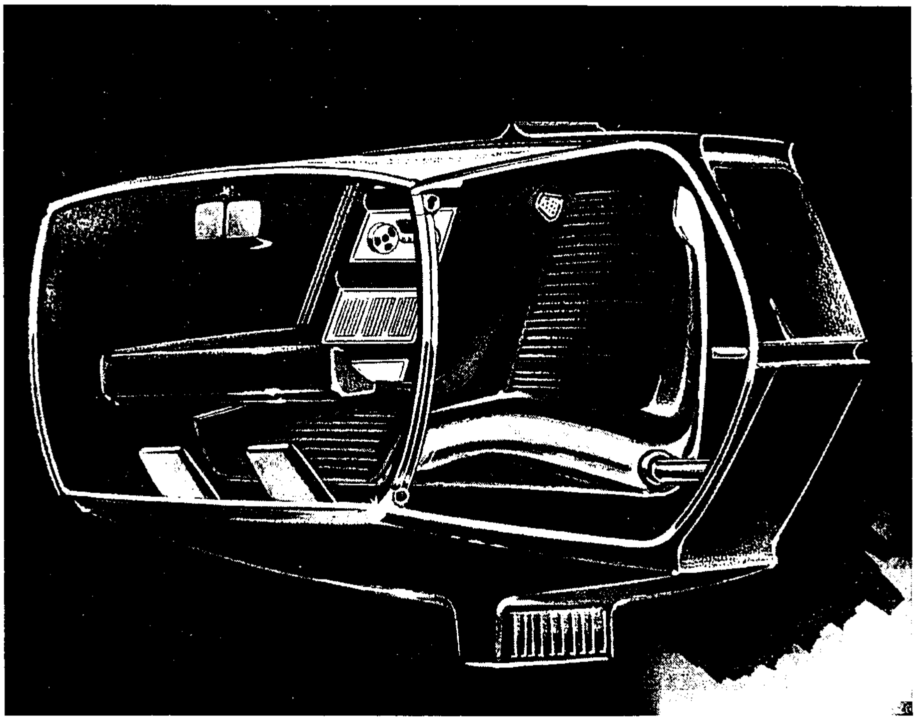


Fig. 16

Figure 16 is the exterior view of the first futuristic cab concept in which special attention has been paid to operator visibility, comfort, and safety. *Figure 17* is an interior view of this cab. It features a contour seat with all the instruments and controls placed on a console in front of the operator. The steering is by hand grips mounted on the console. There is a closed circuit television monitor screen in the roof of the cab to allow the operator to monitor the machine operation to the rear of the tractor or possibly to monitor the interior of a harvesting machine such as the threshing action of a combine.

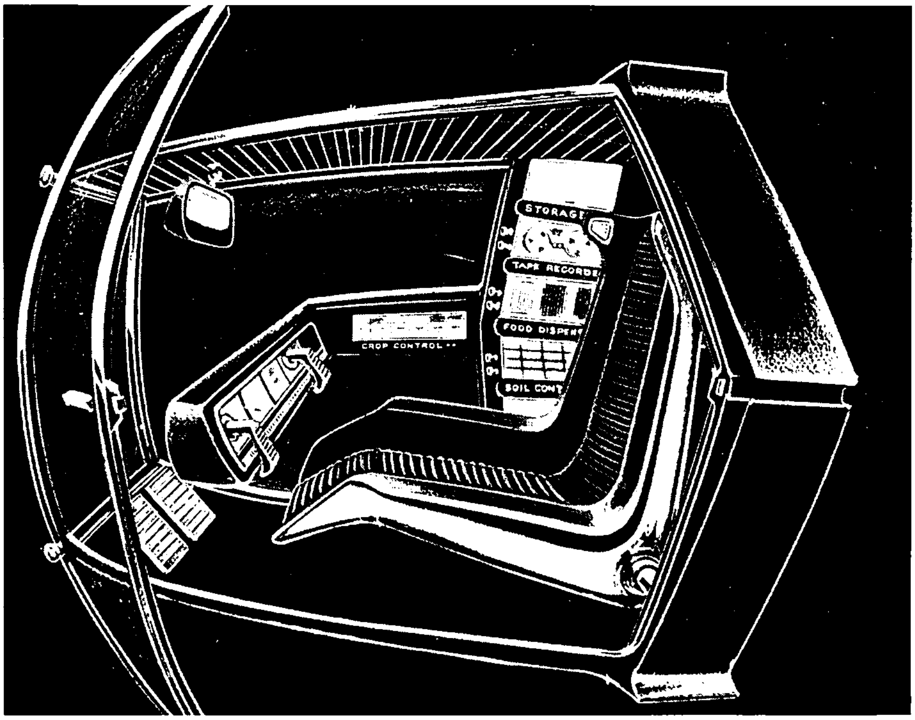


Fig. 17

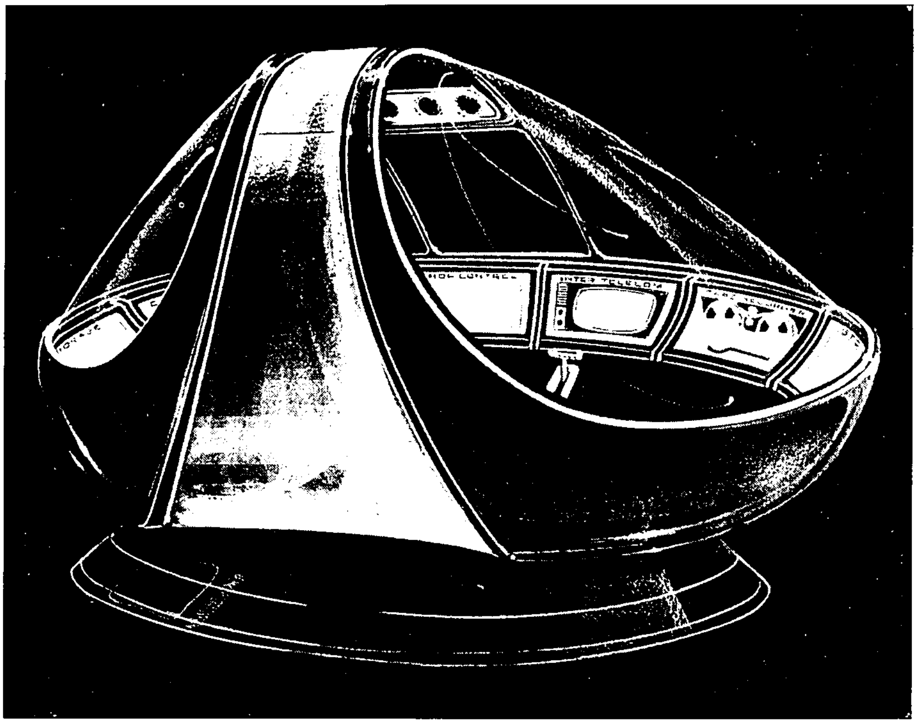


Fig. 18

Figure 18 is a second concept of a futuristic cab. This exterior view shows a cab which again pays special attention to operator visibility, comfort, and safety but has the added feature of a rear access door for applications that need this feature. *Figure 19*, the cab interior, shows the upholstered seat with the attached arm rest, console constrols, and steering. Several compartments around the perimeter of the cab are featured. This includes a storage compartment for general purpose items, a beverage storage center, a soil control monitor center, a crop control monitor center, a closed circuit television monitor, a tape recorder, and a food center.

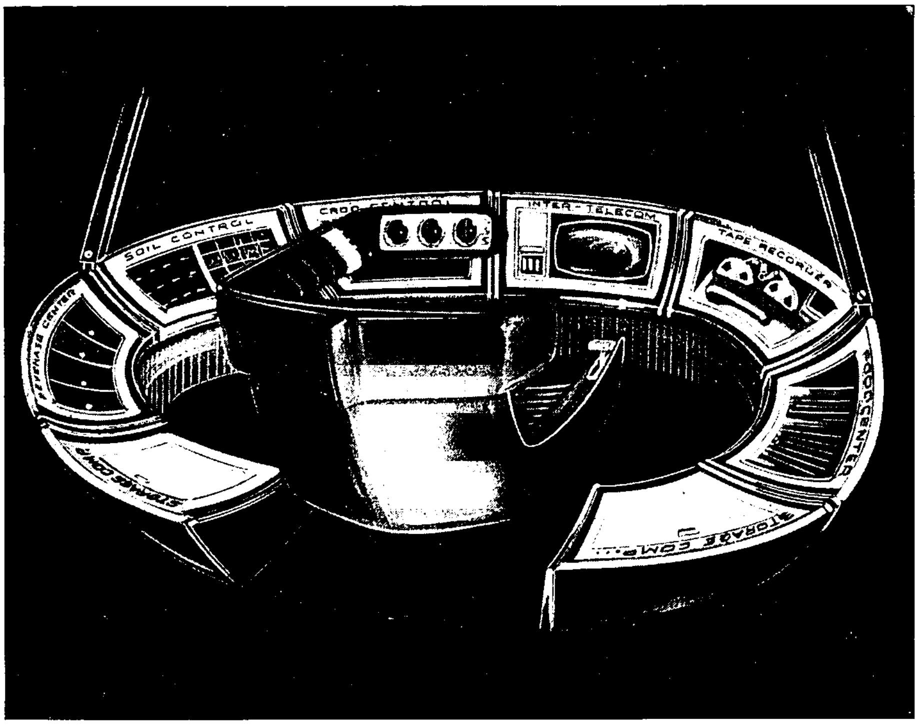


Fig. 19

Combine and windrower reel slats provide an opportunity for innovations in steel to replace the wood often used. *Figure 20* illustrates four design concepts of combine reel slats using very thin gage steel. Each of these designs achieves greater strength by making a closed formed section anticipating a reel slat that is strong, light weight, and having excellent torsional strength.

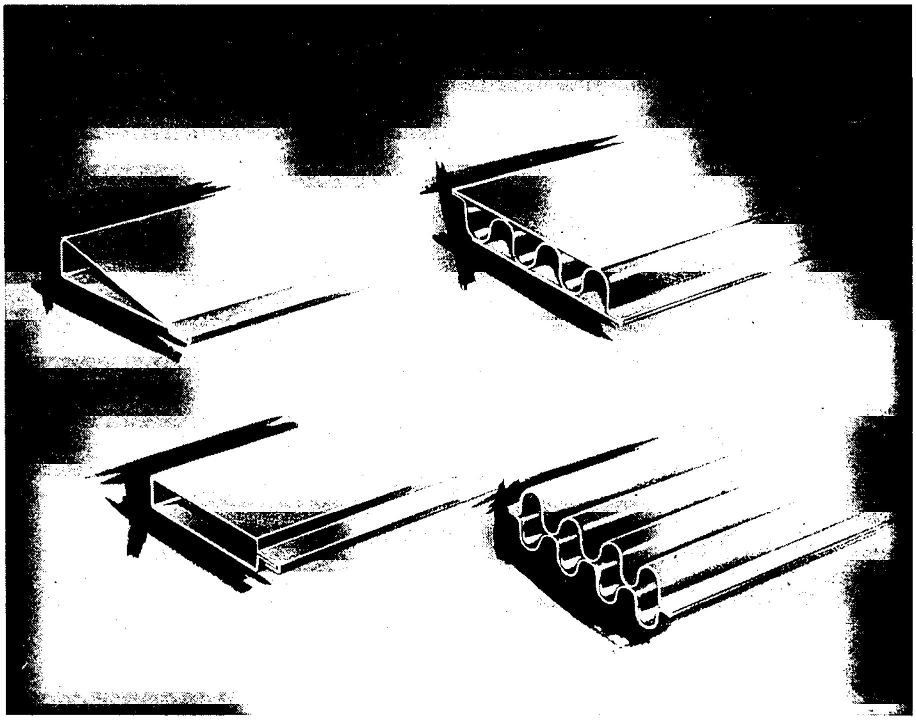


Fig. 20

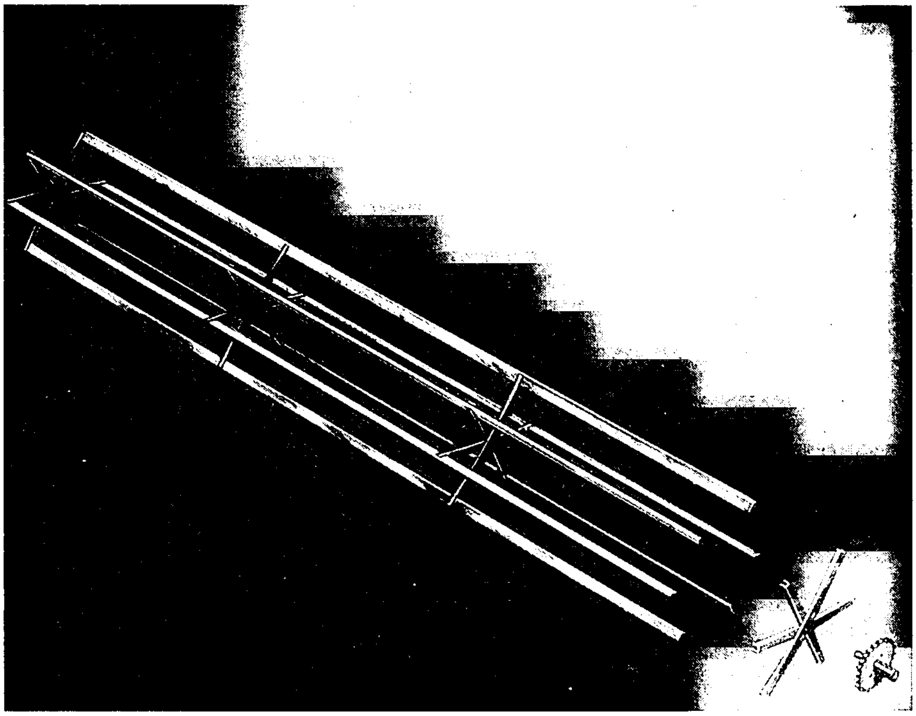


Fig. 21

Figure 21 is a concept of a combine reel assembly using steel reel slats. The reel spider assemblies, made from a simple sheet metal stamping, are designed to exclude dirt and water from the slats when attached to the open ends.When the ends of similar reel spiders are notched, they can be used as the center spacers in the

reel assembly. The excellent strength capabilities of a steel combine reel slat should make it unnecessary to add a center shaft to the reel assembly.
Another interest area involving innovations in steel for agricultural equipment is for safety shields on powered machines, *Figure 22*. Safety shields can be made using decorative steel wire mesh instead of flat sheet steel. This provides a shield design that is attractively styled, ventilated and open to permit escape of chaff and dirt. Greater safety is another feature of this safety shield because of the ability to visually inspect the rotating parts behind the shield. Too frequently the farmer is tempted to remove and discard a safety shield when he is not able to see what is happening behind it. This concept should remove this temptation because visual inspection through the decorative wire mesh is possible.

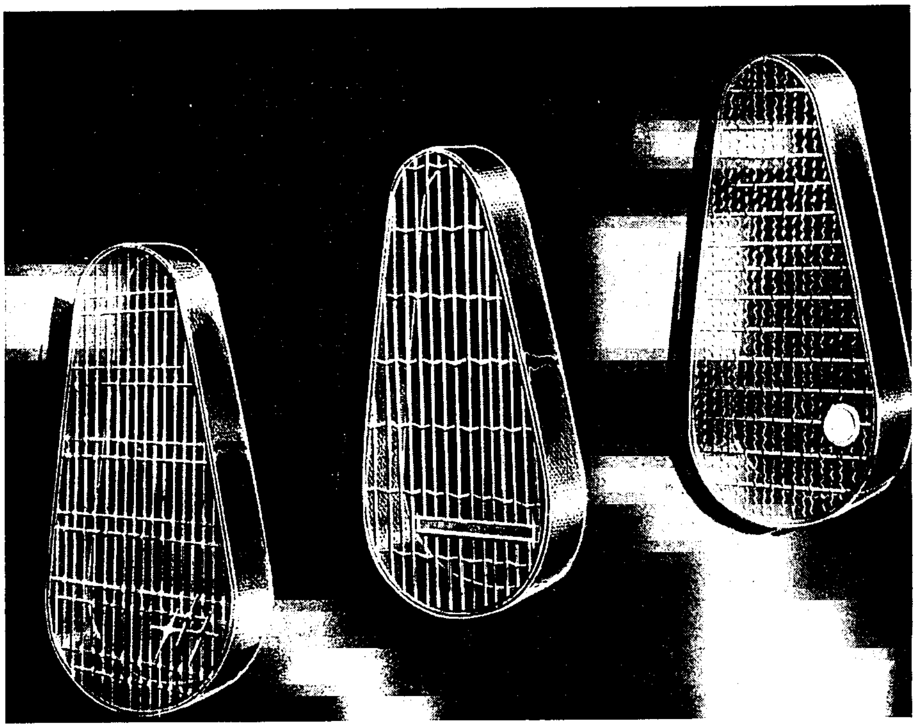


Fig. 22

Systems and Other Trends

Thus far we have described some rather specific design efforts, but there are other systems and trends in which we are interested.

Livestock Systems

There is a definite trend in the United States agricultural industry toward innovations in livestock systems. *Figure 23* is a photograph of a scale model that United States Steel Corporation has prepared illustrating a dairy cow farmstead system. The grain and silage are stored in steel silos and bins and are distributed to the feed mixing area by augers and conveyors. This system envisions a free stall loafing barn in which most of the cows' ration is distributed. The aisle of this barn has slotted floors through which the animal manure falls. It then is washed into a liquid manure storage tank.
A tractor driven steel circulation pump agitates the liquid for bacteria decomposition action and also serves as the pump for loading the liquid manure spreader. Two types of liquid manure spreaders are shown. The model also shows the steel dairy milking parlour and its equipment.

Fig. 23

Handling Agricultural Chemicals

The use of agricultural chemicals in the United States is increasing steadily both in volume marketed and in variety of chemicals. More than six years ago, United States Steel Corporation embarked on a program to study the corrosive effect of many of these fertilizer, herbicides, and insecticides on a variety of materials including aluminium and fiberglass and several steels. The results of field service tests were prepared and published as a technical article. A summary of this work is shown in the *table*. Since this work was done, still newer agricultural chemicals have entered the scene complicating the corrosion story even further. This is a continuing work, but we are convinced that USS stainless steel will gradually be recognized as the appropriate agricultural chemical tank material of the future.

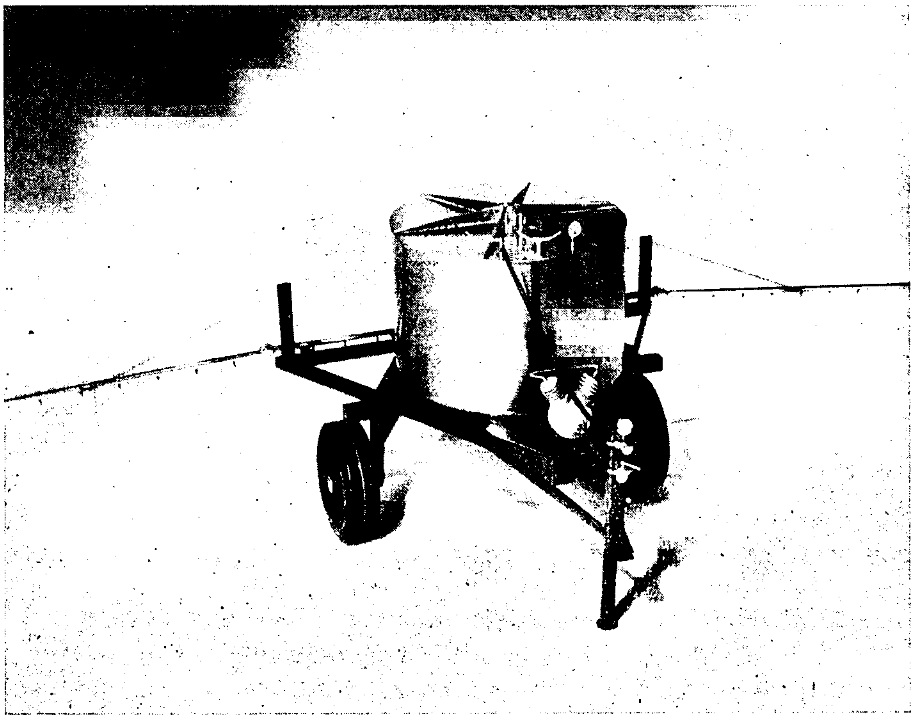


Fig. 24

My firm is also interested in more economical design of stainless steel liquid fertilizer applicators. For example *figure 24* is a scale model of a design concept prepared by our Applied Research Laboratory. Thin gage stainless steel of about 18 or 20 gage can be used since the tank stands on end with the bottom supported by a carbon steel plate. Stainless steel piping and nozzles are also recommended. A rapid increase in use of stainless steel is occurring in equipment for the storage, blending, and distribution of fertilizers.

Corrosion Resistance of Tank-Construction Materials to Agricultural Chemicals

Chemical	Material and Rating				
	Carbon Steel	304 Stainless	316 Stainless	Aluminium	Glass-Fiber-Reinforced
FERTILIZERS					
Nitrogen solutions (no free ammonia)	B	A	A	A	A
Nitrogen solutions (free ammonia)	B	A	A	A	C(¹)
Aqua ammonia	A	A	A	A	C(¹)
Mixed liquid fertilizer (1-3-0)	B	A	A	C	ND
Mixed liquid fertilizer (X-X-X)	B	A	A	B	ND
Phosphoric acid (55% P_2O_5) (chloride free)	C	B	A	C	A
Phosphoric acid (55% P_2O_5) (300 ppm chloride)	C	C	A	C	A
INSECTICIDES					
Aldrin (1 oz/gal)	B	A	A	A	A
Aldrin (100%)	C	A	A	C	ND
BHC (1 oz/gal)	B	A	A	B	A
Calcium arsenate	A	A	A	ND	ND
Chlordane (¹/₄ lb/gal)	B	A	A	B	A
DDT (5% in water)	B	A	A	A	ND
DDT (10% in water)	C	B	B	C	ND
DDT (paste)	B	A	A	B	A
Dieldrin (1 oz/gal)	B	A	A	B	A
Dieldrin (10%)	C	A	A	C	ND
Lead arsenate (100%)	ND	A	A	C	ND
Parathion (0.5%)	B	A	A	A	A
Parathion (10%)	C	A	A	C	ND
Toxaphene (10%)	C	B	B	C	ND
FUNGICIDES					
Copper sulfate (10%)	C	A	A	C	A
Pentachlorophenol	A	ND	ND	ND	ND
Carbamates (5%)	B	A	A	A	A
Mercuric chloride (10%)	C	C	C	C	ND
Sulfur (100%)	A	A	A	A	ND
Zinc sulfate (10%)	C	A	A	B	ND
HERBICIDES					
2,4-D (3 oz-gal)	B	A	A	B	A
2,4,5-T (3 oz/gal)	B	A	A	B	A
Sodium TCA (1¹/₄ lb/gal)	C	A	A	C	A
Sodium chlorate (10%)	ND	B	B	B	ND
Sodium arsenite (8 oz/gal)	A	A	A	C	ND
Arsenic acid (10%)	C	B	B	C	ND
DEFOLIANTS					
Magnesium chlorate (10%)	C	A	A	C	A

(¹) Resins used to formulate glass-fiber-reinforced plastics vary in their resistance to alkaline solutions. Solutions containing free ammonia should not be carried in a plastic tank unless the tank is recommended specifically for alkaline solutions.

Key to Symbols:
A. Resistant to corrosion. Should provide long service life with little maintenance. (Corrosion rates at ambient temperature are generally less than 0.002 inch per year.)
B. Moderately resistant.Will corrode to some extent. Maintenance and eventual replacement may be necessary. (Corrosion rates of ambient temperature are generally between 0.002 and 0.020 inch per year.)
C. Not resistant to corrosion and not recommended for continuous use. (Corrosion rates at ambient temperature are generally greater than 0.020 inch per year.)
ND. No data.

Sources of Data:
1. D. C. Vreeland and S. H. Kalin, Corrosion, Vol. 12, No. 11 (1956) p. 569t.
2. G. S. Cook and N. Dickinson, Corrosion, Vol. 6, No. 5 (1950) p. 137.
3. C. F. Schreiber, Corrosion, Vo . 11, No. 3 (1955) p. 119t.
4. G. A. Nelson, Corrosion Data Survey, Shell Development company, Emeryville, Calif., 1960.
5. Technica Bulletin No. 960, Hanszen Plastics Co., Dallas, Texas.

Fruit and Vegetable Harvesting

The importance of mechanized fruit and vegetable harvesting grows both as our population increases and as the availability of farm labor decreases. There is considerable research throughout the United States aimed at mechanizing the harvesting of fruit and vegetables, and this surely will open new important steel markets.

At the present time tomato harvesters are available commercially in the United States. They will pick up to 15 tons an hour. Apples, cherries, and nuts are shaken off trees and caught in catching frames. Tree shakers are being used experimentally for harvesting other tree fruits such as citrus fruit, pears, peaches. Experimental harvesters are available to harvest strawberries, cucumbers, asparagus, and grapes. Other experimental machines are being used to selectively harvest asparagus, lettuce, and cantaloupe. These machines use sensing devices to "feel" the lettuce, for example, for size and firmness. If both are up to standard a signal actuates a knife and in a fraction of a second the proper head is cut and elevated out of the row. The machine does not slow down.

An experimental asparagus harvester uses photo-electric cells to select the proper spears for cutting out of the row.

Fruits and vegetables which here-to-fore have defied mechanical harvesting are now subject to the efficiencies of mechanical harvesting and handling now enjoyed by field crops.

The harvesting equipment for each of these crops is an innovation in itself. But the methods for handling fruits and vegetables from the harvesters to the processing plants deserve innovative approaches too. *Figure 25* shows an example of steel wire mesh bulk bins which may be used to transport fruits and vegetables in bulk to processing plants from the field.

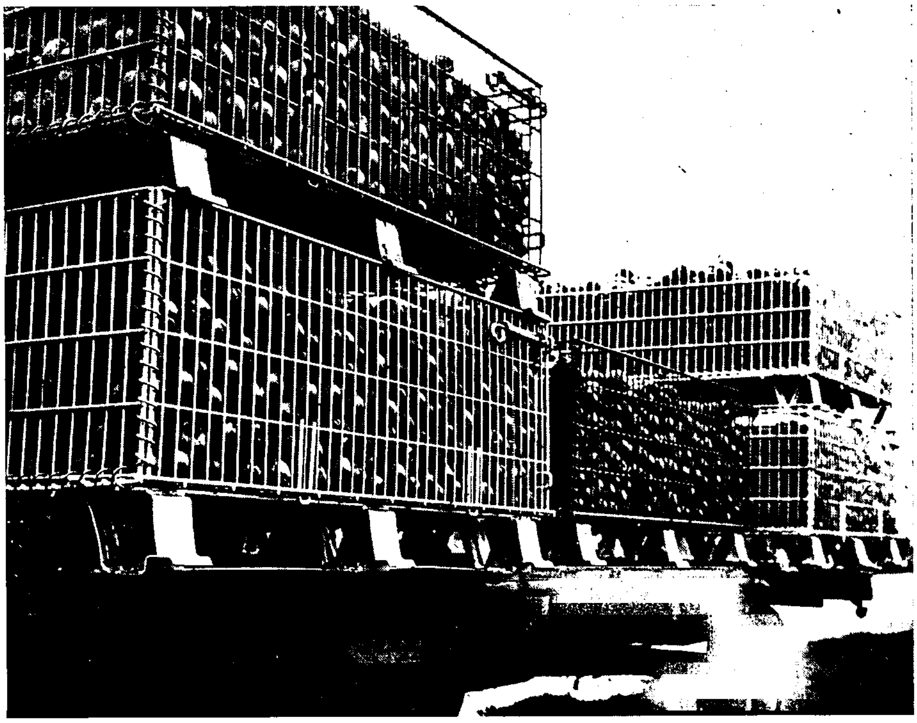


Fig. 25

The wire mesh bin has advantages in cooling the produce and in allowing debris to fall out. The wire size and spacing is critical in minimizing crop damage but a wire mesh bin design has been used successfully to handle and haul tomatoes.

Bins of sheet steel have the preference in handling produce which must be ice-packed, protected from air dehydration in transit, or transported in water.

This paper has presented futuristic concepts to illustrate how some of the requirements for the mechanization of agricultural production can be met. It has also provided reasons why steel marketing men need to be familiar with these requirements in order to successfully market their company's products to the agricultural equipment industry. It is believed that the subject matter presented in this paper, when applied more specifically to European conditions, can be a valuable aid in marketing your steel products.

Prof. Ir. A. HOROWITZ

Technische Hogeschool
Eindhoven

The Construction of Agricultural Equipment; Grades and Standardization of the Steel Products Used

(Translated from Dutch)

It may seem banal to begin my introduction, in such company, by saying that not only are we still living in the steel age, but the steel age only began a hundred years ago. This age can be taken as beginning just after the middle of the last century when the revolutionary Bessemer and open-hearth steelmaking processes were brought into use in rapid succession.

For the first time in the history of steel manufacture it then became possible to produce low-carbon and slag-free mild steel in large quantities from the pig iron available in relative abundance and to cast it in ingots. These ingots were then rolled into sheets, bars, and sections, to obtain a high-quality constructional material with outstanding forming and machining properties. This new iron, or rather mild steel, was then increasingly used for mechanical engineering, as well as cast iron and cast steel.

About thirty years ago came the development of electric-arc welding, as a result of which the potential applications of mild steel became even more extensive. It was now a practical possibility to replace cast iron and cast steel structural components with lightweight welded assemblies. Since then new improved qualities of ductile cast iron have been developed and brought into use, while alloy steel is also being more widely employed.

In addition to steel, aluminium—characterized inter alia by low specific gravity, easy machinability, and relatively high resistance to corrosion—also became more widely used, while in recent years plastics have rapidly become increasingly important as constructional materials.

Although the relative annual production increase in the newer primary materials such as aluminium, and in particular plastics, is considerably higher than that in steel, there is scarcely any suggestion as yet of an incipient aluminium or plastics age: steel still occupies a dominating position in the most important branches of industry. Steel is also by far the most important primary material for the construction of agricultural equipment.

Simple agricultural implements, for example the plough, were originally manufactured by forging. A separate agricultural-machinery industry then slowly developed, manufacturing a large variety of products such as tractors, tillage implements, fruit-processing machines, and many others.

In the last 20 years agricultural mechanization in Europe has been proceeding apace, so that in many countries the agricultural machinery industry has become very large, sales for agricultural implements often equalling, for example, to sales of machine tools.

As already stated, there are many different types of agricultural machines. The industry includes not only large and medium size firms, but also numerous small works where machines and implements are manufactured by mass or batch production, or as individual items, as required.

In all these works, the machining and assembly of rolled steel products are most important operations. Almost all the smaller plants get the necessary castings, forgings, and pressings from specialized firms, while the larger concerns manufacture these themselves.

In many cases, however, a given structural part can be produced from rolled material either as a casting or as an assembly; for these reasons, it is most important for all designers of agricultural equipment to have a knowledge and understanding of the properties of steel products and possible assembly methods.
It is also conceivable that the agricultural-machinery industry will in future use new qualities, shapes, or sizes in addition to or in place of those already customary. As is the case throughout industry, it is chiefly the small and medium-sized works which primarily need to have the required products standardized.
The following is mainly a discussion of the qualities and forms of rolled steel products which can generally be used for the manufacture of agricultural equipment.
As regards assembly methods special attention will be given to welded joints.

Quality

General requirements in respect of the quality of steel used for agricultural equipment are closely linked with the function of the parts produced from the steel.
Closer examination reveals a variety of structures, simple or composite, each of which is characterized by its function; they can be divided into the following main groups:

(a) Structures primarily intended as connecting, supporting or encasing elements, and not required to transmit particularly high forces or capacities; they should be reasonably resistant to corrosion and able to withstand incidental external stresses.
Examples are: chassis and frames, vehicles, containers, tanks, control mechanisms, etc.

(b) Structures which must be able to withstand relatively high mechanical stresses, but have no moving parts or only ancillary ones; in these, light weight and a high degree of wear-resistance are important, while corrosion-resistance is secondary.
Examples are: ploughs, bulldozers, excavator elements, caterpillar tracks and the like.

(c) Structures with moving parts for transmitting or transforming relatively high forces and capacities; in many cases weight and dimensions must be restricted.
Examples are: gear wheels, shafts and transmissions in general for tractor drives and steering systems, and heavily stressed rotating implements.
We shall now consider which types and qualities of material are generally used or may be recommended for the structures mentioned. Such special materials as stainless steels are not considered.

Castings

When possible ordinary cheap grey cast iron is used. For small components, which must not be brittle, malleable cast iron often is used.
If a stronger type of material is needed, cast steel and nodular graphite cast iron are suitable. A characteristic of cast steel is the high mechanical strength which can be obtained, and reletively easy weldability. Nodular graphite cast iron is becoming increasingly important, and in certain cases it can replace the more expensive cast steel. It can be produced in various qualities as regards such tensile strength and elongation, and is reasonably corrosion-and wear-resistant; it cannot, however, be used in welded structures.

Engineering steel

This is suitable for heavily stressed parts in groups (b) and (c) already mentioned, and is usually supplied as bar material or as a forged or pressed semi-finished product. For group (b) ordinary or improved carbon steels are usually satisfactory, for example, st 60 and c 45, or low-alloy steels with tensile strengths up to 60 to 80 kg./mm^2. For tillage implements, manganese steel with higher wear-resistance is often used. Much more effective, however, is a hardening treatment for wearing faces, as applied, for example, to caterpillar tracks and the like. For parts which must be finish-forged and hardened, such as ploughshares, simple water-hardening is practically the only suitable method.
For structures in group (c) alloy qualities such as for example chromium nickel steels often offer great advantages; using these qualities, gear-wheel transmissions and the like can often be obtained in surprisingly small dimensions and thereby give a better and cheaper complete unit.

The engineering steel discussed above is mainly used in groups (b) and (c), in which corrosion-resistance is generally of secondary importance. Parts in group (b) are as a rule sufficiently thick in relation to the strength required and degree of wear occurring to make rusting less of a problem, while the heavily stressed parts in group (c) can usually be satisfactorily protected by oil or grease.

General structural steel

General structural steel for structures in group (a), which in general are subject to relatively light loads, "commercial quality" mild steel (st 00) is in practice often statisfactory, as in the case of ordinary vehicle body manufacture. This material gives good results at the lowest possible purchase price and can be obtained in all shapes and sizes, such as sheets, bars, sections and tubes.Where heavier demands are made, however, it is better to use higher-carbon steels or even low-alloy corrosion-resistant steels.

As the first example we shall take a structural steel st 52 with a minimum tensile strength of 52 kg./mm^2., a yield point of at least 30 kg./mm^2., and fully satisfactory elongation, i. e. altogether 1.5 times as strong as the ordinary commercial quality can be expected to be.

This can lead to substantial weight-saving in many structures, although it must be borne in mind that as regards buckling—which may occur in struts and thin-walled components—the determining factor is not increased strength but constant rigidity or the modulus of elasticity. As the stronger material is satisfactorily machinable and weldable, in many cases the smaller amount used can offset the higher price.

The qualities of structural steel mentioned above rust easily; as they are often used in thin-walled form, it is important to protect them against corrosion by coats of paint. These can be applied very effectively if bright-rolled or bright-pickled material is used. In agricultural equipment, however, the quality of corrosion protection is usually unsatisfactory, while maintenance is often inadequate or not carried out at all.

It is therefore definitely worth-while to investigate whether a corrosion-resistant, low-alloy, relatively cheap steel such as, for example, United States Steel's Cor-ten cannot be used with advantage in certain cases. This steel, which has approximately the same mechanical properties as carbon steel st 52 already mentioned, is perhaps less easily weldable. Under many corrosion conditions present in actual practice, however, it forms a firm brown skin of rust which effectively protects the underlying material from further attack. This corrosion-resistant steel has already been used with success in many applications, including the construction of goods wagons and transport equipment.

The special qualities of structural steel mentioned are not as a rule readily obtainable from stock in all required dimensions and shapes; further, the use of a number of different qualities of structural steel necessitates special care as regards checking and stock control. In view of these difficulties mentioned, and of lack of experience, it is understandable enough that special qualities of structural steel should be the exception rather than the rule in the manufacture of agricultural equipment.

Shape and dimensions

Although methods of manufacturing agricultural equipment generally need not differ from similar constructions in related fields, some unusual features are frequently encountered. These are, however, not only the result of customers' special requirements, such as light weight and high overload capacity: they have also developed from tradition, and the workshop equipment available.

We shall now examine somewhat more closely designs using rolled steel products such as sheets, bars, strip, sections and tubes. In many cases a choice can and must be made between solid-wall and lattice construction; the first-mentioned consists mainly of plates, the second of bars, sections and tubes, intermediate forms being of course also possible.

In most cases the different components are joined by welding. A good designer will try to keep the individual joints as simple as possible, and in many cases this can be achieved by prior cold forming of the components. In general a steady trend is observable from hot-rolled standard sections to cold-rolled thin-walled sections, and from open sections to closed tubes—a movement considerably promoted by the diminishing price disparities for these materials, and by improved welding techniques. There is often a noticeable preference for closed round tubes, mainly because these are easily obtainable in many different sizes, and the round shape, for any given cross-section, gives the best results as regards torsion and buckling stresses. In many cases, however, a square tube cross-section offers advantages design-wise, while if bending stresses tend to occur in a particular direction, oval or rectangular shapes are definitely to be recommended.

It is a striking fact that cold-rolled open sections and non-circular closed tubes have not been systematically standardized, and that manufacturers are still content to use suppliers' lists compiled by rule of thumb. This is quite understandable as regards sections, because the production process is relatively simple, and in addition, special profile sections to suit a specific design can frequently be used with great advantage.

As is generally known, strong light-weight structures can be assembled from sections and tubes; but cases can be mentioned where the use of solid material is definitely preferable. This applies in particular to parts which are mainly subject to bend stresses and have to be able to withstand severe impacts, such as parts for ploughs and digger elements.

To explain this in more detail it is proposed to compare, as an example, the bending strength and bending resistance of tubes and bars, based on the same weight per unit length.

For the sake of simplicity only the round section will be discussed here; the same considerations apply, of course, to other shapes.

Bending strength and bending resistance are usually characterized and assessed by means of the moment of resistance (W) and the moment of inertia (I) of the cross-section. The permissible bending moment is then the product of the maximum permissible bending stress and moment of resistance (W) while the elastic deflection which then occurs is in inverse proportion to the moment of inertia (I).

The maximum permissible stress depends on the quality of material selected and on the type of load; with an alternating load it is considerably lower than with a load which is mainly static in character. For intermittent peak stresses, however, the decisive factor is the "elastic limit," i.e. the stress which just fails to produce a clearly perceptible permanent deformation.

In the case of materials with a distinct yield point and satisfactory elongation such as e.g. most qualities of steel, the "moment of plastic resistance" (P) can now be advantageously introduced. Particularly in a solid cross-section, this is considerably higher than the ordinary moment of resistance and when multiplied by the yield stress of the material it gives what is known as the "(plastic) yielding moment."

A tube of round cross-section can now be characterized simply by the ratio of internal to external diameter. This parameter $q = \frac{d}{D}$ determines the type of tube cross-section; q lies between I and O; for a solid bar $q = O$. From q is obtained the ratio of the wall thickness s to the external diameter D: $\frac{s}{D} = \frac{I-q}{2}$.

F, W, I and P are usually expressed in D and d, but a parameter g and F may also be introduced. This gives us:

$$D = \frac{2}{\sqrt{\pi}} \frac{1}{\sqrt{1-q^2}} F^{1/2}.$$

$$I = \frac{1}{4\pi} \frac{1+q^2}{1-q^2} F^2 \qquad W = \frac{1}{4\sqrt{\pi}} \frac{1+q^2}{\sqrt{1-q^2}} F^{3/2}$$

$$P = \frac{4}{3\pi\sqrt{\pi}} \frac{1+q+q^2}{(1+q)\sqrt{1-q^2}} F^{3/2}.$$

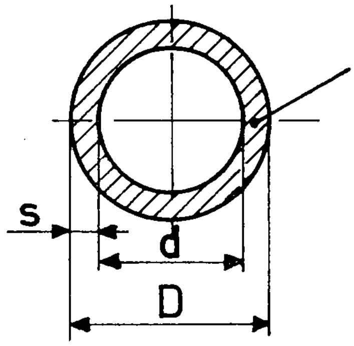
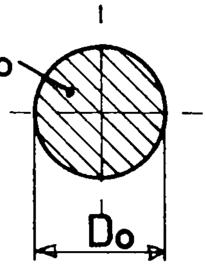
For a solid bar $q = 0$, thus

$$D_0 = \frac{2}{\sqrt{\pi}} F^{1/2} \qquad I_0 = \frac{1}{4\pi} F^2$$

$$W_0 = \frac{1}{4\sqrt{\pi}} F^{3/2} \qquad P_0 = \frac{4}{3\pi\sqrt{\pi}} F^{3/2}$$

If any random tube is compared with a solid bar of the same cross-sectional area the following is obtained:

$$\frac{D}{D_0} = \frac{1}{\sqrt{1-q^2}} \qquad \frac{I}{I_0} = \frac{1+q^2}{1-q^2}$$

$\frac{d}{D} = q$	$0 < q < 1$	$q = 0$
$\frac{s}{D} = \frac{1-q}{2}$		
$F = \frac{\pi}{4}(D^2 - d^2)$	$D = \frac{2}{\sqrt{\pi}} \frac{1}{\sqrt{1-q^2}} F^{1/2}$	$D_o = \frac{2}{\sqrt{\pi}} F^{1/2}$
$I = \frac{\pi}{64}(D^4 - d^4)$	$I = \frac{1}{4\pi} \frac{1+q^2}{1-q^2} F^2$	$I_o = \frac{1}{4\pi} F^2$
$W = \frac{\pi}{32} \frac{D^4 - d^4}{D}$	$W = \frac{1}{4\sqrt{\pi}} \frac{1+q^2}{\sqrt{1-q^2}} F^{3/2}$	$W_o = \frac{1}{4\sqrt{\pi}} F^{3/2}$
$P = \frac{1}{6}(D^3 - d^3)$	$P = \frac{4}{3\pi\sqrt{\pi}} \frac{1+q+q^2}{(1+q)\sqrt{1-q^2}} F^{3/2}$	$P_o = \frac{4}{3\pi\sqrt{\pi}} F^{3/2}$

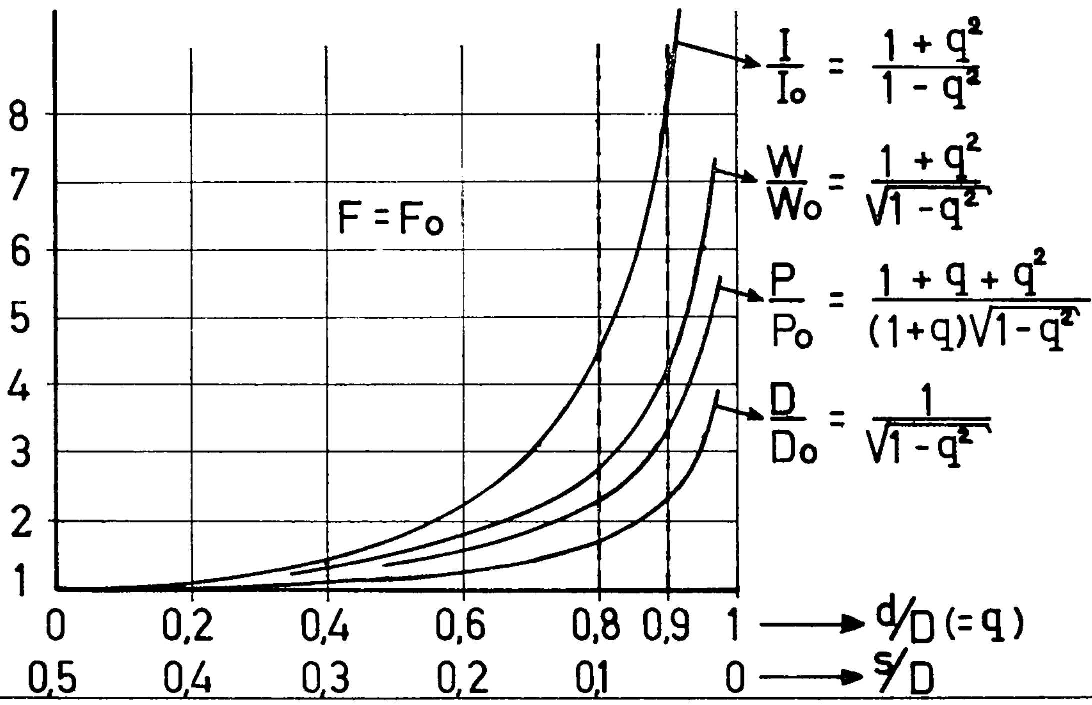


Fig. 1

$$\frac{W}{W_o} = \frac{1+q^2}{\sqrt{1-q^2}} \qquad \frac{P}{P_o} = \frac{1+q+q^2}{(1+q)\sqrt{1-q^2}}$$

These ratios are shown on the graph on p. 204 as a function of $\frac{d}{D}$ or $\frac{s}{D}$.

For the ordinary tubes most often used $\frac{d}{D}$ lies between 0.8 and 0.9, or $\frac{s}{D}$ between 0.1 and 0.05; the range of these values is shown in the *figure 1*.

If now, assuming an identical cross-sectional area, a bar and a tube are to be made equal in strength, the permissible material stresses in the material or yield stresses, must be in inverse proportion to the respective moments of resistance.

Since bars, unlike tubes, can readily be obtained in special qualities, this requirement can be reasonably well met in many practical instances.

A solid construction is much more resistant to impacts, however, as deflection is considerably greater: when the load is the same the impacts are inversely proportional to the moments of inertia.

In addition any permanent deformation can be corrected much more easily.

Finally, a solid component with variable cross-section can be produced fairly easily, and this can lead to considerable savings in materials, as well as an increase in the useful elastic deflection.

A numerical example may serve to make this clear. The graph shows that a bar 25 mm. diameter has approximately the same cross-sectional area as a tube of 50 mm. external diameter and 3.75 mm. wall thickness. The following can now be read off from the graph:

$$\frac{I}{I_o} \approx 6 \qquad \frac{W}{W_o} \approx 3.3 \qquad \frac{P}{P_o} \approx 2.7 \text{ (plastic)}$$

If ordinary commercial-quality steel with a yield point of 20 kg./mm² is selected for the tube and if improved carbon steel C60 with a yield point of 75 kg./mm.² is used for the corresponding bar, the ratio of the yield points for the two materials is $\frac{75}{20} = 3.75$. This is more than $\frac{P}{P_o} \approx 2.7$ so that the bar will have a considerably higher elastic limit than the corresponding tube.

Further, for the same load, deflection of the bar will be at least six times as much as deflection of the tube. Thus, compared with the corresponding tube, the bar can absorb six times as much deformation work, which is particularly favourable for resistance to impact loads.

Considerations such as these can often help designers to make a choice between a tube or solid construction. However, this is not the place to go into this aspect in detail.

Connections

It is certainly not my intention to discuss here all methods of connecting steel components. The many ingenious removable connections and joints often used, particularly in agricultural equipment, will not be considered, nor the modern adhesive connection wich despite its great potentialities is still only used to a very minor extent; only the ordinary, commonly used methods of forming connections such as bolting, riveting, pressing and electric welding will be discussed.

Bolted connections are used for many purposes; their main feature is that they are detachable, while in addition they do not as a rule cause any inadmissible deformation in the parts concerned.

To keep connecting flanges and the like as small and as light as possible, high-quality steel screw bolts with hexagonal heads are commonly used; these are also cheap and easily obtainable.

Riveted joints are now usually only found by way of exception; to all intents and purposes they have been completely supplanted by electrically-welded joints. The use of rivets is limited to a few special cases where it is necessary to prevent play or loosening as a result of vibration, while at the same time keeping the parts replaceable at the cost of a little trouble.

A typical example is the fixing of hardened steel blades in cutter bars.

Pressed joints are also only used in special cases. Dimensions with close tolerances, commonly used in the construction of many machines and tools, are not generally employed. Usually a round pin is pressed into an undersize hole so that the surrounding metal is considerably reamed; for this purpose the pin must

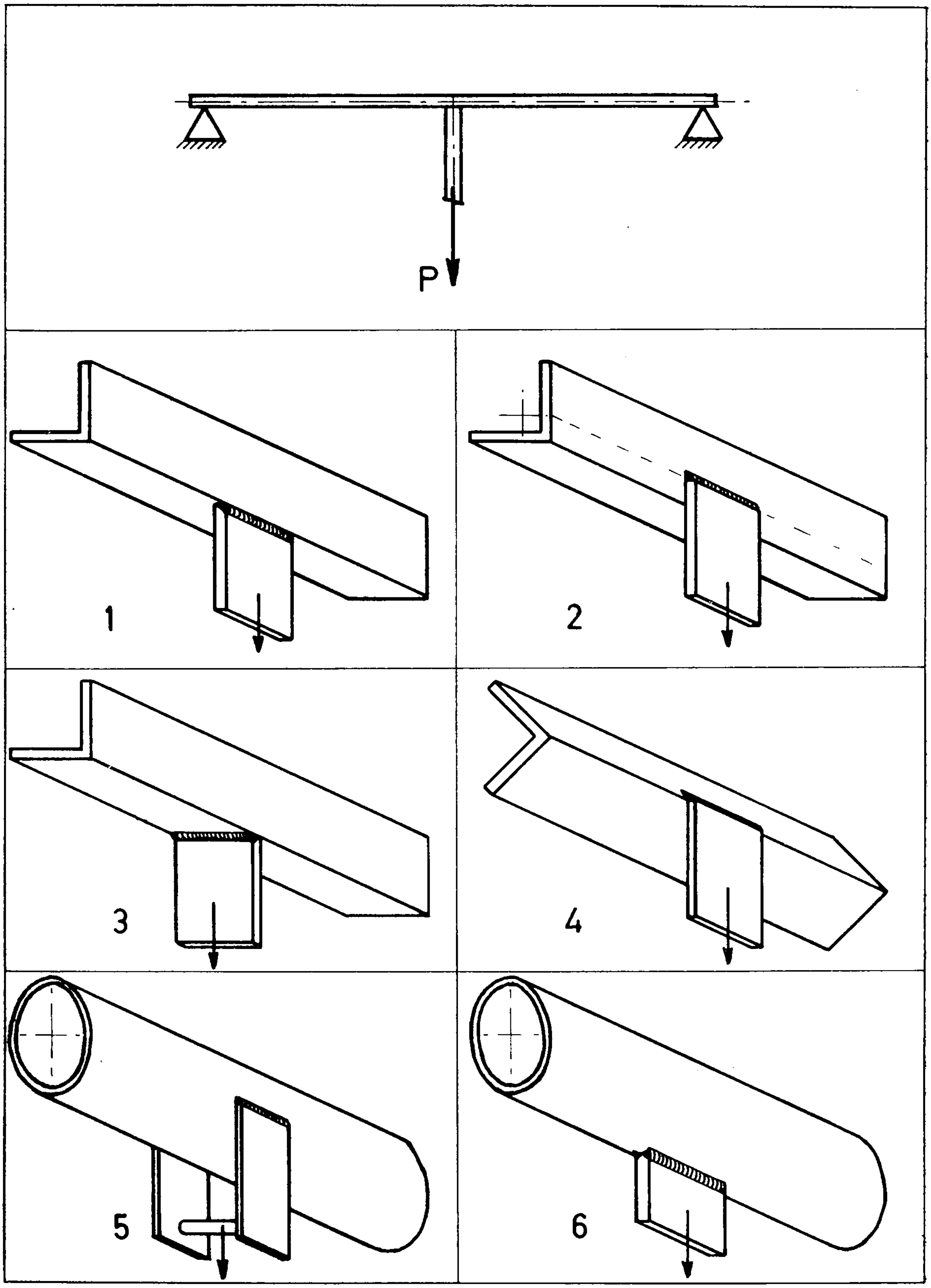


Fig. 2

have a hardened surface and also a sufficiently rounded or conical end. Obviously, this method gives a strong but relatively inaccurate joint. A typical application is the assembly of roller chains and caterpillar tracks. Fixed non-removable connections are usually produced by electric welding, of which there are two main methods, resistance welding and arc welding with electrode material. The first method will not be discussed; it is sufficient to say that in the field of thin sheet-metal work rivets have been almost completely replaced by resistance spot welding.

For all structures made of material which is not too thin, arc welding with electrodes is the usual method. Since this process was introduced about 1930, electrically-welded connections have become increasingly important. This development has been greatly favoured by the numerous improvements and new inventions which have been and are being introduced.

The development of this welding technique will not be considered further here; sufficient to say that this technique is particularly important for the manufacture of agricultural equipment as it can be employed successfully even in small workshops.

When assessing a welded connection a distinction must be made between the quality and execution of the welding operation proper and the structural design of the welds. Although the strength of a weld also depends on the quality of the welding operation, this general aspect will not be discussed here; the structural design of welds, however, will be examined more closely.

A badly designed weld can give rise to local stress peaks in the vicinity of the weld seam, under load. With anotherwise permissible average stress the yield point at these sites can easily be approached or reached, though this will not, as a rule, cause difficulties in the case of a load which is mainly constant.

With an alternating load, however, these peak stresses may cause cracking and ultimate fracture. These dangerous load conditions can occur in service or during transport.

As such structural defects occur regularly, and particularly in agricultural equipment, the correct positioning and design of welds will be discussed in rather more detail.

These points are mainly taken from Prof.Willi Kloth's recently-published work "Atlas der Spannungsfelder in technischen Bauteilen."

In general sudden changes in cross-section should be avoided because they give rise to a detrimental notch effect; further, the weld must be deposited over as large an area as possible and must have sufficient cross-section in relation to the load present.

By far the most serious mistakes are made in cases where a bar is subjected to bending stress from a tension or compression member transversely connected to it and the highest bending moment occurs at the joint. This type of connection will be discussed further by way of example.

There are some guiding principles for correct structural design which will be explained by means of the examples shown in *figure 2*.

(a) Avoid having the weld on the bending member at places where high stresses and deformation are already, i.e. so far as possible select the neutral zone free of stress and deformation.
In this respect only examples 2, 4 and 5 are correct; the others are wrong.

(b) If a connection as recommended under (a) is not possible, the best solution is that which allows the dimensions of the weld in the direction of maximum deformation to be as small as possible. *Figure 3* shows an example of this.

(c) Stresses at right angles to an unstrengthened wall should be avoided in welds.
As regards the bending member, examples 3 and 6 do not meet this requirement at all satisfactorily.

(d) When determining the position of the weld a distinction must be made between tension or compression members and bending members. For the first category the centres of gravity of the weld and the cross-section of the member should so far as possible coincide. For the second category the centre of gravity of the weld should coincide with the position of the centre point of shear force in the cross-section of the member. In a section with two axes of symmetry at right angles the latter coincides with the centre of gravity of the cross-section. If this requirement is not satisfied, this means extra bending and torsion moments and thus extra stresses in the material. In this respect examples 4 and 5 are completely satisfactory, or almost completely so.

(e) Finally a requirement which is so general as to be more or less obvious, but which is often ignored for practical reasons: place bending sections so that they are as strong as possible in relation to the stress. Example 4 is much better in this respect than example 2.

Delegates' Papers and Comments

Rudolf ISSELSTEIN

Ministerialrat
Düsseldorf

Basic Factors in the Mechanization of Agricultural Production

(Translated from German)

It is only in the advanced agricultural countries that either the need or the basis for agricultural mechanization is present in full measure. The great feature of the transition to an industrialized economic pattern is the switch from labour-intensive to capital-intensive operation—in this case, to agricultural engineering and building construction. Agricultural engineering in the broad sense of the term is thus playing a major part in the present farming revolution in many Western countries. Since its impact is far more comprehensive than that of any ordinary productive factor, it has notably conduced to the development away from a subsistence economy towards one based on division of labour, is indeed the prime mover therein.

The function of agricultural engineering is to push up productivity by the judicious use of machine-power, to increase real earnings, and to enable human effort to be more efficiently deployed. Mechanization is not, therefore, an end in itself, but a means to the lowering of agricultural production costs; it improves working conditions on the farm, and at the same time keeps a skilled labour force on the land. In no case should more than 50% of a farm's production costs be represented by the cost of the actual work performed. Consequently, the increasing capital-intensiveness involved by technical progress is altering not only the cost structure but the entire pattern of farming. Mechanization is obliging the farmers to redistribute the economic balance as among soil, labour and capital.

No farm should employ one more worker than is absolutely necessary. Mechanization must be complete: in the fields the whole chain of operations from soil preparation and tillage through the sowing and raising of the various crops to their final harvesting must as far as possible be mechanized from end to end, and so too most operations in the farmyard itself. If there is still anything left to be done manually after all this, it should not involve undue physical effort.

Industry produces by machine. Agriculture does too, but via the soil, which is a living organism. This is perhaps the great difference between the two.

To restate briefly the aim and object of agricultural engineering: its primary purpose is to replace the human

labour that is no longer there. Also, it must make the work both easier and more efficient, thereby leading to higher productivity and a higher standard of living for all those working on the land.
In discussing the basic factors in agricultural mechanization, we must take as our starting-point the design and construction of specifically agricultural machinery and equipment. Here, however, I must first say a few words about the interaction of agriculture and the economy as a whole, and about investment and turnover levels, to establish a yardstick for us to assess the role of steel utilization as a means to progress.
Modern agriculture is the key element in a modern economy. Since substantial portions of the national income are spent on agricultural produce, mistakes in agricultural policy can have incalculable consequences. To reverse or correct measures once adopted is extraordinarily difficult.

Interaction of agriculture and the economy

In agricultural circles, and in others too, we occasionally hear it said that farm mechanization is just a dodge to get the farmer's money. This indicates a pretty wrong-headed attitude to the whole development of the world economy in line with technological progress when leading agriculturists can assert that there is no need for farming to keep up with the times in this respect. Nor is it clear why agriculturists of all people should be indifferent to the truly epoch-making achievements of automation. Unfortunately, there are among them certain settled pessimists who feel that in agriculture as in one or two other sectors there is little prospect of getting operations automated. These people indeed go so far as to claim that even as regards mechanization agriculture is at a disadvantage and that it could never achieve the same productivity, let alone the same income levels, as are found elsewhere. The working farmers, however, are a living demonstration of the falsity of this attitude. They are already well ahead with their efforts, and they are much too hard-headed and sensible not to want push-button operation. They insist on it and introduce it wherever they can. The action they have been taking in the last few years in particular has made agriculture a major customer of industry and created close mutual confidence between the two.
From time to time there is a breathing-space in the advance of mechanization, but the process is nothing like complete. On the contrary, further radical changes are looming. Agriculture and industry working shoulder to shoulder for the future is by now an established theme—the way to grow better and better produce, the way to get rid of the hardships of farming. Both sides realize their symbiosis and know that any attempt by doubters to weaken the vital link between them is a menace to the economy.
Industry is coming to the land, and it is necessary that vertical integrations should be accepted as signs of progress. Agriculture must make a point of cultivating direct co-operation not only with industry, but also with the craft trades and with business and commerce. Farmers today are more and more coming to see that better returns can be assured only by more intensive specialization and division of labour. Industry can help them by contributing its financial, manufacturing and scientific know-how: by so doing it offers them a whole new basis for organizing their activities, quite apart from State aid, if any. Self-help and link-ups with other sectors of the economy must become a permanent feature of agricultural management.
The tremendous technical strides made in the past ten years and its growing involvement in the rest of the economy have entirely altered the position of agriculture, though neither it nor industry has yet fully grasped the necessary extent of their interaction and co-operation. That agriculture is a market operator in a big way is clear from the following figures. German farmers' expenditure on the purchase and maintenance of machinery and technical aids in 1950-51 totalled just under 2,500 million marks: ten years later it was twice that amount. Expenditure on tractors and agricultural mechanical equipment alone rose over the same period from 725 to 2,196 million marks. And the trend is still going on.
The job of technology in farming is, firstly, to increase the efficiency of human effort, and secondly, to maintain and if possible increase the yield of the soil. These it can only do if the degree of economy and social development in the country concerned is such that the necessary conditions are present. The agricultural revolution going on before our eyes, with all the problems it involves, was set in motion by technology. It is reflected in a whole range of changes in farm size, work organization and the pattern of production generally. The process of change is well under way. And it is only by progressive adaptation to the steady advances in agricultural engineering that that process is able to go forward.

Energy vital to mechanization

The remodelling of agriculture, then, is governed by agricultural engineering. Agricultural engineering embraces not only the introduction and use of machinery as such, but also the organization of energy supplies, technical methodology, and agricultural building. Energy in particular is obviously an indispensable part of it, since in the final analysis the technological development of agriculture cannot proceed without an adequate flow of energy.

The differing degree of technological development between the cultivator and the tractor, representing thousands of years of intellectual progress, is reflected today in the contrasting levels of food production and human nutrition: on the one hand we have agricultural overproduction resulting from agricultural engineering and the intensive use of energy, on the other underproduction by agricultural methods using no modern technical aids and little energy.

Ongoing economic expansion means growing energy requirements, but it demands security of energy supply. Having regard to the all-important position it has gradually come to occupy, energy has now to be used to meet every possible type of economic situation—according to the nature of the energy source concerned—and to play its part in the tackling of the great tasks facing the world. No easy matter if the increasing scarcity of human labour is to be made good by, inevitably, the use of energy-driven "mechanical slaves."

What are the implications of the energy situation for agriculture? Only consider how agriculture has changed from being self-sufficient in energy to being dependent on outside sources. A sufficient flow of external energy has become the bedrock of agriculture: modern agricultural economies cannot do without it. Its dominance is so great that we could not interfere if we wished without immediately causing a food shortage of the most disastrous proportions. The focal position of animal traction in farming has been completely eroded. External energy, where the basic conditions are fulfilled, enables much higher acreage yields to be obtained; oil and electricity have definitely broken the agricultural sector's self-sufficiency in energy over a wide area.

The extent to which European agriculture is lagging behind the rest of the economy in energy consumption is apparent in the various regions. A tractor consumes an average of eight tons of gas-oil a year; the mean consumption is rising as a consequence of the larger number of running hours resulting from advancing full motorization and the multi-purpose nature of the tractor.

In the past, whoever had at his disposal a fair number of oxen, horses and human labour, could enjoy a relatively high standard of living. Today the work is done by steam, electricity and the internal-combustion engine, and the rich man is the one who has plenty of horse-power operating for him. The use of energy to save time and labour is growing steadily in both agriculture and industry—which is one reason why engineers, economists, managing directors and Government experts responsible for the organization, modernization and technical development of the economy of their country are so keenly interested in the subject of energy supply.

The drive to make agriculture more efficient would come to nothing if the basis for a cheap and abundant flow of energy were not secured. Energy today is the key element in the economy, because with the rising demand pretty well every sector is now dependent on it. From this angle agriculture too is concerned. The decisions forced upon it by progress must be made in such a way as to keep its demands all the time in line with the general economic situation.

Agricultural production is dependent on sufficient energy availabilities. Consequently, as a major buyer in the energy market, agriculture is entitled to insist on efficiency and quality. In other words, it now needs to concern itself not only with farm management, technology, building and so on, but also, to a very considerable extent, with questions of energy supply.

Agricultural mechanization in EEC

Agricultural mechanization is proceeding on a substantial scale all over Europe. The manufacture of farm machinery and tractors is mainly centred in eight countries, whose producers in 1958 formed the "Comité Européen des groupements de constructeurs du machinisme agricole ("CEMA")," and which account among them for approximately 95% of Western European production.

The total number of tractors in use in the eight countries at the end of 1960 was close to 2,650,000, with 31.1% in Germany, 29% in France, 19% in Britain, 9.5% in Italy, 4.8% in Austria, 2.6% in the Netherlands, 2.2% in Belgium and 1.8% in Switzerland. These figures give little idea of the tractor concentration, which is better illustrated by the number of farms of over one hectare in relation to the number of tractors in use. The average for the eight countries together is 35 tractors per 100 farms. Britain leads easily with 104, followed by Germany with 59; France is just about on the average with 36, while below it come Austria with 34, the Netherlands with 30, Switzerland with 30 and Belgium with 22, Italy ranking bottom with 9.
Alongside tractors, combine harvesters are increasingly becoming a yardstick of mechanization. 186,400 combine harvesters were employed to get in the 1960 crop in the eight countries, 89% of them in the three leading countries alone (France 30.6%, Germany 30.0%, Britain 28.4%), with the other five, Austria accounting for 4.0%, Italy for 2.6%, the Netherlands for 2.1%, Belgium for 1.8% and Switzerland for 0.5%.
As regards the proportion of harvesters to cereal acreage, Britain is top with one per 55 hectares, Germany next with one to 78, then come Austria with one to 106, the Netherlands with one to 125, France with one to 144, Belgium with one to 190, Switzerland with one to 250, and Italy again bottom with one to 1,160.
In addition to these comparative data on levels of agricultural motorization and mechanization, it may be worth quoting some figures concerning consumption of iron and steel, electric current and oil. (These do not include expenditure on premises and stock, other overheads, and expenses in connection with new buildings). The manufacture of technical equipment for agriculture is estimated as absorbing about 10% of iron and steel production. Consumption of gas-oil works out at well over two million tons a year, and of electricity at over 3.5% of the total current generated, and there is still plenty of scope for higher sales of energy to the agricultural sector. The total capital sunk by agriculture in machinery and technical aids now substantially exceeds the value of the livestock.

Changing patterns of life and work

There is no need to become speculative in describing the farm of the future. Existing facts and figures offer any amount of indications from which we can forecast developments in the years ahead.
What, then, of these coming years of advancing European integration? Will more hundreds of thousands of agricultural workers—farmers' own families and hired help—have left the land by 1975? It seems certain, indeed, that the drift to the cities will continue all over Europe.
But on the farms that remain we may expect a steady levelling-up, not only in size, by the leasing of extra acreage as it becomes available, but in the whole pattern of life and work Apart from a number of large-scale agricultural corporations,Western Europe is on the whole faithful to the concept of the individually-owned farm. Now as time goes on the only labour such farms will be able really to rely on will be the farmers' own family, which incidentally will be smaller than in the past. Most of them are not sufficiently large or sufficiently intensively cultivated to support more than one family. The individual farmer of the future will work primarily with the aid of his wife and children and his capital equipment. A levelling process is taking place. In the case of the larger farms this does not necessarily mean mechanization at any price: quite often the answer is to concentrate on only one or two lines of production with simplified chains of operation, and even to sublet portions of land. Both on the bigger farm and on the smallholding the farmer is turning more and more into his own head worker and head engineman.
Structural improvement grants benefit principally the rising smallholder and the type of family farm hitherto badly situated, with scattered lots and inadequate capital equipment. The big farms hardly need them. The basic trends are much the same everywhere in the Western world. The old-style villages are disappearing more and more, and economic and social levelling is proceeding apace. The increasing use of high-powered tractors, currently rating 40-50 h.p. with implements suitable for large acreages, of wide cuts with combine harvesters, of automatic animal feeding installations, of technologically advanced storage facilities and equipment for one-man harvesting of roots and tubers, to name only a few of the new departures—all this is pointing the way to a future already clearly visible in outline.

Fewer farmers producing for more people

The only way to cope with the hunger in the world is to grow more food. So it is hardly likely that there will be any cutbacks in European agriculture production. Agriculture is as dominant a sector as ever. Every country in the world is trying to raise the standard of living of its people trying to achieve adequate feeding, sound health, better education and productive employment. But their efforts are being seriously impeded by the disproportionately steep rise in population all over the world. In the next 35 years the world's population will very probably double, so that by the year 2000 there will be six thousand million mouths to feed. The world economy can barely keep pace, so that the drive to improve living standards is making little headway. It is a world problem. Science in the last twenty years has been devising more and more ways to conquer hunger and satisfy human needs, but the unprecedented population explosion in so many countries has made malnutrition more widespread than ever. It has never been possible to grow so much food to the acre as today, yet hunger has never claimed so many victims. Agriculture everywhere faces Herculean tasks. No country's farmers can afford to sit back: all of them have their hands full producing for the coming myriads.

In view both of the growth in total and the growth in urban population it is becoming more and more necessary to press on with agricultural mechanization, and this in its turn is leading to a major expansion in the production of tractors and agricultural machinery everywhere. The lower the ratio of country to city-dwellers, the greater the need for the farmers to step up their production of foodstuffs and natural fibres of every sort and kind in demand in the world. But more efficient farming with fewer workers engaged in it means increased recourse to machinery. Hence, obviously, production of agricultural machinery is becoming more and more important to the welfare of humanity. World tractor production is expected to be up at least 15% by 1970, in order to keep abreast of the need for more food and higher agricultural productivity.

Even in the computer age, prediction is a venturesome undertaking, but it is necessary nevertheless to think ahead with vision. Technology is in constant process of change and improvement, in search of yet better and more efficient means of production. Machines and implements do more and more in less and less time: human labour is released to move to the cities, and fewer farmers go on producing for more people. The rural population is expected by 1975 to amount to only 6% of the whole. And this handful of farmers and farm workers must satisfy the expanding population—with better quality food at that.

We must bear in mind, too, that the efficiency of agriculture is increased not only by mechanization, but by developing new production methods and processes that will ensure higher yields from beast and plant. Agriculture is not yet at the end of the road, despite all the progress that has been made.

Here is a brief record of what has been achieved so far. We are in the middle of an agricultural revolution, technological and economic. We have progressed from the horse team to the fully-motorized farm, from hand reaping to the combine harvester, from twenty workers per hundred hectares to one. And yet, actually, this is no very great advance. Not that I am out to carp: I just want to point out that we need not imagine the four-wheel drive multi-gear tractor, the standard tractor with automatic transmission, the hydrostatically-powered combine harvester, or even fully-automatic livestock feeding in the stall is the very last word in progress. There still are and will be plenty of problems for technology to solve, for the world today is a very different place than it was twenty years ago. Tremendous strides have been made in agricultural engineering in those twenty years—and remember that in another twenty years it will have changed out of recognition all over again. "Forward!" is the watchword of technology.

Obviously, we cannot know the number or scale of the new methods, processes and machines that will be devised, nor their effects on growing and stockbreeding. All we know is that technological improvement in agriculture enables us to produce with a smaller labour force, while on the other hand the preparation and processing of the produce for marketing requires more in the way of services from the feedstuffs industry. Unlike agricultural production itself, the processing and marketing stage will involve employing larger numbers of people notwithstanding technological progress.

It will not be the fault of agricultural engineering and the agricultural equipment manufacturers if future food supplies are not assured. Such a range of agricultural machinery is now available that even the farmer with the most *outré* wishes will find what he is looking for. Everybody can be helped.

As well as investing in production and processing, the farmer must make it very specially his business to learn.

From existing data and calculable future trends—population increase, the ratio of the rural to the urban population—it is possible to estimate the scope for real economic growth, provided full employment, price stability and a balanced external-trade position are brought into a reasonable interrelation. We all know the current threats to economic growth—excessive consumption, rising prices, low investment—and can easily see where this would lead the individual national economy or a combined economy like EEC. It is clear that European agriculture should be not a smaller but a bigger customer of the producing and manufacturing industries.

Among other things, the ever-increasing mechanization of agricultural production will have an exceedingly important part to play in ensuring that the fast-growing population is adequately fed.

J. COCHET

Responsable du service d'information prospective
Fédération nationale des centres d'études techniques agricoles
Paris

The French Farmer and Machinery

(Translated from French)

France is traditionally an agricultural country and wants to remain so. The following features are typical of our agriculture:

— somewhat outmoded farming structures;
— a labour force which some consider to be "residual";
— inadequate capital at production and processing levels;
— a level of intensity in crop cultivation which is already high and will increase;
— a community spirit which encourages the development of the group enterprise;
— a trend towards specialization. The traditional mixed farms are tending towards a more limited number of products;
— the size of the active labour force, which is 18% of the total labour force, whereas in more advanced countries it is only 7-10%.

It is obvious that in this context judicious—I almost said intelligent—mechanization will help the French farmer who wants to play an important part in the European Community and offer competitive prices.

What is the role of agricultural machines? They are both capital goods and consumer goods. As capital goods they help to reduce the production costs of agricultural products by increasing productivity. Capital goods are managed. The capital expenditure must be paid off. Their introduction into a production line is economic if the actual production costs show a genuine drop. But this economic survey must be made within the context of the whole farm. Is the labour thus made available redirected to the labour market or redeployed elsewhere on the farm? Or do the machines and labour not redeployed both have to be paid for together? If the whole operation is economic the farmer can obtain credit. Most farmers whose properties are worthy to be called farms consider agricultural machines as capital goods and take these economic considerations into account. The use of agricultural machines improves the standard of living of farmers.

As consumer goods agricultural machines reduce human toil and working hours, making the farmer's life less arduous. This improves living conditions as regards work and time. However, this type of improvement can only be obtained by expenditure. This is satisfactory if at the same time the situation is as described above, an economic operation at production level. If this is not so, it is the money required for the family budget which is spent. There is no cause for alarm if the money is available and other proprieties are met, such as the children's eduction; but the matter is different if the money is not available and credit is needed. It is then a consumer credit, and there must be money coming in to repay the loan.

In this case, watch consumer credit!

Many small and medium-sized farms are in this situation. The fact that the farm and household budgets are often mixed makes it more difficult for the farmer to realize the situation.
In any case the machine is gradually replacing human labour and it is useless to discuss whether the machine is driving out the workers or the shortage of workers is inviting the machine. The two factors are concomitant and this in itself raises several problems for farmers.

Agricultural machines as capital goods

After looking at the general role of agricultural machinery on the farm, let us examine the various aspects of machines as capital goods. These aspects are clearly realized by an increasing proportion of farmers but only the heads of agricultural enterprises worthy of the name take them into account in their day-to-day decisions.

The machine and productivity

The value a man can produce in a working hour depends on the available power of his engine and the output of the machines.
The difficulties of using machines also increase with their size.
We saw above that there is a close connection between labour and machinery. Economically, this is represented by a balance between the cost of labour and the output of the tractor, for example.
A CNEEMA survey shows that with 1,500 hours use per annum the economically advantageous output of a tractor is 65 h.p. for a total cost of 3.25 FF per hour (including social security charges). 3.25 FF per hour is in fact the minimum cost at present. For labour at 5 FF per hour the economic output is 75 h.p.
It appears then that the outputs of 110 and 120 h.p. of which one hears are not economically justified. The cost of farm labour would probably have to be about 8 to 9 FF,and we are still far from that.
It is obvious that the machines worked by the tractor should ensure that the available output is fully utilized. Their dimensions will thus depend on these optimum outputs. Their performance depends on their width and speed.

The purchase price of agricultural machinery

The fixed costs amount to 50% of the total cost of utilizing the machines for tractors or 70% for harvester/threshers. Depreciation makes up the majority of these fixed costs. The purchase price is thus of vital importance.
But some figures give food for thought, in particular the price per kilogram of agricultural machinery.

— Car	9.50 FF/kg.
— Agricultural tractor	10 — 11 FF/kg.
— Harvester/thresher	11 — 12 FF/kg.
— Pick-up/balers	8 FF/kg.
— Disc plough	7 — 9 FF/kg.
— Large-scale sowers	7 FF/kg.
— Mouldboard plough	5 — 6 FF/kg.
— Manure spreader	5 — 6 FF/kg.
— Fertilizer spreader	5 FF/kg.
— "Cultipacker" roller	2.5 FF/kg.
— "Crosskill" roller	1.5 FF/kg.

In view of:
— the low amount of machining,
— the relative accuracy of simple machines,
— the large number of as-forged parts,
— the large number of parts merely ground, fettled, re-founded,

these prices show that the organization of production requires substantial improvements. There are at least two ways in which these prices could be reduced:

a) Concentration of companies, reduction of overheads, decrease in the number of models (unbelievably high in most categories of equipment. For example there are 27 makes of sowers available in France, each with 5 to 12 basic models available individually with a variety of equipment; 35 makes of fertilizer spreaders; 40 makes of manure spreaders—and that is far too many!).
   More long production runs ... and abolition of pseudo-re-finements and the "consumer goods attitude" (see below).
b) Effort to achieve productivity in factory, scientific organization of production lines, mechanization of jobs, automation. But this can only be done with long production runs. The first point should therefore be given priority.

Concept of cost

The time when the farmer had to replace his first tractor is long gone. That was when he became aware of the idea of depreciation (tractors do not breed). Many machines are used by several farmers and accounts must be kept.

To ensure that utilization costs are as low as possible the farmer seeks to keep his machinery in full employment.

Full employment in agriculture means only on the available days. For each season of the year the work must be properly organized and even then it is not possible to work every day. There is the climate, the state of the ground, plant physiology, attacks by pests.

Hence a tractor considered to be multi-purpose is well utilized if it works 1,500 hours a year, and 200 to 250 hours a year would be a very reasonable figure for a combine harvester which is still to some extent multi-purpose.

Fortunately the farmer is able to separate the concept of use from that of ownership. Group farming for purposes of joint use of machinery is not a vain expression. It enables large capacity machinery to be employed at a satisfactory level despite the small size of the farms. Account must be taken of this in assessing market prospects.

Concept of the production line

It is rare for a machine to be used by itself. There is a rapid succession of operations in soil working. There is the supply of fertilizers, seeds and dressings to the fields and the removal of the products harvested. These are complex tasks carried out either by a farm's own machines (on a large farm) or by machines from different farms in group farming. The concepts of work organization are being increasingly applied in agriculture.

This requires firstly proper technique to determine a working method which is valid for several years. Here we come up against the rapid development of agricultural techniques, perhaps, but also the variability of machines, their improvements or pseudo-improvements. It must be confessed that many farmers are not reasonable and change their techniques at the slightest excuse. French farmers, it seems, do not want to lag behind and I think they tend to overdo it.

Secondly the organization of a line involves the balancing of the various jobs comprised in it. The machines intended to fit into such a line have very varying performances. This is particularly true of fodder harvesting lines.We should not forget that the delivery of the crop to the farm and possibly its processing when this cannot be delayed form part of the line.

It appears to be up to the farmer to design his line as a whole by using equipment of one specific make. The result is not outstanding since it is only approximate and provision has not been made for everything. It is true that some manufacturers try to design their products in this fashion, but their efforts are limited to work in the fields and they easily forget the farmyard installations following or preceding field work. Too few manufacturers succeed in this. Undoubtedly, the dimensions of the companies do not permit an organization of this type, except perhaps by way of specialization, where the economic risk is however high.

Maintenance of machinery

Less than a generation has passed since the advent of mechanization in farming. Many farm workers have to drive, regulate and maintain machinery without having had any suitable training.
There are few local opportunities for retraining or further training for farm workers. France has no equivalent to the Deula-Schulen so successful in Germany.
It is not surprising that all these surveys reveal that maintenance on the farm is inadequate.
The situation is quite different when the farm is large enough to employ a man full-time or even part-time in the workshop. If this is not possible, the only expedient is the blacksmith turned repairer. But he is a makeshift repair man since the manufacturers' training efforts cannot go beyond their distributors and agents. The impressive number of models and non-observation of standardization make the multi-purpose repairman's task even more difficult, whether he is a former blacksmith or a farmer.
It is true that collective repair workshops have not yet proved successful except in cases where they service a fleet of farm machinery under the same head, such as CUMA. For privately owned machinery it is still better to trust the men whose job it is.
To facilitate daily maintenance on the farm:
— simplify maintenance; intervals, technical nature, time required;
— consider training courses run by manufacturers (what is done at present in this line is inadequate and not sufficiently practical).
For average and minor repairs:
— the large farm can obtain the necessary equipment;
— the small farm would like to have suitable facilities within the local district, or region. Perhaps in the future we shall have small radio-equipped breakdown vans called out by telephone.
For major repairs of the overhaul type:
— the agent for the make generally gives satisfaction. However, better collaboration between the agent and his customer (who is card-indexed) would permit advance planning and spreading of the work load.

What are the main qualities required?

There are machines and machines, as the farmer well knows. In a situation where competition is increasing as customs barriers are dismantled and is hitting a market with a declining growth rate, quality should normally be decisive for the different makes.
What then does the farmer expect of a machine?
a) A quality result in his work.
It is chiefly a matter of designing and developing (if possible before they are put on the market) machines suitable for work under French conditions. For too long America has been forcing its models on us without allowing for the fact that intensive cultivation there is at a far higher level than in France.
This is particularly obvious in the case of harvesting machinery. It is not so much a matter of total output as of suitability to absorb a large volume with a working width imposed by the characteristics of the machine. Germany often proposes expensive methods because the principle there is "to do everything with one man alone on the farm." This is not so in France and the trends towards group farming means that lower capital expenditure is possible.

England, more industrial than agricultural, pays her workers far more than France. It is only natural that she should be more advanced in mechanization and be willing to try techniques with a loss level too high for us (fodder harvesting).

The French farmer has confidence in design offices in an agricultural context comparable to our own. History is there to prove him right.

However, the farmer has some difficulty in defining his specifications. Closer contact with agricultural research laboratories and advisory staff would help him in this.

b) Facilities for utilization

How much time is lost in ancillary work when suitable days (and sometimes even hours) are numbered. It is necessary to:

— find a rapid and simple method of getting started;
— facilitate rapid movement;
— simplify the setting up of machinery for work;
— adopt processes likely to speed up supply and extraction operations;
— increase servo-controls; semi-automatic controls require a degree of technical knowledge far beyond the average operator;
— reduce maintenance times (see above);
— make machines less sensitive to slight variations in conditions: humidity, soil resistance, heterogeneous nature of the harvest.
— think of the night work often necessary in the cold of winter or the heat of summer;
— ensure that machines on tow can be easily controlled from the driver's seat;
— improve still further the speed of coupling and uncoupling implements;
— make easily handled machines: visibility, turning circle;
— develop small auxiliary accessories on tractors, for example front hooks; German machines have many clever devices.

c) Robustness

Certainly agricultural conditions are hard and drivers are generally not very mechanically minded, but it is not enough to have a thorough after sales service. Breakdowns are very costly for the farmer.

— the cost of repairs is little compared to the other losses;
— the loss of crops may be high if sowing is not done in time, if fertilizing is late, if the harvester cannot work, if the processing, packing and storage installation is out of order, if the product does not reach the market at the right time ...
— but there is also loss on the work site itself: machines stationary on the work line, idle labour, etc. There is a loss even if the decision to send men and machines to a different site is taken quickly.
— the down time does not only depend on after sales service. It is shorter if the farmer is able to diagnose the trouble properly.
— by definition a breakdown is not planned in advance, but occurs at random. Repair skills must therefore be available at all times. This is a permanent concern of the person in charge. His ability could be better employed.

Before the war the words "agricultural robustness" had some meaning. It is not a matter of being old-fashioned and lamenting the past, but present-day machines are not what they should be or could be from this point of view.

We want simplicity and robustness under the conditions applicable in France.

I know many farmers who are willing to pay a little more for more robust equipment.

d) What about standardization?

It is discussed. Some extremely competent people are working on it. Specifications are given. But in practice ...

There are probably several reasons for this failure to observe standardization:

— the delays caused by the working-methods of standardization committees mean that their decisions are taken when the subject is no longer so topical. Other arrangements have been made in the meantime and as a result nothing is done. Progress moves quickly and by its nature standardization works somewhat in arrears.
— new progress is being made every day and this is one of the riches of the agricultural sector. Because

of sales competition on the home market commercial requirements predominate over all else, at least in the short term. But every coin has a reverse side and this dynamism results in a certain degree of anarchy.

However, on a wider European market and in particular with our German partners, who are most enthusiastic, standardization requirements will be stricter. This unexpected aspect of the Common Market will certainly benefit French farmers.

There are many concrete examples: position of the power take-off, position of the coupling hook, system of power take-off with rated performance, dimensions of couplings for the three-point linkage, etc.

Agricultural machines as consumer goods

This chapter will not be developed in detail since it is not really our subject. However, I think it is important in a field like this to attract the attention of those responsible.

Undoubtedly machines reduce labour and working hours and the farmer is well aware of this, but some points should be concidered:

— Work in the fields is largely mechanized but in medium sized and small farms it is the women who do such manual work as remains: hoeing, planting out, picking, while the man drives the machines. The position is even worse for work in the farmyard where mechanization is less advanced.
— The farmer is psychologically ready to buy on the sole pretext of "reducing labour." The result, on small farms, is a sales system resembling that for household goods, which are other consumer goods. This represents a serious danger for the continued existence of this farmer and his family if the money is not available.
— The mini-models of the mini-tractor type and other machines of the "hobby farming" type have no place in agriculture whatever the size of the farm. The main objective is to increase productivity, and these mini-models will not help to do that. They are exclusively consumer goods for leisure activities of people who can afford them; gadgets on the grand scale.
— The variability of the models, pseudo-refinements which only improve the appearance and not the operation of a machine contribute to the attitude that agricultural machines are consumer goods. There is some risk of the artificial creation of a type of fashion for a round or straight radiator shell, a square or pointed bonnet ... Industrial design is one thing, but to turn it into a fashion to the extent that each year the dictates change? No!
— The many different models and the profusion of accessories which add nothing to the machine's results make everyone believe that it is a model uniquely designed for him and suited to his special working conditions. Frequently this is not so, and it is going too far to present the machine in that light. This does not help to promote mass production.

The salesmen and those who prepare the sales literature bear a heavy responsability when they cause a farmer to buy a machine which is not suitable or which he does not really need. The financial balance is precarious in many farms. One false step is enough to upset it, particularly if the false step costs 10,000 to 20,000 FF.

It is far better to keep a large number of customers in a sound financial position.

It must be acknowledged that the salesman is often more efficient than the agricultural adviser.Why should he not objectively help the farmer to think out and calculate his mechanization problems?

At this point we must stress that the agricultural machine is not an end in itself. The farmer is buying a machine to do something.

Certainly, the reliable manufacturer already organizes a pre-sales service, an assistance service and an after-sales service. Some repairers offer a contract maintenance service for tractors, etc.

However, there is no need to own the land to develop it and profit from it. Slavery, which was a form of ownership of another means of production, disappeared long ago in civilized countries.

The vital third factor in production belongs less and less to the farmer. Only circulating capital still genuinely belongs to him.

It is therefore possible to consider separately ownership of production capital in the form of machinery and its use.

The farmer will increasingly buy a service.Why are the formulae for contract work more advanced in the USA than in our country? What is the practice of sub-contracting in industry? If agriculture is to become industrialized, it will use industry's methods.
The fourth production factor is the most important, and yet it is never discussed: it is skill. This cannot be bought or sold. The farmer has it or hires it.
Let us hope that this skill will enable the farmer to view the whole of his production factors as an industrialist does and to combine them so as to make the most of them in achieving economic objectives, the only objectives which really count. In this the agricultural machinery industry has a part to play, since for a large part it introduces progress. A new machine is often synonymous with a new technique, or else it is a copy of an existing machine.
The manufacturer should combine with others and put on the market robust and well designed machines and these machines should give agricultural labour increasingly high productivity.What about structures? They are like laws, they come later. It is technology and economics which are important.

Dr.-Ing. H.-O. MEUTH

John Deere — Lanz AG
Mannheim

Development Trends in Structural Steels for Tractors.

(Translated from German)

Steel, together with cast iron, is the main structural material for tractors. This is due to its extraordinary versatility.Working and heat treatment make it possible to modify the properties of steel so that it is suitable for use under extreme conditions and high stresses.

Steel and the forms in which they are supplied

For the purposes of this paper, it is convenient to divide the steels used in tractor construction into three categories on the basis of the forms in which the steelmaker generally supplies the steel to the customer.

1. The largest category includes steels supplied in the form of billets, merchant bars and forgings.
   Steel grades suitable for heat treatment are mainly supplied in these forms.
   These include those designated in the German standard as high quality and special steels, which are required to have the following proporties: observance of analytical limits, uniforms structure, where necessary finegrained structure for direct quenching from carburising temperature, good degree of purity, i.e. without disturbing impurities and uniform hardness behaviour or a specific hardenability.
2. The second category includes flat products, merchant bars, sections, plate, sheet and strip. These are generally manufactured from plain carbon steels and are not designed for heat treatment. The main requirement for these steels is good workability. They include free-cutting steels insofar as they are machined. In the case of flat products, plate, sheet and strip, generally subjected to non-cutting shaping, suitability for cold forming is the main requirement.
3. The third group comprises finished parts such as screws, nuts, discs, springs, roller bearings and the like. These parts are assembled in the tractor in the state in which they are supplied. The steel is selected

as a function of the specifications for the part and the choice is generally left to the steelmaker as the supplier, since he has the necessary specialized experience. Obviously all types of steel may be found in this group.

Finished parts account for the smallest proportion of the weight of the whole tractor; material developments in this field are therefore unlikely to affect tractor design and there is no need to go into further details on this category.

Two development trends, which have an obvious influence on the use of steel and the associated methods, may be observed in the tractor industry.

Increase in tractor performances.

One of these trends is the steady increase in engine performances in agricultural tractors as a result of the growing demand for power. The higher engine output is combined with an increase in the size of the vehicle. This can be illustrated by a few figures: the average outputs of tractors in Europe are today between 35 and 40 h.p. This level was achieved as early as 1960 in tractors in the USA, which today average 60 h.p. However, the increase will not be as rapid in Europe.

Higher output involves an increase in the size of the tractor. This means larger components and higher stresses. These in turn require stronger steels or the application of heat-treatment processes, which enable equivalent or even higher strength properties to be obtained in non-alloy or low-alloy steels. Both result in increased costs.

Concentration in the tractor industry

The second trend is a development process within the tractor industry itself, where as a result of mergers and other concentration measures the production of tractors is now limited to only a few companies, which in return are economically and financially sound.

The intensification of competition makes it essential to absorb increased costs by rationalization as far as possible. But automated furnace plant and other costly equipment are required for the rationalization of heat treatment processes. Only financially powerful companies can find the necessary capital.

The concentration now found in the tractor industry is conducive to such technical developments. This is also true in another way: as individual companies have a larger share of the market they are producing larger quantities and can thus make extensive use of mass production methods. Only in this way can the best advantage be derived from the actual rationalization measures.

Examination of the new developments in the field of steelmaking and the related heat treatment processes, particularly for special steels, reveals that they have an almost identical effect on tractor production.

New developments in steelmaking

Mention should here be made of the oxygen steels (LD steels) which account for barely 20% of the steel produced in Germany today, a share half that of openhearth steel and twice that of electric steels.

The quality of steels blown oxygen is definitely good. As regards purity in particular, it is comparable with that of open-hearth and electric-steels. These steels have a lower hydrogen content and hence there is less danger of flake formation.

Because of the short heat times, accuracy of analysis is sometimes problematical.

For the present there are in effect no price advantages over open-hearth and electric steels because the shorter heat time is offset by the higher pig iron charge and purer scrap. Because of the uncertainties still involved, the melting of special steel charges is only economic in conjunction with large heats of soft or deep drawing steels so that any unsuccessful melts can be used without loss.

The position is similar with regard to continuous casting, which is at present limited to flat products. The high yield and the elimination of ingot moulds and cogging make it possible to reduce costs, but there are

still difficulties as a result of carbon segregation and shrinkage cavities. Consequently a wait and see attitude has been adopted on the continuous casting of special steels.
Vacuum treatment of steels involves considerable costs. It is used chiefly for degassing, but it also improves the degree of purity. Advantages for the steelmaker are the increased accuracy and the saving of annealing times with steels liable to fake. Vacuum treatment is worth-while only with steels for components for which labour costs are high, e.g. turbine blades or crank shafts.
Roller bearings, which are also used in tractor construction, are an exception in this respect. Roller bearing steels show a clear increase in useful life only if the whole melting process takes place in a vacuum—vacuum treatment in the ladle alone is not sufficient.

New developments in heat treatment

The three steelmaking innovations mentioned above are not as yet having any noticeable effect on tractor production, but the opposite is true of the heat treatment processes used during production to process and improve the steels. The trend in progress here covers all stages of steel fabrication and introduces automation which takes control of the process out of human hands.
There is a tendency to start with cheap steels, i.e. plain carbon steels or steel only lightly alloyed with manganese, chromium, molybdenum and more recently boron, and to bring the required of heat treatment processes in which there is still scope for rationalization. These possibilities will be examined in more detail later in connection with the components for various functional parts of the tractor.
The first process in working crude steel in the form of billets or bars is forging. This is chiefly done in specialized forges, often attached to the steelworks, and only in exceptional cases belonging to the tractor factories.
The transition from forging hammers to presses leads to more accurate forgings and hence to reduced machining costs. The final stage in this development will be gear wheels complete with teeth produced from the blank on grooved rolls and only needing a finishing treatment.
Forging must be followed by a heat treatment (annealing) to create a suitable structure for machining. Attempts are being made to combine heat treatment processes usually carried out separately and thus save reheating. Use is made of the forging heat of the workpiece either in an immediate annealing process or by quenching from forging heat. This gives an austempering structure which has good deformability, i.e. good toughness properties, with increased strength, and can also be machined satisfactorily.

Carburization processes—Gas carburization

Only the surface layers of most components are required to have a high strength or hardness, both of which demand a certain carbon content in the steel. However, for machining a soft steel with a low carbon content is preferred. These conditions can be met if the finished workpiece of soft steel is carburized from the outside. The classical example of this is the gear wheel, the most important component of any gear train.
Today increasing use is being made of gaseous carburizing agents, which enable the carburization process including quenching to take place uniformly according to an optimum programme. Chemical action leading to defects is thus eliminated. Provided no disturbances occur the prescribed hardness is always achieved. However, it is essential to have steels with sufficiently close analytical tolerances which produce only minor fluctuations in hardenability after the end quench test. Such close specifications for hardenability scatter are necessary if the customary preliminary testing of steel charges by means of pilot lots are to be eliminated in heat treatment in continuous plant.
Gear parts are already being carburized and hardened successfully in programmed batch furnaces or fully automatic continuous furnaces.
It is also essential for the composition of the material to remain absolutely constant for as long as possible a production period. This is achieved when the steel is obtained in large consignments from one melt or heat. The conditions for heat treatment can then remain the same for all components made from this consignment and they can be passed through the production processes in complete lots. Consequently, each melt must

be kept carefully separate from the next. The successful results obtained with gear wheels for example are minimum wear and high accuracy, both of which are essential for a quiet gear.
For components subject to high stress, e.g. gear parts, (see *Table 1*) steels of the following alloy type are used for gas carburization: chromium-molybdenum steels with and without the addition of boron, nickel-molybdenum-chromium and chromium-nickel steels, all fine-grained (ASTM 5-8) for direct quenching.

Table 1 — Casehardening Steels

Alloy Type	DIN designation	Euro Norm	ISO Steel	French Standards AFNOR	British Standards BS	American Standards SAE/AISI	Examples of use in tractor construction
C	C 10/CK 10		1a	XC 12		1010	Oil pump wheels, gear wheels subject to low stress, bolts, pumps shafts.
	C 15/CK 15		1c	XC 18f	En2D	1015	Control rods, bushes, cam shafts
	C 22/CK 22				En3C	1018	
Mn	20 Mn5F			20M5f	En3C En14A	1022F 1024F	Gear wheels subject to medium stress, gear wheel shafts, counter shafts, gear shafts, bevel gears, rocker arms, gudgeon pins, pilot journals, differential bolts, gearshift housing, countershafts, rocker shafts
Cr	15Cr3			18C3f			
Mn Cr	16MnCr5 20MnCr5		2b 2a				
Cr Mo	20CrMo2 20MoCr4 23CrMoB3		3a 3b			 4118	Gear wheels subject to high stress, main shafts, axledrive bevel wheels, gear shafts, double gear wheels, gearshift sleeves, power take-off, shaft sliding gear, bevel gear
Cr Ni Mo	20NiCrMo2		5a	20NCD2f	En362	8620H	

F = fine grained

In parts subject to medium stress we are trying, on the American pattern, to make do with the cheaper steels of the SAE 1024 type, alloyed solely with manganese, but also fine-grained, so that they can be quenched direct from the carburizing temperature.
Distortion is still the main problem with case-hardened gear wheels. As a result only the region of the teeth is now partially hardened by induction after carburization. The still soft bore with the spline section can then be reamed out subsequently. In this way any lateral out-of-trueness occurring during hardening can be rectified. This combined heat treatment is also economically advantageous with the cheap manganese steels.

Salt bath nitriding

Increasing use is being made of salt bath nitriding for gear parts subject to predominantly sliding friction and gear wheels subject to medium stress, and recently even for crank shafts, whose fatigue strength under alternating stress can be considerably increased. The bath temperature, which is far below the transition point, causes practically no distortion.
Almost all structural steels are suitable for bath nitriding since there are no demands as regards hardenability. The improvement in the strength properties is chiefly noticeable in non-alloy steels for hardening and tempering, but depending on the service conditions of individual components it may also be used for steels alloyed with chromium or manganese. (*Table 2*)
Bath nitriding may also be combined with induction hardening. This gives hard and particularly wear-resistant surfaces.

Table 2 — Steels for hardening and tempering

Alloy Type	DIN designation	Euro Norm	ISO Steel	French Standards	British Standards	American Standards	Examples of use in tractor construction
C	C35/CK35 C45/CK45			XC35 XC48f	En5 En43B	1035 1045	Axle arms, shift forks, trailer yokes, chain links, gear-shift levers, connecting rods, eccentric shafts, locking screws.
	C55/CK55			XC55f	En9K	1055	Clutch shafts, shafts.
Mn	36Mn5 40Mn4		7	35M5f 35M5f	En8A En8C	1037 1039	Guide pieces Guide rods, draw hooks
Cr	34Cr4 37Cr4 41Cr4		4 4a 5	32C2 38C4 45C4f	En18B En18C En18D	5132 5140	Rear axle shafts, bearing caps, guide-rods, stub axles, rocker shafts, elevating spindles, torque tubes, tie rods.
CrMo CrNi Mo	42CrMo4		 12	42CD4 40NCD2f	En19C	4142 8640	Draw-hooks, tie rods, spring hangers
CrV	50CrV4			50CV4	En47	6150	Differential cases, adjustable draw-bars
Si	55Si7			55S7	En45	5155	Draw-bars, levers of implement system

Hardening with induction heating

Induction hardening with the possibility of partial heat treatment not only provides economic advantages in the production process by eliminating the need for expensive carburization and allowing the use of cheap non-alloy steels, but also provides better load capacity as a result of higher service strength.

However, there is still no uniform line regarding the steels suitable for induction hardening (*table 3*). In the USA the emphasis is on manganese steels, but they are known to be sensitive to over-heating and also have poor transverse properties. In Germany fine-grained carbon steels are preferably used; these are least liable to exhibit hardening cracks with a medium carbon content.

There are already several examples of gear wheels which have successfully been changed from case-hardening to induction hardening. Shafts and bolts are particularly suitable for induction hardening. This process is also likely to be very advantageous for rear axle shafts, in which the strength distribution can be adapted fairly accurately to stressing conditions. A practical example: with the use of induction hardening a normal heat-treatable steel of medium strength can be superior to high-strength steels in the serviceability test (Prof. Gassner, Laboratorium für Betriebsfestigkeit, Darmstadt).

The mechanical behaviour of rear-axle shafts of three different steel qualities was compared. The first axle shaft was of a high-strength steel quenched and tempered to 145-160 kp./sq.mm. tensile strength, the second of an ultra-high strength vacuum—melted steel quenched and tempered to 180-200 kp./sq.mm., and the third of a normal heat treatable steel quenched and tempered to a strength of 110-120 kp./sq.mm. and then hardened to 54 to 60 Rockwell over its whole length by induction heating, the hardness penetration depth being 0.2 d. (shaft diameter).

The static torsional yield point of the ultra high strength axle shaft was 20% higher than that of the other two shafts. However, the alternating torsional yield point under dynamic torsional stress was highest for shaft three and lowest for shaft one. In the serviceability test with a load summation corresponding to practical service, shafts one and two behaved exactly the same, while shaft three of the cheapest steel withstood a torsional strain about 20% higher. This favourable result attained with the shaft of lowest strength may be attributed to the deformability still present in its core, which gave the component a longer life and a higher load capacity.

Table 3 — Steels for induction hardening

Alloy Type	DIN designation	Euro Norm	ISO Steel	French Standards AFNOR	British Standards BS	American Standards SAE/AISI	Examples of use in tractor construction
C	CK35/CF35			XC35	En5	1035F	Gear levers, shifting forks
	CK45/CF45			XC48f	En43B	1045F	Eccentric shafts, cam shafts, elevating spindles
	CF53			XC55f	En9K	1055F	Differential housing, final drive gear
Mn	20Mn5F			20M5F	En3C En14A	1022F 1024F	Gear wheels, chain link-pins, sliding-gear shafts
	36Mn5F 40Mn4		7	35M5f 35M5f	En8A En8C	1037F 1039F	Power take-off shafts rear-axle shafts,
Cr	37Cr4 41Cr4		4a 5	38C4 45C4f	En18C En18D	 5140	gear shafts roller-bearing axles
Cr Mo	42CrMo4			42CD4	En19C	4142	gear wheels

F · fine-grained

Table 4 — Steels not intended for heat treatment

Steel Type	DIN designation	Euro Norm	ISO Steel	French Standards AFNOR	British Standards BS	American Standards SAE/AISI		Examples of use in tractor construction
General structural steels	St37			A33	En2	1015		Washers, nuts
	St37-2			A33	En2	1015	Weldable	Gear levers, guides plates
	C15			C12d	En2D	1015	Weldable and cold workable	Holders, angles
	St50			A56	En8A	1035		Pivot lugs, shift-fork shafts
	St52-3			20M5f	En14A	1024	Weldable	Trailer frame pieces, trailer plates
	C35			XC35	En5	1035	Cold Weldable	Check shafts
	St60			A65	En8C	1040		Trailer bars
	St70			A65	En43A	1050		Toothed segments, supports
Free-cutting steels	9S20 9SMn23 22S20			10F2 12MF4 20F2	En1A En32M En7A	1113 1117		Differential shafts, hollow shafts Pins, bolts, bushes, ratchet bars Levers, nipples, plugs, adjusting pieces

Steels not intended for heat treatment

In conclusion mention will be made of the steels (*table 4*) not intended for heat treatment. There are no revolutionary innovations in this sphere, nor are such to be expected. Nevertheless in almost all the forms in which this second category is supplied important improvements in quality have been attained, particularly as regards machinability.
High demands are made on sheet as regards surface quality and deep-drawability. Thanks to careful control of the heats, precise observance of analysis and cold temper rolling, these can today be met, sometimes even in the case of unkilled steels.
In addition to good weldability flat steel products must have good cold forming properties as this is required by today's production methods, predominantly assembly-line processes. Steel bars and sections intended for machining are resulphurized. They are distinguished by a brittle swarf as required for processing on automatic lathes, and permit a long tool life, but because of its high price this is only economic if large volumes have to be machined.

Dott.-ing. Fernando NEGRO

Direttore Uffici tecnici trattori F.I.A.T.
Torino

Steel Products used in Farm Tractors and Earth-moving Machines

(Translated from Italian)

During the past twenty years or so, all leading farm manufacturers have also been turning out earth-moving machines, particularly bulldozers and leaders. In some cases this work has lately assumed greater importance than the manufacturers of farm tractors, so that in considering the problems involved in the use of certain steel products in tractor design we must not confine ourselves to farm and tractors, but also take into account industrial tractors and the various implements that now form an integral part of the machine.
It is also well known that the design of farm and earth-moving tractors is being constantly modified to improve the power/weight ratio of the vehicles. This obviously calls for higher-grade materials and a more careful study of the stresses and shapes of the various components with a view to better use of the materials.
Whereas the problems relating to the engine and the transmission units are similar to those in other types of vehicles (for road and rail transport, etc.), certain specific problems arise in tractor design that mainly relate to the load-bearing structures (whether cast or welded) and parts subject to abrasion when in direct or indirect contact with the soil (tracks, blades, shovels, etc.).
The supporting structures are made of castings in the case of small housings which not only have to bear the load but also house transmission gear. Ordinary grey iron is generally used for such castings in farm tractors. Since industrial tractors are subject to greater stresses spheroidal graphite iron is used, and occasionally castings.
The load-bearing structures of the bigger tractors are usually made of welded steel sheet; in addition to the above-mentioned housings, typical larger parts to be noted are the central frames of loaders and bulldozers, roller track frames, loader lifting arms and curved bulldozer blades.
These parts are usually subject to alternate stresses or repeated dynamic loads and hence liable to fatigue. Consequently, the materials selected should have a sufficiently high ultimate tensile stress and yield point and be readily weldable. Instead of ordinary carbon steels, low-alloy steel sheet (usually containing manga-

nese) with, of course, a low carbon content of about 0.2%, is now being used on account of its weldability. A more recent trend is the use of such higher-alloy steels as chrome-manganese of manganese-molybdenum-vanadium. Being more expensive however, these materials are only employed for very highly-stressed parts of which the size and weight cannot be increased without unbalancing the machine, or because the parts in question have to be repeatedly raised and lowered and must be as light as possible to avoid wasting power and enable the maximum useful load to be lifted.

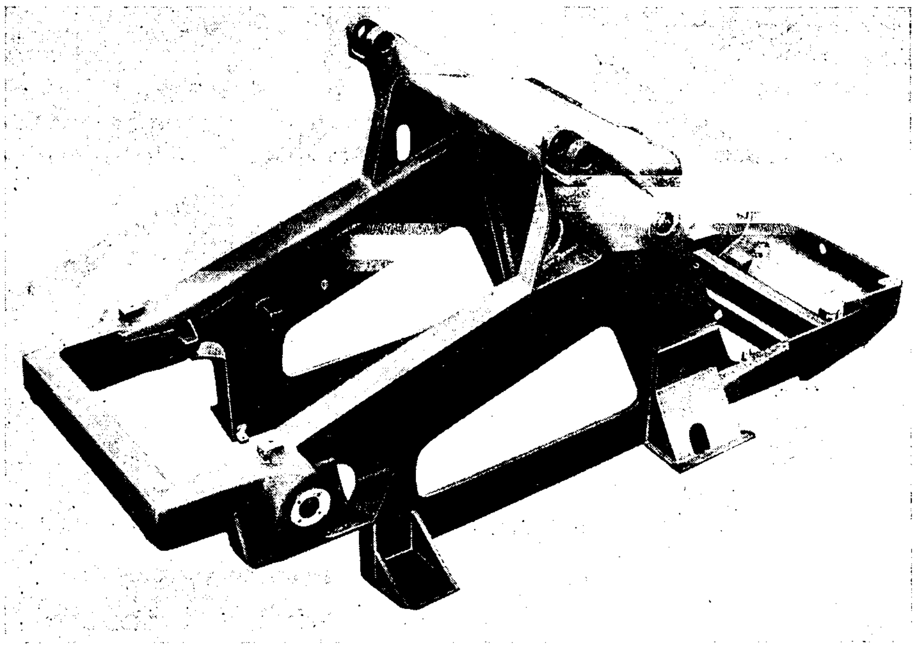


Fig. 1

A typical example is the bucket of the front loader; the overall weight of a 125 hp. crawler type loader was reduced by over 200 kg. by changing from carbon steel having a yield point of 25 kg./mm.^{2} to alloy-steel sheet having a yield point of 60 kg./mm.^{2}, but the considerable difference in cost between the two steels put the materials costs up by about 25%.

Having regard to the fatigue resistance of welded structures, correct welding is obviously very important. It is clearly no use employing high-grade steel if the welds (which cannot always be applied to lightly stressed zones, however desirable this may be) are defective owing to the low resistance of the seam or insufficient penetration, or they seriously endangered the structure of the material in the adjoining zones. However where standard sheets are used it is now possible to obtain good results with modern welding techniques, i.e. with suitable machines, electrodes and protective gases, and periodic non-destructive checks of the most important zones.

Materials for parts subject to wear through contact with the soil, e. g. ground plates, track links and rollers, knives and teeth of grabs, have undergone similar developments. Instead of non-alloy steels, which in this case had a higher carbon content (0.4%-0.5%) to allow of surface-hardening, we now use manganese steels and, for some particularly critical parts, higher-grade steels such as chrome-molybdenum or chrome-nickel. Good abrasion resistance can be obtained by proper heating of the surface or in depth without using alloy steels. But this is inadequate for very thick parts requiring at least slightly alloyed steels for a satisfactory hardening depth. A typical example is the rollers of a crawler-type tractor *(Fig. 2)* whose strength and life were greatly improved by using a steel with about 1.5% manganese instead of ordinary (0.45%) carbon steel.

Most of the machine's weight is made up by load-bearing structures and parts subject to wear; for example, a track-laying bulldozer of a total weight of 18 tons contains about 7 tons of load-bearing structure consisting of welded structural steel, and about 4.5 tons of parts subject to abrasion; a crawler type loader of a total weight of 14 tons contains about 6.5 tons of load-bearing structure and about 3.5 tons of parts subject to wear. Thus in these machines over 60% of the total weight consists of the materials in question which are now expected to have increasingly better resistance and longer life without being so expensive as to overprice the finished product. In fact, the main reason why manganese steels have come to be more and more widely used to-day is the greatly improved wear resistance they give without unduly increased cost.

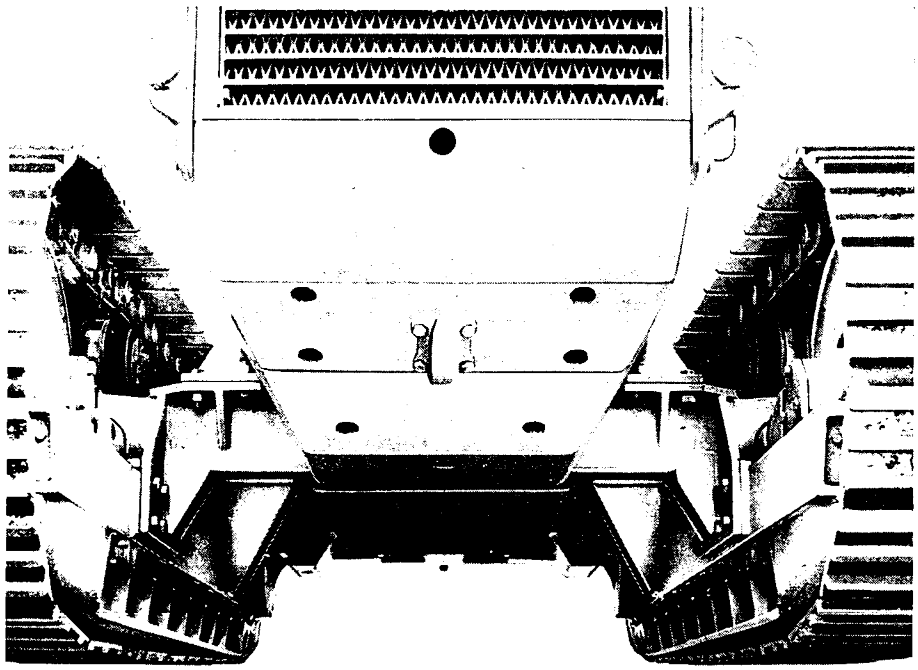


Fig. 2

Based on the annual world production of different types of machines, their average weight, and the proportion of steel used in them, the annual requirements in steel for the construction of tractors and earth-moving machines may be roughly put at about 2,000,000 tons.

This is obviously a matter of economic importance and one already well known to steelmakers, but to which I feel attention should be drawn so that due weight may be given to its technological and economic implications.

In this short paper I have no intention of going into greater detail, especially as I am not a steel expert myself but rather a user of modern steel products in my capacity as head of a department designing tractors and earth-moving machines. As such I have often wondered whether the present popularity of these types of steel is justified, or whether others may be preferred in the near future. Obviously there is no stopping progress, and my own Company, with its own steel plant, is now studying the use of more sophisticated types of steel with a view to further technological and economic improvements in the manufacture of farm tractors and earth-moving machines.

J. H. KLOOSTERHUIS

Schuitemaker Machines N.V.
Rijssen

Steel in a Unit System of Manufacturing Farm Trailers

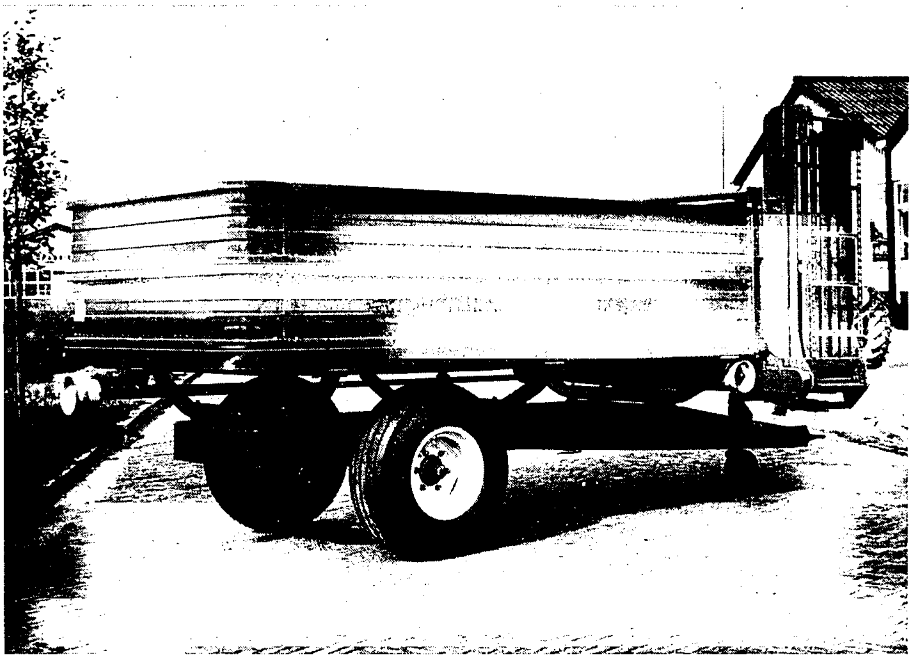
(Translated from Dutch)

For some years past we have been working on the development and manufacture of a general purpose trailer for farm transport. We have evolved a particular design and method of production and thought you would be interested to hear something about our reasons for doing so. A few examples will suffice to illustrate the practical applications of this trailer.

First, a clearer idea of it will be afforded by the following brief description.

The basic unit consists of a frame, floor and three attachment pipes. The frame includes a complete drive system and a conveyor. The three attachment pipes enable the basic unit to be positioned on an underframe; a 180° angle of rotation of the unit on the frame permits both front and rear discharge (viewed in the direction of travel).

The sides of the trailer are 400 mm. high panels; one, two, three or four panels can be superposed to form a 400, 800, 1200 or 1600 mm. side, depending on the specific gravity of the load material. A range of attachment is available, e. g. a cross-conveyor for side discharge, an elevator for lifting the load to a given height, grass distributor rollers for the metered discharge of grass, hay, etc., a manure spreader, etc. *Figure 1* shows a truck with two-panel high sides, discharging its load by means of a cross-conveyor and an elevator that can be set skew (beet trailer).



Our first trailer had wooden sides and floors, the upper and underframe and certain other parts consisting of welded, cold-rolled sections.

For efficient serial production, however, we were obliged to:

a) replace the one-piece wooden sides by detachable 400 mm.-high panels for building up sides of the required

height. As these panels have to take a substantial shear load, the material selected was steel, which is cheaper and easier to process than such rival materials as aluminium;
b) adopt a rational technique for joining (in the present case we used spot welding and, more indirectly, punching) and also finishing. For this purpose all other wooden parts had to be replaced by steel ones. One important component was the floor, now also made of steel;
c) wherever possible, make good use of the cold-forming technique, as steel has various potentialities in this respect.

Bearing in mind these requirements, to obtain the most suitable sections we purchased a cold-shaping rolling mill with a 1,000 mm. feed width.

The panel section was rolled from one piece and then spot welded.

Since the floor section was 950 mm. in width the floor could be assembled from two sections (for a 3 or 4-ton trailer) or three sections (for a 5-ton trailer). The other principal sections were also designed with these three types of trailer in view. Should the floor and panels be used under exceptionally corrosive conditions, Sendzimir galvanized strip can be used as the basic material of the sections; the material normally used is ungalvanized. One interesting application of cold forming consists in the bending of various sections. Originally the angle joints of the various frames were made by sawing through two section lengths at an angle of 45° and rejoining them by arc welding. This procedure is now rendered unnecessary by starting from the entire section length required and making 90° bends at the right points by means of a special bending machine. The panel section is dealt with in the same way to obtain a good join with the upperframe and a simplified join between the front and side panels.

The added advantage of purchasing coil for the rolling machine is that any desired section length can be processed.

For instance, an underframe is made from a U-shaped section about 13 metres long shaped into a one-piece frame during the bending process.

You will appreciate that the absence of weld seams is a particularly desirable feature in a heavily loaded underframe.

We have mentioned several reasons for changing over to steel. The 4-ton steel trailer is already coming off the production line at regular intervals, and after a slight adjustment to the machine tools it will soon be followed by a 3 and 5-ton type. The rolling mill and bending machine are used for this purpose for some part of the time, and otherwise for making components for other manufacturers.

After a critical appraisal of the subject our choice fell on steel. We must be constantly investigating the new potentialities and uses of this material, aided by the good advice of steel manufacturers, and our investigation must always include other materials, thereby ensuring a correct choice in the future.

Prof.-Directeur Ch. DRICOT

Ministère de l'agriculture, administration de la recherche agronomique
Station du génie rural et Centre d'étude de la mécanisation en agriculture
Gembloux

Standardization of Agricultural Machinery

(Translated from French)

Manufacturers were already aware of the benefits of standardization at the end of the 19th century. In 1878 an attempt was made to fix a speed for traction engines, and around 1900 seed-drill designers had begun to make a standard type of fore-carriage. Some simplification had already been achieved by 1930: for instance, the number of forks and lifters had been reduced from 1,300 to 300.

The efforts made in this direction have varied from country to country according to the circumstances and requirements prevailing at particular times—the wartime scarcity of raw materials and the need to have fewer and better types of machine thoroughly adapted to their purpose.

There has been little co-ordination of the attempts made to tackle these problems by the systematization, standardization and official certification of agricultural machines. In some countries parts of machines have been standardized, e.g. the plough share or beam, while in others it has first been tought to reduce the number of more or less identical types of machine and then to standardize the parts.

It was evidently felt that the logical sequence was

— to systematize the machines i.e. reduce the number of models;
— to standardize the component parts of the models remaining after this weeding-out process;
— to institute regulation tests for official certification that the machines were technically and practically adapted to their purpose.

To proceed in this order it is necessary that the machines should have been found to do an adequate job. Consequently, it might be complained that the procedure was unnecessary, since the machines in any case worked more or less satisfactorily. However, we must bear in mind that over the years manufacturers have been pressed to bring out new ranges, and moreover have not always been able to include components already standard in industry which would have enabled them to produce higher-quality machines.

With a view to reducing the number of types of implement intended to do the same job, we undertook, in co-operation with *Fabrimétal*, to fix the standard gradations for dimensions and designs. The elimination of unwanted types might have been more drastic had we not had to allow for the reasonable integration of existing models into the projected standard series.

By 1964 the following had been studied by *Fabrimétal* and systematized by the Belgian Standards Institute (IBN): ploughs, harrows, cultivators, hoes, fertilizer distributors, seed drills, threshers, vehicles.

The first stage was systematization to be followed by the drafting of standard dimensions for the components, and standards of quality for the materials used. In the case of seed drills, for example systematization fixes such characteristics as length, weight and mode of operation and standardization fixes standards for the materials to be used.

These studies naturally required the prior agreement of the manufacturers; moreover, although systematization need not necessarily be on precisely the same lines in all countries, it was thought feasible to find common types which might be acceptable at international level.

After the war a number of new machines, such as combine harvesters and balers, appeared on the European market, as well as new concepts such as three-point linkage, while there was a tremendous rush to mechanize. Between 1950 and 1960 capital expenditure on mechanization increased by 275% in France, 270% in Germany, 88% in Belgium, 87% in the Netherlands and 60% in Italy.

The money was spent on agricultural machinery, choice of machine depending on farming conditions in the countries concerned. However, the largest share went on tractors and harvesters, as can be seen from *Table 1*.

Table 1 — Breakdown of capital expenditure

Tractors	%	Harvesters	%
France	52	Belgium	35
Belgium	47	Germany (FR)	28
Germany (FR)	44	France	23
Netherlands	36	Netherlands	15

International organizations concerning themselves with agricultural machinery

As can be seen from the above table, the number of tractors has grown very fast during the last 15 years: in the Common Market countries it has increased from half a million to about three million.

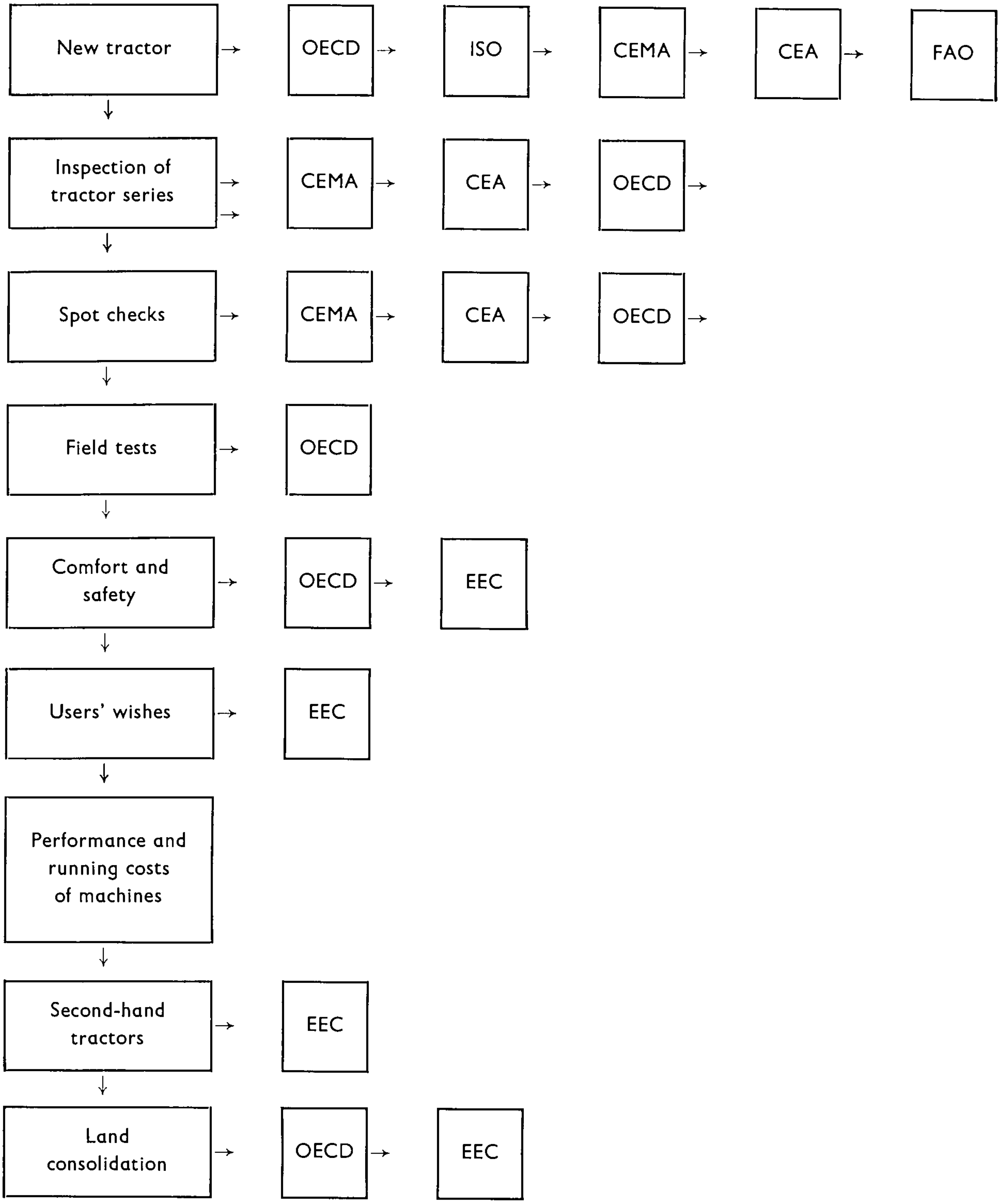
The testing stations have always concentrated to some extention on the tractor as the basic unit of mechanization, but from 1947 onwards mechanization went ahead at an unprecedented rate and the following international bodies took up the matter:
— the Food and Agriculture Organization of the United Nations (FAO),
— the Organization for Economic Co-operation and Development (OECD),
— the International Standards Organization (ISO),
— the Association of Manufacturers of Agricultural Machinery (CEMA),
— the European Economic Community (EEC),
— the European Confederation of Agriculture (CEA),
— the International Commission for Agricultural Engineering (CIGR).
These are dealing with the tractor from a variety of angles. Thus OECD is concerning itself specially with the testing of tractors and agricultural machinery; ISO is responsible for checking and endorsing the testing procedures laid down by OECD, and for standardizing machine components; CEMA can submit proposals it would like to see accepted by OECD, ISO and EEC; EEC concentrates mainly on impediments to trade in machinery, on drivers' comfort and safety, and on the second-hand tractor markets.
CEA is to be permitted to put its views to these various international organizations.
In the course of time such other possibilities have developed as:
— inspection of tractor series;
— spot checks to determine the horsepower of tractors in actual use (in Belgium 7,000 tractors have been tested in this way);
— field tests and investigation of performance and running costs;
— availability of second-hand tractors.
The schema on p. 235 shows how the various matters are handled by the international bodies. It is clear that there should be some form of co-ordination among these different organizations.

Standardization at international level

— OECD has published a tractor testing code which has been accepted by the Council of Ministers. Efforts are now being made to add cab, braking and noise tests to the code.
— ISO is studying the tractor testing code with a view to its official acceptance. It also has in hand projects relating to the standardization of sizes of discs and knife sections; characteristics of spray booms; effective cutter-bar width, number of fingers and knife sections in combine harvesters; greasing points on agricultural machines; types of V-belt and driving chain for agricultural machines; fixing points on frames and hardened surfaces to take the wear in harrow tines, shares, cultivators and hoe blades.

Problems raised by the use of agricultural machines

Users want to know:
— what the machine will do technically speaking;
— how it should be selected to meet the needs of the particular farm;
— what it will cost to run in specific cases;
— what it will cost to equip a farm with machinery for completely mechanized operation.
Manufacturers want to know:
— how the design can be improved;
— what is the best approach to standardization of agricultural machines and components;
— what types of machine they should be designing to meet Europe's future needs.
These problems will have to be solved by modern methods, such as technical studies proceeding by synthesis, and analytical studies.

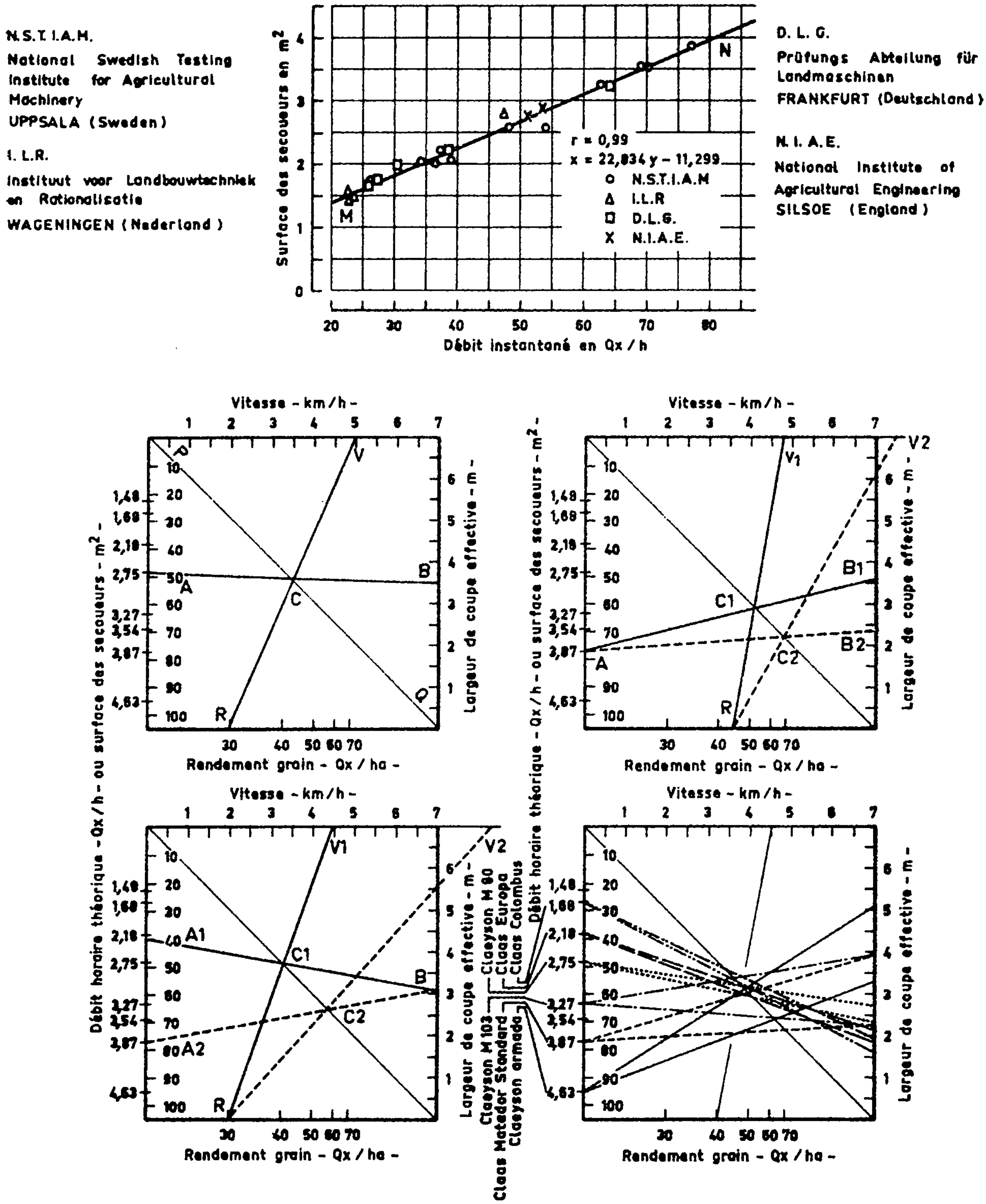


Technical studies proceeding by synthesis

Machines having multiple mechanical functions can be studied on the basis of the results of tests carried out by official agricultural-machinery testing stations. This type of study has been done on combine harvesters: 130 tests by European testing stations have been examined and a ratio established between the shaker area and the instant output of the machine.

Figure 1, showing the technical characteristics of the combine harvester (see *Proceedings of the 1965 Steel Congress*), indicates the following:

Diagram 1 : Existence of a ratio between the shaker area and machine output;



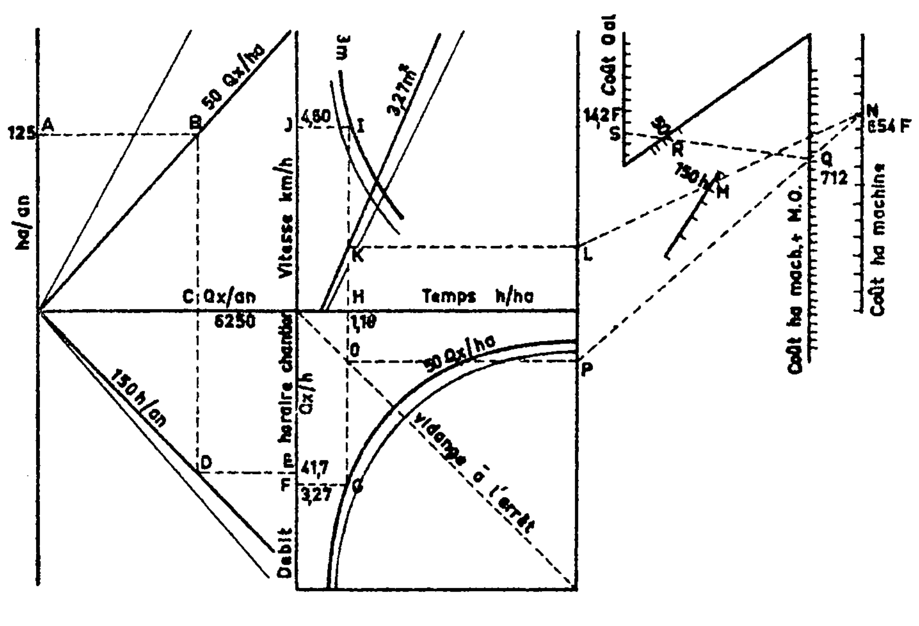
Surface des secoueurs en m²	—	shaker area m²
Débit instantané en Qx/h	—	Momentary output in Qx/h.
Vitesse km/h	—	Speed - km/h.
Débit horaire théorique en Qx/h	—	Theoretical hourly output - Qx/h.
Rendement grain en Qx/ha	—	Crop yield - Qx/ha.
Largeur de coupe effective en m	—	Effective cutting width - m.

Fig. 1 — Research on combine characteristics with a view to standardization

Diagram 2: Interpretation of this ratio.
Example: the machine has
Shaker area (A) = 2 75 m.², output 48 quintals/h.
Cutter-bar width (B) = 3.60 m.
Yield of crop (R): 30 ql/ha.
Synthesis line: PQ
If we join AB it intersects PQ at C; joining RC gives us V = forward speed of 5 km./h.
Diagram 3: Influence of cutter-bar width on forward speed;
Example: the machine has
Shaker area (A): 3.87 m.²
Cutter-bar width: (B_2): 2.40 m.
Yield of crop (R): 45 ql/ha.
Via AB_2 R C_2, we obtain a forward speed of nearly 8 km./h.
But if we had used a 3.60 m. cutter-bar (B_1), we should via A_1 B_1 R_1 C_1 have obtained a forward speed of 4.8 km./h. at V_1.
Diagram 4: Ratio of forward speed to rate of work.
Example: the machine has
Shaker area (A_2): 3.87 m.², giving an output of 76 ql/h.
Cutter-bar width (B): 3 m.
Yield of crop (R): 30 ql/ha.
Via A_2, B, R, C_2, we get V_2 = 9 km./h. If it is desired to reduce this speed to 4.5 km./h., we get via V_1, R, C_1, B a reduced output of A_1 of 38 ql/h.
Diagram 5: Comparison of combine harvesters of various types, rates of work and cutter-bar widths.
Where S is the shaker area in m², and L is the cutter-bar width in m.
An analysis of this diagram enables some degree of standardization to be determined via the ratio S:L which will ensure a reasonable forward speed and acceptable grain losses.

Choice of machine and running costs on a particular farm

Figure 2 enables us to determine the choice of machine and its running costs.



Débit horaire chantier — Hourly output
Vidange à l'arrêt — Speed km./h.
Vitesse km/h — Stationary discharge
Coût ha machine — Cost of machine per hectare

Fig. 2 — Choice and cost of running a combine

Example: a farm growing annually 125 ha of cereal crops having a yield of 50 ql./ha., requiring an annual work total of 150 hours and stopping to unload the grain into trailers.

Via A B C D E F G K I J L N Q S we obtain at
E: type of machine to be chosen (shaker area = 3.27 m.[2]).
J: speed = 4.6 km./h for a 3 m. wide-cutter bar (I).
N: cost/ha of combine-harvester = BF 654.
Q: cost/ha of combine-harvester + labour = BF 712.

We prepared these technical-economic harmonograms so as to be able to determine the technical and economic factors which influence all the operations of grain harvesting—combine-harvesting, straw baling, transport and loading of bales and grain.

Technical studies proceeding by analysis

This method may be used for machines whose functions can be separately examined. It has been used for forage harvesters. A study of these machines has shown that they perform the following separate mechanical functions:
cut and chop up the product,
create an air blast,
overcome friction and convey the material.
Example:
C = total torque transmitted by the p. t. o.
at N rev./min.
Q = hourly output of chopped material,
a, b, c, d = coefficients of individual machines studied.
The general equation is: $C = aN^2 + b + cQ + dNQ$

Machinetype	Torque	air blast	+ friction	+ cutting and chopping	+ conveying
A	C_1	$= \frac{320}{10^7} N_2$	+ 2.75	+ 0.475 Q	$+ \frac{125}{10^5} N Q$
B	C_2	$= \frac{68}{10^7} N^2$	+ 1.50	+ 0.920 Q	$+ \frac{147}{10^5} N Q$

We may thus conclude that the torque required for the air blast in system A (flywheel chopper) is higher than for system B (cylinder chopper) but that machine B chops more vigorously.
It will be seen that this type of machine analysis;
a) enables the designer to note how any modification of the machine is likely to affect the power requirement;
b) enables machines to be classified according to function and thus contributes towards the standardization of forage harvesters.

Practical study of the machines

Studies by synthesis and analysis may be applied in the case of expensive machines or those having complex functions. But alongside the tractors and harvesters, which account for most of the capital expenditure, there are many other machines of a variety of types.
To bring home this point, we need only mention that the number of firms exhibiting at recent international agricultural shows was at Brussels, 245; at Paris, 420; at Frankfurt, 450.

For ploughs alone, the number of exhibitors was as follows.

	Brussels	Paris	Frankfurt
Mouldboard and swing ploughs	15	8	8
Ridging ploughs	12	10	6
Reversible ploughs	16	16	35
Multi-furrow ploughs	23	20	14
Disc ploughs	12	22	4
	—	—	—
	78	76	67

This being so, if we wished to standardize these implements, our first requirement would be the results of tests on;

a) technical characteristics of the machine (ease of steering, strength, etc.);

b) practical working performance of the machine.

These data are essential—for the user, to help him make his choice, for the manufacturer, to help him improve his design, and for the organizations responsible for standardization.

Here OECD has a part to play in laying down standards for quick practical tests to supplement the meagre information available for many of these machines.

Ranges of equipment and standardization

Industry is supplying agriculture with machinery and implements having an ever-increasing working capacity. On large farms mechanization has raised the productivity of the labour force by providing increasingly efficient equipment. On small and medium-size farms however, these advances in machinery design are liable to lead to undesirably sudden changes. It is also a fact that while more and more capital is being put into mechanization, large numbers of farmers are going out of business. The study of standardization is more complex than it used to be, because now social and economic factors have to be taken into account.

Future objectives must be:

— faster writing-off of machinery to maintain progress in design and benefit from technical advances;

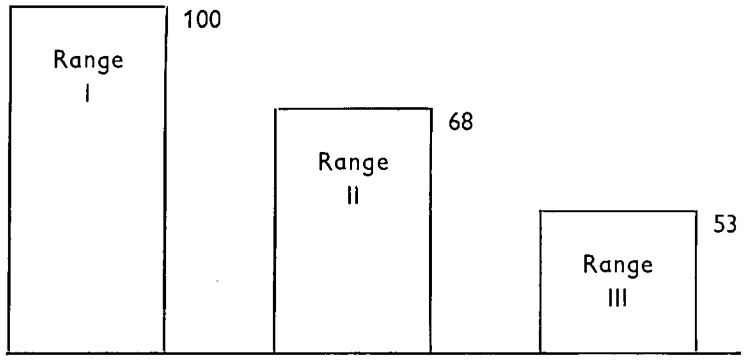
— standardization of machines, and at the same time concentration by manufacturers on machinery able to do what is wanted when it is wanted and to pay its way.

The following *table* gives the technical characteristics of machines making up three farm equipment ranges to do the same jobs, but suitable for 30, 50 and 80 hp. tractors.

Table 2 — Tractor and equipment used in each range

	Range I	Range II	Range III
Tractor (hp)	30—40	50—55	60—80
Plough	single-furrow (0.35—0.40)	double-furrow (0.70—0.75)	triple-furrow (0.95—100)
Stubble plough	1 m.	1.5—2 m.	—
Dics harrow	—	—	3 m.
Weeder + harrow	2—2.5 m.	3 m.	3.5—4 m.
Cambridge roller	2.5 m.	3 m.	4—5 m.
Fertilizer distributer	2—2.5 m.	3 m.	3.5—4 m.
Seed-drill and harrow	2—2.5 m.	3 m.	3.6 m.
Hoe	2.5—3 m.	2.5—3 m.	2 × 2.7 m.
Sprayer	6 m.	10 m.	20 m.
Self-propelled combine harvester	(50—60 hp) 2.5 m.	(80 hp) 3 m.	(100 hp) 3.6—4 m.
Beet harvester	single-row	single-row	6-row multi-phase
Field heap spreader	1 m.	1.4 m.	1.4. m.
Trailers	2—3 tons	4—5 tons	6—8 tons
Manure spreader	2 tons	3 tons	4—5 tons
Pick-up baler	~ 4 t/h	~ 7 t/h	~ 7 t/h

Allowing for the items which have to be considered when working out production costs, we get the following *Schema*:



This shows how great an influence the equipment used has on production costs. The reduction in these costs is not evenly spread over the three ranges, between I and II it is 32%, but between II and III it is 15%.
It is essential to utilize machinery at a sufficiently productive level to avoid a future widening of the cost gap between producers. As things stand at present, Range II appears to offer distinct advantages for a family farm. This type of study ought to be extended to other sectors.
In modern farming it should be possible to cut manufacturing costs by standardizing machines and components. But it is vital that the types retained should fit into equipment ranges and meet all technical and economic requirements.

Conclusion

The foregoing is intended to offer a basis for:
— advance study of equipment ranges for various types of farm;
— programming of design improvements in agricultural machinery;
— encouraging manufacturers to concentrate on farm machinery designs of the future with the aim of reducing the number of types of machine, standardizing components and producing models which will be more efficient and a better buy for individual farmers and farmers' syndicates.

M. FAUCONNET

Fédération nationale des syndicats d'exploitants agricoles
Paris

How Technical Information is Aiding Mechanization in Agriculture

(Translated from French)

As you will have realized from the very interesting papers we have already heard, the machinery available to European farmers has changed enormously in the past twenty years or so. The preceeding papers have given an idea of the broad future trends in the European markets for agricultural machinery.

Recent developments in agriculture

Since the war European agricultural production has grown at close on 4% p.a., thus doubling in less than 20 years, notwithstanding a steadily accentuating flight from the land. Between 1954 and 1962 the French agricultural labour force decreased by 25%, while its productivity rose by 6.8% a year, as compared with only 5.5% in the other producer sectors taken together.
Agriculture is being completely transformed — and there is some way to go yet, as is evident if we compare the average yields in European countries with those achieved on top-efficiency farms.
In essence, this tremendous technological progress is based on the practical application of our steadily-advancing knowledge of genetics, chemistry and mechanics.
Thanks to the development of new varieties, such as hybrid strains of maize, the increasing recourse to artificial insemination in cattle and, it is hoped, also before long in pig breeding, and the establishment of selection centres, farmers now have very much better-quality vegetable and animal material to work with, while with the aid of fertilizers, specially-prepared animal feedstuffs, pesticides and veterinary medicaments they are able to exploit their high production potential more and more efficiently. At the same time, this in itself is not enough: it is necessary that all the operations involved in modern farming should be carried out more efficiently, and this has been rendered possible by mechanization and motorization, which have increased the amount of work that one man can do, and have enabled many operations to be performed better, and more particularly to be performed precisely as and when desired.
Farmers, then, are buying more and more industrial products for the purposes of their own production. From 1959 to 1965 (I apologize for again quoting only the French figures, but I prefer to stick to those I know best), expenditure by French farmers on goods and services increased from FF 7,767 to FF 13,068 million, while their turnover went up from FF 32,323 to FF 48,529 million.
But they are purchasing capital goods too, and these often take precedence of the other items of expenditure, as we can see from the trend in availabilities of some types of farm equipment.

Trend in availabilities of some types of farm equipment

Type of equipment	1948	1965
Tractors	68,000	1,000,000
Combine harvesters	1,160	100,000
Pick-up balers	—	100,000
Milking machines	20,000	170,000

However, enough of these dry statistics. Obviously, such increases could not have occurred had individual farmers not been immensely receptive to the adoption of new methods, and they would not have been thus receptive had it not been for a major popularization and technical training campaign. The need was realized very early on in the Netherlands, which is doubtless why Dutch farming has reached such a high standard and Dutch farmers' earnings are comparable with those in other walks of life.

Implications of technological progress for farming

Events are moving so fast as to change the whole face of the agricultural sector, resulting more especially in a shift of population to the cities, in higher productivity of labour, and in growing capital requirements.
For the individual farmer, this has involved quite a number of new problems with regard to land, capital and labour.
Land: The increasingly high-powered and complex machines of today need to be utilized to capacity. This is impossible without systematic redivision and consolidation of farm holdings: thus the smaller farm of under 20 hectares (50 acres) is on the way out, while the number of those covering 50 hectares (125 acres) and over is rising steadily.

Capital: Capital expenditure per head of agricultural working-population (exclusive of capital tied up in the land itself) varies from FF 10,000 to FF 500,000. The amount of capital needed depends more on the degree of intensivization and mechanization than on the type of farming pursued. Consequently, agriculture is now increasingly faced with the problem of finding the money to pay for the necessary investment.
Labour: With modern motorized equipment it is necessary to have farmers and farm workers trained in its operation and maintenance. Attention has also to be given to questions of farm layout and work organization. The organizational set-up of present-day farms may or may not lend itself readily to mechanization and motorization. In France, farm equipment pools or co-operatives (CUMA), "labour banks" and, latterly, joint-farming combines (GAEC) have been instituted to improve matters in this respect, and the Fonds d'Action Sociale pour l'Aménagement des Structures Agricoles is endeavouring to adapt individual farm set-ups to modern production conditions.

What farmers expect of the agricultural-equipment industry

As has been repeatedly emphasized at this Congress, mechanization is becoming an absolutely vital factor in production. As a farmer myself, I should like to say a few words to the equipment manufacturers. I will make it short and sweet, since I know they will listen carefully.

— First of all, farmers are more and more coming to need efficient after-sales service, to deal quickly with any breakdowns. It is impossible to exaggerate the importance of this, in order that the farmer can be sure his equipment will not be out of action for any length of time at periods when he requires it.
— Still more should be done to make the machinery convenient and safe to handle. This is far too important an aspect to be neglected, and I am hopeful that the manufacturers will take speedy action to deal with the deficiencies still to be found.
— To come to what I consider the nub of the matter: the farmer is obliged more and more to plan his investment. He has to be able to pay off his equipment, and, in particular, to break even on his switch from labour to capital. For each type of crop or stock that he raises he must establish a production chain, comprising a co-ordinated plexus of equipment to enable him to mechanize the operations throughout. Now there is a great variety of equipment on the market, and the farmer sometimes has difficulty in making his choice, expecially as standarization in this regard is still only in the very early stages. It is the manufacturers' job to deal with this problem.
— It is very much to their interest to undertake research in this connection, for the capital sums needed per person engaged in agriculture may work out as high as FF 500,000 — just about as much as is needed to create a job in industry. Accordingly, full-scale agricultural engineering is manifestly essential, particularly as hardly more than a beginning has so far been made in the mechanization of stockbreeding and of the various operations in the farmyard proper—to say nothing of the increased use which is certain to be made in future of, for instance, irrigation, and glasshouse growing.
  Agricultural engineering has, to my mind, the further advantage of enabling closer contact to be maintained between the farmers and the equipment manufacturers, since it constitutes the essential link we still lack, as we are coming to realize, between the work of the production planners in the industry and the practical conditions at the consumers's end, on the farm.

It is to the credit of the present High Authority Congress that it has opened the way to European-level discussions between representatives of agriculture and of industry, and I trust that the debate now starting will prove of benefit to both sides.

Heinrich PETERS

Direktor der Klöckner-Humboldt-Deutz AG
Köln-Deutz

Haulage Equipment in Agriculture

(Translated from German)

Machines in trade and industry are generally designed for fixed installation. The material they process is brought to them or is produced continuously at the same place.

Agriculture uses the production power of the soil. Agricultural work, whether tilling, sowing or harvesting, is therefore on the move. Agricultural machinery moves and works at the same time.

It is no wonder that engineers with the farmers' interests at heart early tried to adapt the new power, the steam engine and the internal combustion engine, for work on the move.

The forerunner of the tractor was the steam traction engine (a self-propelled engine to operate stationary machines). It made threshing mobile; threashing in the field instead of in the barn with animal power.

Soon after the discovery of the 4-stroke internal combustion engine by Nikolaus August Otto, it was also installed in traction engines. Not long after, attempts were made to mechanize the steam plough, until then cable-drawn. Then the self-propelled motor plough was developed.

The tractor with its dual function as a draught machine and a power source was developed from the motor plough and the traction engine.

In addition to these technological functions, the newly developed motor power should to an increasing extent help to achieve the economic goal of replacing human and animal labour.

Hence the use of the tractor today is considered an index of the degree of mechanization of agriculture. In West Germany draught animals declined from 1,824,000 in 1950/51 to 462,000 in 1964/65. With about 1.15 million tractors on about 14 million hectares of useful agricultural land,West German agriculture is today almost one hundred per cent mechanized. On the basis of tractors per hectare agricultural land, it is superior to any other agriculture in the world.

When the agricultural tractor was first introduced, it served primarily to replace draught animals and the trailer implements had to be drawn along the ground. Not until the power take-off was introduced did it also become possible to drive attached harvesting machines from the tractor.

When the tractor became an operating unit it proved a strong stimulus for the mechanization of other work. Harvesting and processing machines with power take-off drive were developed.

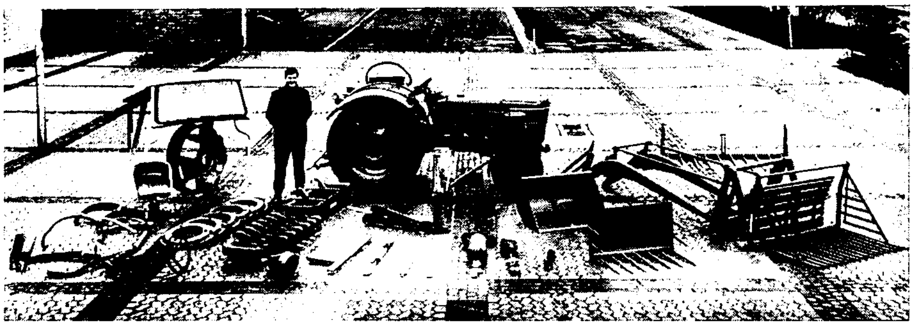
The attachment of the mower made the tractor an implement carrier. Particularly in the farming region of the Northern foothills of the Alps with its extensive pasturelands the mowing of hay crops several times a year is one of the heaviest tasks for the draught animals. The provision of an engine for a grass mowing machine is the third function of our present-day tractor.

The introduction of the hydraulic power lifter was a further refinement on the tractor. The "Power Lifter" — at first only intended for the raising and carrying of tractor-mounted implements — with its hydraulic system fills an important function in controlling the working depth of implements and balancing the weight of the working unit formed by the tractor and the implement. In ploughing, in particular, the regulating power lifter helps greatly to increase the economic usefulness of the tractor: the plough can be of simple construction as it no longer needs its own chassis and working depth control; the existing motor output can be converted into tractive power more efficiently when the plough weight is automatically taken by the rear axle of the tractor.

The introduction of the hydraulic power lifter on the tractor in conjunction with suitable implements also facilitates its use as a loading and staking machine in agriculture, trade and industry. The motor power can be converted to horizontal tractive power by the driving axle and to vertical lifting power by the hydraulic system.

The requirement for tractors of the future can be stated briefly as follows:

1. Increase in economy:
   - Higher performance at the necessary speed.
   - Best possible conversion of engine power into tractive power.
   - Best possible transmission of the engine power of the tractor to tractor mounted implements and trailed machines by further development of mechanical and hydraulic power transmission.
   - Wide adaptability to the demands of various types of crops—track width, ground clearance, etc. (at present special models such as narrow-track tractors are necessary).
   - Simple coupling and uncoupling for additional equipment such as front loaders, mowers, etc.
   - Reduction of maintenance costs as regards both materials and time.
   - Best possible accessibility, even for repair work.
2. Further development of driver's comfort.:
   - Protection of driver against weather.
   - Design of driving seats comfortable even at high speeds.
   - Simple and clear arrangement of operating levers.
   - Simple control of implements from the driver's seat (one-man control) by means of power lifters, rapid coupling devices, remote controls, etc.
   - Availability of numerous accessories to adapt the mass produced tractor to the special needs of individual farms. (see *figure*).



These claims mark out a field in which tractor designers all over the world have already achieved considerable success. Development will undoubtedly continue in the future.

Certain design features have in the meantime been confirmed by science and practice so that with certain deviations they may now be considered as compulsory, e.g. the ratio of engine output to weight: about 40 to 50 kg. tractor weight per h.p. This effort to obtain a certain minimum weight in the interests of tractive power accounts for the great importance of cast iron in tractor production.

In Europe today tractors with outputs of up to about 85 h.p. or in isolated cases up to 130 h.p. are being produced. The number of large farms which can economically use tractors of more than 100 h.p. is limited. The tractors used on large farms today may be up to 80/85 h.p., but are generally between 50 and 60 h.p. The family farm today uses tractors with outputs between 20 and 45 h.p.

As successors of the heavy single-axle tractors, the small four-wheeled machines of 10 to 12 h.p. for special crops are gradually building up a market.

The development of the tractor to its present stage would have been impossible without steel, in particular without the improvement and reduction in price of high grade steels. The load bearing parts (engine and gear box) are made almost exclusively of cast iron, but the transmission and steering are subject to extremely high stresses. High quality materials such as case-hardening and heat-treatable steels with optimum hardness, strength and toughness values are required for their production. The cheaper these steels are, the more economic is tractor construction.

The value of the tractor is determined to an increasing extent by the quality of the material used and its processing. In the face of the farmers' demand for technical development and versatile equipment, the manufacturer is forced to make constant efforts to improve his products. Mass production of tractors with the constantly increasing wage costs for mechanics and repairmen makes it essential to raise the level of quality incessantly without appreciably increasing tractor prices.

While the gross earnings of industrial works in Germany rose by about 70% from 1958/59 to 1964/65, tractor prices have only risen about 20% in the same period.
If the production and use of the tractor are to remain economic, expensive manual labour must be employed as little as possible not only in production but also on repairs and after sales service.
With mass produced tractors this is achieved by the use of standardized components. In the engine, the tractor body, the superstructure and gears the same or similar parts are used over a wide range of engine powers. This means that individual parts can be produced in large numbers, giving accurate but more economic production and maximum reduction of the share of wage costs.
The smaller tractor models often have excessively large components as a result. However, this is not a disadvantage since in tractors additional weight gives higher tractive power. At the same time of course the number of parts needed for the whole tractor programme is greatly reduced. The stockholding of spare parts after sales service can be considerably reduced. The specialists can exercise better supervision and availability for delivery and profitability are increased.
Accessories form the bridge between the standardized model and the special requirements of individual farmers.
For a tractor these are the attachments necessary for agricultural work (ballast weights, mowers, front loaders, drive-belt pulleys, etc.) or accessories to improve the driver's comfort (e.g. cab roof, comfortable seat, power steering).
The modern tractor can supply all of these many special accessories.
The effects of technical progress may be seen in the tractor sector too and will serve the farmer by providing modern machinery with higher productivity.

R. CARILLON

Centre national d'études et d'expérimentation du machinisme agricole
Paris

The Development of Agricultural Tractors in France During the Next Few Years

(Translated from French)

Although internal combustion engines were first used in agricultural traction vehicles at the onset of the twentieth century, the number of French agricultural vehicles only began to grow, and then only very gradually, after the end of World War I. At the outbreak of World War II there were only 35,000 tractors in use.
The mechanization of French agriculture has therefore been a fairly recent occurrence, and while today there are over a million tractors in use in France, only ten years ago there were no more than 300,000.
The sudden expansion in the demand for tractors, which forced manufacturers to react rapidly from 1955/1966 onwards, was a result of the country's economic expansion, causing 3.5 million agricultural workers—half of the total number engaged in farming in 1938—to leave this basic sector to find work in other sectors. By sheer necessity, production had to be maintained and increased with a reduced agricultural labour force, owing to the growth in the population and the improvement in the quality of the food eaten. To do this, farmers have acquired tractors and other agricultural machinery in ever-increasing quantities as an effective means of raising agricultural productivity.

The size of the French agricultural machinery market

At constant prices (1965 francs) the French agricultural machinery market has shown continuous growth, from 7,050 million francs in 1948 to 3,300 million francs in 1965:

1948	1949	1950	1951	1952	1953	1954	1955	1956	1957	1958	1959	1960
1,050	1,150	1,150	1,050	1,080	1,250	1,400	1,650	2,000	2,850	2,700	2,400	2,350

1961	1962	1963	1964	1965
2,750	2,600	2,850	3,200	3,300

Similarly, annual sales in France for the period 1935-1938 were between 1,000 and 2,000 tractors, 200 to 300 motor-cultivators, 20 to 50 combine-harvesters, and 60,000 metric tons of various other machinery. The average level of sales today is:
— 75,000 to 80,000 tractors with an average output of 35 h.p. to 45 h.p.
— 60,000 to 70,000 motor-cultivators and motor-hoes.
— 10,000 to 12,000 combine-harvesters.
— 280,000 to 300,000 tons of other agricultural machinery.
By 1970, forecasts indicate that this figure will have risen to 85,000 tractors and 450,000 tons of agricultural machinery.

The French agricultural machinery industry

A logical outcome of French agriculture and its requirements was the founding and continued growth of an agricultural machinery industry in France.
It was during the second half of the nineteenth century that this industry was really started, with craftsmen setting up the first production units based on models they had invented.
The French agricultural machinery industry is therefore a long-established industry—older in fact than the car industry — but it has been able to grow and adapt itself with the improvement of equipment and the extension of its market. It is well-placed in Europe and the rest of the world, and a recent development has been the continuing growth of its exports to numerous countries.
From a European standpoint, French manufacturers hold the following positions (USSR excluded):
— 3rd for traction production, after the United Kingdom and the Federal German Republic.
— 2nd position for agricultural machinery production, after the Federal German Republic.
As far as world tractor production is concerned, the leading countries are the United States, the USSR and the United Kingdom, all in front of the Federal German Republic, so that France is the fifth most important manufacturer of agricultural tractors in the world.
In 1964, the French tractor industry manufactured 75,000 agricultural tractors, and 50,000 motor-cultivators or motor-hoes, a considerable increase on previous years; in the same year 260,000 tons of agricultural machinery were manufactured.
The French Fifth Plan, launched in 1966, forecasts that in 1970, 91,000 tractors and 396,500 tons of agricultural machinery will be manufactured.
On its 1965 figures the French agricultural machinery industry has a turnover of around 2,500 million francs or about a sixth of the car industry's turnover; it employs some 45,000 persons, manual workers, staff and management (this figure does not include staff of dealers and repairers).

The main lines of the development of agricultural machinery in France.

The modernization of French agricultural machinery has now reached its economic level. The time has gone when it was essentially a question of replacing animal traction by machine traction, so that production could be maintained following the rural exodus caused by industrial expansion.

Today farmers are trying to create modern production units, scientifically organized in order to achieve the lowest possible costs. To achieve this aim, larger groupings are proposed and given various forms of official encouragement.

This has resulted in a clear move in favour of more powerful and more efficient equipment, as co-operative use of equipment becomes more common, and the size of farms increases.

Thus, 98% of all tractors have diesel engines, and their average power output is constantly growing; at present it is just about to pass the 40 h.p. mark. Similarly the majority of combine-harvesters are self-propelled with a cut of 3 m. or more.

At the same time agricultural structures are changing rapidly, as is the farmer's way of life. Instead of being a peasant, the French farmer is becoming the head of a modern concern, applying the latest techniques, closely following progress and constantly striving to increase his income.

This deep-rooted development cannot but affect the agricultural machinery market in the long run. For instance in 1955 certain sources forecast that French agriculture required around 1,500,000 and 1,700,00 tractors with average output of 24 h.p. Whilst today it is considered that the ideal number of tractors is between 600,000 and 800,000 tractors with an average output of over 40 h.p. which in the future might be over 50 h.p.

The general development of agricultural tractors in France over the next few years

The average French agricultural tractor, in use today, is wheeled (98.5%) with a diesel engine (75%) and has a nominal output of 30 h.p.

The average agricultural tractor, sold in France today, is wheeled (98.4%), diesel-engined (97% of all tractors sold) and has a nominal output of 38 h.p.

It is undeniable that the widespread use of diesel power is now an accepted fact in French agriculture. Besides the basic advantage of the diesel engine for agricultural tasks, which demand large power resources, at the same time as having the lowest possible operating costs when working at less than full power, diesel oil is sold untaxed to farmers. Petrol on the other hand, even though not taxed so highly when sold for agricultural purposes, is still three times as expensive per litre as domestic diesel oil.

A continual increase is also taking place in the power output of tractors. This development is the result of economic necessity, as agricultural wages increase at a quicker rate than the price of industrial products used in farming (see *table*). Admittedly the increasing use of more powerful tractors should be accompanied by a parallel increase in the size of farms; but it is also a trend arising out of the exodus from the land, and to some extend is encouraged and controlled by the public authorities, particularly as a concomitant to "group agriculture" i.e. farmers grouping together.

	1957	1960	1963	1965	Source
Average agricultural wages	100	137	176	210	INSEE
Industrial products (PINEA)	100	121	130	133	INSEE

This hunt for power which started fifteen years ago, can justifiably be considered a matter of concern for tractor manufacturers, because if, as seems likely, there is a fixed level of demand for total tractive power in French farming, then the numerical sales of new tractors should decrease in exact proportion to the increase in average power.

But although it is indisputable that the numerical market for tractors declines as equipment becomes more powerful, the number of tractors in not decreasing in ratio to the increase in their output. One could make a long and boring exposition of this point, but let us simply say that because of the nature of farm tasks it is difficult to use a tractor continuously at full power or anything like it; thus a tractor becomes less and less economic as its power output is increased. This means that in practice the work done by a 30 h.p. tractor in two hours can not necessarily be done by a 60 h.p. tractor in one hour.

Two conclusions should be drawn from this. Firstly a manufacturer's turnover cannot but continue to grow, even if the number of unit sales fall because of the increase in power, Secondly, at any given moment there is always a balance between the various economic factors in play in agricultural production—broadly between capital and labour—and this governs the maximum power output, which there is no point in exceeding.

In France this maximum power output was between 35-40 h.p. during the period 1950-1960; today it is around 55-60 h.p.; and it seems that during the next few years it will increase to 70-80 h.p.

It is therefore not yet worth building giant tractors with a power output exceeding 60-70 h.p. Future progress will be made by slow stages, governed by the relationship between the increase in agricultural wages and the cost of industrial products necessary to farming.

Technical development in French agricultural tractors during the next few years

Apart from satisfying market requirements and increasing power output, agricultural tractors are also undergoing technological developments.

Broadly speaking, an effort is being made to achieve a better use of power at different levels and to improve conditions of comfort and safety for drivers.

As far as the first point is concerned, semi-continuous transmission systems are the precursors of fully continuous systems which only became economic once the power output of each tractor has risen sufficiently. Increasing use of hydraulics is taking place, hydraulic lift systems are being continually improved, external hydraulically operated tools are becoming commoner, and hydraulic transmission systems are used to a greater extent to assist braking and steering.

From the point of view of comfort and safety, attention is now definitely focused on the necessity to provide sprung seats on tractors, even if it is impossible to place the whole chassis on springs, because the traditional requirements of ploughing demand a precise balance between the plough, which is mounted or semi-mounted, and the tractor wheels. Additionally cabins are becoming indispensable, as much for the protection they give against the weather, as for the safety they can also give, at least if they are made of a rigid metal frame firmly mounted on the tractor and capable of withstanding damage should the tractor turn over on its side, or turn over on slopes or at bends in the road.

Thus, in spite of the fact that wheeled agricultural tractors, as they increase their power output, tend to become lighter in relation to their normal power output, their construction includes an increasing number of complicated parts (transmission systems, hydraulic lift, etc.) and more and more metal units with a precise role, which do not simply serve as added weight.

Compared to the tractors of 1930-1938, or even to a large number of those made between 1945 and 1955, the modern agricultural tractor is without doubt a more sophisticated machine, with an improved finish and greater skills.

Such a development is part of the general trend in mechanical equipment and it will continue in the future. But it would be utopian to make a forecast for the distant future. It is possible that present-day conceptions of the tractor could be challenged within 20 or 30 years if there were revolutionary changes in the ploughing sphere: the great stress put on a tractor's tow-bar by the effort needed to turn the soil with a ploughshare, could be eliminated if, for example, chemical ploughing is introduced or if the use of large rotary cultivators becomes widespread.

Again, if for road transport lorries replace tractors and trailer, than a complete change would come about in the construction of agricultural tractors. Although such developments are not yet common in France, it is not impossible to imagine that the appearance of larger sized farms might induce farmers to reconsider the question of road transport, and lead to the use of specialized equipment, rather than continue to use, as at present, multi-purpose tractors whose road-holding qualities are not always beyond reproach.

These two examples show it is possible to forecast on a medium-term basis, that agricultural tractors will progressively improve with the introduction of increasingly versatile machinery. Whilst over a longer period of time, it is equally conceivable that fundamental changes may occur to challenge a number of technological characteristics now thought to be immutable.

R. PICARD

Syndicat général des constructeurs de tracteurs et de machines agricoles
Paris

Trend in French Production of Tractors and Agricultural Machinery, with a Tentative Forecast of Developments in the Next Few Years

(Translated from French)

The French tractor and agricultural-machinery industry in 1965 turned out 401,000 tons of equipment, and recorded a turnover of FF 2,417,000,000 It is the largest industry in the mechanical-engineering sector with the exception of the motor industry.
The following *table* shows the trend in its production since 1956.

Table 1

Year	Tonnage produced			Turnover in current francs	Turnover in constant francs
	Total	of which: Tractors	Machinery		
1956	310,966	115,000	195,966	1,218	1,218
1957	356,584	136,624	219,960	1,607	1,550
1958	383,438	142,980	240,458	1,803	1,570
1959	337,055	128,362	208,693	1,786	1,380
1960	311,841	114,913	196,928	1,672	1,260
1961	345,464	111,717	233,747	1,917	1,420
1962	343,468	105,499	237,969	1,889	1,360
1963	350,866	105,702	245,164	2,066	1,430
1964	378,689	118,381	260,308	2,309	1,585
1965	401,376	134,465	266,911	2,417	1,610

These figure suggest a number of conclusions.
The turnover as calculated in constant monetary values shows an increase of 32% in nine years, representing an annual growth of about 3.15%.
The tonnage produced shows an increase of 29% over the same period, representing an annual growth of approximately 2.9%. Broken down between tractors and agricultural machinery, the increase works out at 17% (about 1.8% p.a.) for the former and 36% (about 3.5% p.a.) for the latter. The somewhat surprising leap in 1957-58 must be considered an aberration, due to a boom in demand which was not warranted by the actual position and which distorted the trend in the years following, landing the farmers and equipment manufacturers in difficulties which were not overcome for quite some time.
To sum up this rather oversimplified account of the recent past, the long-term trend was reasonably satisfactory, but there was a good deal of short-term instability.
Obviously, if we calculated only from 1960, the expansion would appear much more striking, since production in that year was down again to the same level in 1956: this would be quite injustified, however, as to omit the years prior to 1960 would produce an incomplete picture of little statistical value.

Proportion of Steel used in making tractors and agricultural machinery

As matters now stand, it is something of a gamble to try to calculate how much steel is included in the tonnages just given. Even those directly concerned appear to possess only sketchy or out-of-date information in the subject.

Perhaps it will be one of the achievements of this Congress to have encouraged them to look into the matter further: contacts have now been established which we can all feel sure will be fostered and developed in the coming weeks.

In 1957, the agricultural-equipment namufacturers made a fairly thorough survey which suggested that tractors contained 5% of non-metal substances and agricultural machinery 13%. The proportion of non-ferrous matter in the metal content was put at 1% for both categories together with the remaining 99% made up 65 of steel products proper and 34 of other ferrous products (iron castings, steel castings, drawn wire, tubes).

In 1958 and 1959, the Office technique d'utilisation de l'acier (OTUA) issued a market study on the agricultural equipment industry, in two parts, one on tractors and the other on agricultural machinery. This is the only really competent account of the subject in existence. Unfortunately, it is several years old. Meantime, wood has pretty well gone out of use altogether; pastics have come to the fore; iron castings are less popular; there have been various changes in the use made of steel in its different forms; short, such figures as could be quoted would no longer correspond to the facts. As there is no means of checking mistakes, it is impossible to know what one's information is worth, so it is better not to say anything, rather than risk saying something completely wrong.

However, with the studies now in preparation, we may hope before long to have some usable data on the subject.

Future of the agricultural equipment industry

— On completion of Plan V

The working party set up under the fifth National Modernization and Equipment Plan to study the agricultural-equipment sector made about a year ago an attempt to forecast what the position there would be by 1970. It based its calculations on:

a) the movement of added value in agriculture as envisaged in Plan V (+ 2% p.a.);
b) the shrinkage in the working population on the land similarly assumed in the preparation of the Plan (— 3.5% p.a.);
c) the expected productive investment in agriculture;
d) the general growth target fixed by the Government during the implementation of the Plan (approx. 5% p.a.);
e) existing availabilities of certain types of equipment (especially tractors and combine harvesters) and possible rates of renewal;
f) current and expected technological improvements, especially in non-cereal harvesting and handling;
g) the probable final establishment of the Common Market during the period;
h) the culmination of the Kennedy talks in a general dismantling of tariffs.

The indices arrived at were as follows.

Table 2

	Index	Index	Year-to-year changes in % 1965—70
Tractors			
French home sales	100	128	2.6
Exports	100	320	12
Total sales	100	156	5.3
Agricultural machinery			
French home sales	100	165.5	5
Exports	100	237	8.8
Total sales	100	175	5.5
Overall			
Total sales	100	167	5.4

These figures are computed in terms of constant monetary values. The 5.4% growth rate forecast is a decidedly optimistic one, very much higher than the 3.15% recorded from 1956 to 1965, but after all it is not much above that for 1960-65, which was 5.1%. The first few months of 1966 were pretty encouraging, as the first quarter showed an increase of 28% over the first quarter of 1965: however, perhaps there is not much sense in comparing a five-year trend with a primarily cyclical market movement of three months.
It may be in order to hazard a figure as to the tonnage of production, to give those interested something to chew on. Total French production of tractors and agricultural machinery in 1970 would work out, on the basis of the above calculations, at round about 550,000 tons.

— In the long term

The figure I have just cautiously mentioned may sound optimistic to some. Very likely it is as regards a date so close as 1970. But it tallies well enough with what is bound to come.
To quote M. Charles David, Director-General of Planning and General Affairs at the Ministry of Agriculture, "While opening up as it has the highest hopes for better incomes and greater prosperity for the farmers, the machine has driven off the land some whom it has maimed, and drawn the rest relentlessly into a new-style economy, industrialized and competitive, in which they must take their place with the same high standing and the same acceptance of risks as managing directors."
I do not think it is possible to sum up more tellingly the human, economic and technical problems posed for those concerned by the mechanization of agriculture.
In 1963, there were in France 1,900,000 farms supporting a total of 6,900,000 people (3,500,000 men and 3,400,000 women). This represents a working population of approximately 4,200,000 (2,300,000 men and 1,900,000 women), about 20% of the country's total working population, with a share, in 1962, of 9% in the gross national product.
Now in the most advanced industrial countries the share of agriculture in G.N.P. is smaller: in the same reference year it stood in Germany (FR) at 6%, in Belgium at 7%, in the United States and Britain at 4%.
Looking at the United States, we can safely say that a further reduction is to be expected in France in the proportion of the working population employed in agriculture and its share in G.N.P.
Nevertheless, absolutely, the share of agriculture in G.N.P. must increase, since it will be necessary in the years ahead:
1. to feed an expanding French population;
2. to export larger amounts to the Common Market countries and the affluent countries generally;
3. to do more and more to help with the problem of food supplies in the emergent countries.
To put it in a nutshall, the aim must be to produce more with a smaller labour force. This must be done in such a way that income per head of working population rises at a rate enabling the disparity between individual rural and urban earnings to be ironed out as quickly as possible.
At present the agricultural working population is contracting at over 3% a year. At the same time, over the eight years 1955-63, the number of farms has decreased by nearly 400,000; it is the holdings of under 20 hectares (approx. 49 acres) that have disappeared, while there has been an appreciable rise in the number of farms above that size.
There are now 550,000 holdings of less than five hectares, and 380,000 with a working area of between five and ten; the remaining 1,000,000 all have over ten hectares. Still, with a fifth of the country's working population in agricultural and 930,000 farms of under 20 hectares, we have a long way to go.
These developments indicate that the farm is in process of turning into an industrial entreprise, to be operated and managed as such.Which in its turn implies an increase in productive investment, and most particularly investment in agricultural equipment, the machine tools of farming—an increase further accentuated by the shortage of labour, which has inevitably to be made good by recourse to the laboursaving machine.
As for possible dates or possible figures, it is impossible to suggest any: the factors involved are far too numerous and complicated. But it is abundantly clear that the trend, already well under way, will go faster and faster and the demand for agricultural machinery rise and rise.
Will the machinery itself be the same? Some of it will; on the other hand, there is likely to be an increase in the amount of single-purpose equipment, some items tractor-drawn but more self-propelled. However,

all that is a matter for the specialists. What is certain is that requirements of iron and steel products will increase approximately in line with the tonnage of machinery manufactured.

Conclusion

I referred just now to the emergent countries, and I must refer briefly to them again in conclusion. The prevalence of malnutrition in so many parts of the world is a grave problem. The largely non-industrialized countries in which it is found, though primarily agricultural, have an exceedingly low output of foodstuffs: to help work up that output it will also be necessary to manufacture machinery quite unlike that used in the major temperate countries — small hand-operated or animal-drawn machines, for which the need is enormous This is a matter that will definitely have to be tackled and at any rate partly disposed of in the years ahead: the whole future of our civilization depends on it. We must trust that civilization will not prove incapable, despite the high technological level it has achieved, of organizing itself to fulfil its duty.

The needs, then, are gigantic. We must pinpoint them as precisely as possible, calculate the amounts of raw materials and of finished and semi-finished products which will be required to make the equipment that is wanted. This is a task that will brook no delay, and if all concerned recognize its urgency it should be easy to get them to meet and start work. Such meetings, I feel, could appropriately be arranged as a follow-up to this Congress.

Klaus-Friedrich von WERDER, Kassel

Burkhard von der OSTEN, Eschwege

Machinery for Harvesters

(Translated from German)

The term combine harvester has acquired significance only in the past 100 years, when developments in agricultural engineering reduced to minutes and hours operations which used to take days and weeks. For instance, where once months elapsed between the harvesting of the crop and the threshing of it in the barn bay, today the corn finds its way from the stalk into the drying bin on the farm within the space of a single day.

Fodder crops

Cattle are still kept on 90% of all European farms. On these farms the harvesting and supplying of the fodder is the main problem throughout the year. The daily gathering of green fodder takes 1 - 2 hours a day on most farms, or still longer, depending on the distance from the holding. This daily chore first led even small farmers to purchase a tractor in order to save time.

The long-straw harvester and the chaff-cutter have been the two main lines of engineering development. Chaff can be stored in less space and is easier to transport, hence progressive farmers, consultants, and scientists have made propaganda for the chaff-cutter. However, the machinery and equipment calls for a considerable capital outlay.

Interest centres on the field cutter, the original form of which was the so-called precision cutter with adjustable length of cut, the parallel development being the beater cutter, which is of simple design, much cheaper than the precision cutter, but of questionable efficiency. As a counter-argument against the above advantages it is urged that where the terrain is uneven and the fields are covered with molehills it fouls the fodder, and that the more unevenly cut crop is not quite so easy to move in and out of the silo as the short-cut product of the precision cutter. However, the beater cutter has already been used for hay-making, individual manufacturers piling the crop, not through the swiveling nozzle pipe but in swaths through an open flap. This more unevenly cut hay crop dries half a day to a full day quicker than normally cut hay. It can then be picked up by a baling press, or by a loading truck to be described later.

The precision field cutter is usually constructed as a trailer with power transmission. It can also be attached at the side, which gives the unit greater manoeuvrability, because the chaff cart can be attached directly behind the tractor, unlike the collector cart, which generally can only be operated with a second trailer, i.e. with a second man. From this group developed the self-propelled field cutter, which was unable to make any headway because of its high price.

Both these types of field cutter were mainly used for harvesting green fodder for ensilage. Cut hay packs very tight and is more difficult to handle in the farmyard. The final link in the fodder-harvesting chain is the silo, which can be constructed as a high-level silo; enamelled or lacquered steel is one of the materials from which it can be made in this case. The chaff can be unloaded through so-called discharging screens, which operate like the distributor mechanisms of stable-dung distributors, or through worms which feed the chaff into the collecting trough of the blower through side openings in the cart.

In recent times, the loading cart for the harvesting of long-straw fodder has had a meteoric rise. The inventor and manufacturers have been proved right in their contention that the chaff-cutter would never find favour with the bulk of the farmers because of its costly follow-up equipment. The machines of the long-straw harvesting chain follow each other in this order:

— the mower, which is generally built onto the tractor as an intermediate unit,
— rear-harvesters, which have recently been on offer (the double-bladed cutter has been in ever greater demand recently, because of its reliable performance);
— a new rotary mower with high-level cylinders with only four cutters on each;

Then follow the various types of hay-processing machinery. In addition to the well-tried radial tedders and the universally used rotary tedders, there are sweep, cylinder and chain tedders, which are multipurpose but not universal. The somewhat expensive stalk-crusher is still on offer. Opinions are divided as to whether this unit is to be recommended for our climatic conditions. The dried swath used to be loaded with a load-charger, front loader, or hay-trailer. The hay-trailer is a special link in this chain. With its four steel rods and not much else it is an extremely simple unit, but one which can only be used at short distances from the farmyard owing to its small capacity. The advent of the loading truck has meant the virtual end of the load-charger, and the front loader has not the capacity to keep pace with the loading truck.

Although the high capacity of the loading truck solves the problem of clearing the fields, at present it merely transfers it to the farmyard where there are three possible processes: the chaff blower, the unloading blower and the grab. Only the grab can be used for long-stalked hay from the loading truck. Its advantage is that it and its operator can be left to load the truck completely in one operation. While the loading truck returns to the field, the farmyard man has time to stack the load.

The two types of blower with which green fodder is transferred to the silo are more elaborate. It takes a considerable time for the cart to be unloaded via the trough of the unloading fan or the chaff blower. Its inventor has tried to get round this bottle-neck in the loading programme by introducing the rotary unloader. The load of the cart is transferred all at once into a flat cylindrical steel tank from which an ingenious device transfers the green fodder to the unloading blower or chaff-blower. This is the latest development so far in the units of the fodder-harvesting chain.

Grain-harvesting

The harvester thresher and the grain store in the farmyard are the first and last links of a chain, a particularly short one in this case. In the meantime, both links have attained technical perfection, whereas transport and delivery of the grain are still in need of improvement in the opinion of many farmers.

Before discussing the harvesting and threshing chain which is the only acceptable one in the present state of our knowledge, we will mention a few other processes which are still in use but whose development will not be discussed in further detail.

The harvester-binder is on its way out. The industry supplies only a few of them to order, assembling them virtually from spare parts still in stock.

For certain conditions side-delivery harvesters are used. In the United States self-propelled machines of this type are actually marketed. Side-delivery harvesters are useful for rape-harvesting in very wet districts. In seasons in which there is a great deal of sprouting it may be necessary to harvest in loose swaths with long stubble and then to pick up the swaths with a harvester thresher when it has dried out. Chopping and threshing of the swath for a time looked as if it would become important, since the field cutter as a universal high-efficiency machine for all-the-year-round use was given a great deal of publicity. But chopping and threshing was unable to make headway, since only a few of the special threshing machines could be sold, so that the industry lost interest.

The harvester-thresher also replaced sheaf-threshing of rape seed. Thus there was hardly any need to build special machines for these applications.

And so the harvester-thresher prevailed in Europe and became the machine used for grain-harvesting. The long-drawn-out argument about the respective merits of self-propelled and drawn harvester-threshers need not concern us. The fact that three German and two foreing manufacturers are still mass-producing seven different types of drawn machine adequately indicates the demand still existing for these cheaper machines. Indeed, two of the German firms resumed production only a few years ago. Up to the beginning of the fifties a well-known German make of powertransmission harvester-thresher was actually the only one of its kind on sale in Germany.

Not until the American and Canadian manufacturers had adapted their machinery to European conditions (smaller surface areas, higher humidity, higher yields per acre, straw not abandoned), were automatic machines able to make any impact on the German market. Today they have an 80% share in the market. They are now on sale in Europe with widths of cut ranging from 1.70 to 4.10 m. On account of the traffic regulations in force in most countries—in West Germany in particular they are a particularly serious obstacle to the spread of the harvest-thresher with great width of cut—some manufacturers design harvesters for rapid assembly and dismantling, so that they can be attached to carts on the road. A South German manufacturer, using a Dutch patent, has divided the oversize harvester and designed it to fold upwards.

According to Dohne, daily outputs range from 80 cwt/day with a width of cut of 1.70 m. to 206 cwt/day with a width of cut of 3.50 m. In northern and central Europe the season for harvesting and threshing is generally short. The aim is then to do as much as possible by means of a high daily output. Farmers are therefore prepared to accept the very high investment cost of these machines.

The so-called straight-through process is the distinguishing feature of the self-propelled machine: from the blade cut to the ejection of the straw behind the shaker trays the direction in which the grain moves is unchanged. Since its rate of travel and the speed of rotation of its threshing drum are infinitely variable, the harvester-thresher can be adapted to any harvesting conditions. The feeder screw above the cutter, the reel speed, the distance from the bin, the drum speed, the guiding of the air, and the screen size are the stages on this route. The hydraulic system is the technical means used to raise the cutting mechanism in uneven fields and to lower it as far as possible for grain-storage, to adjust the distance between the reel and the cutting mechanism, to make the hydrostatic transmission still more manoeuvrable and its speed more minutely variable.

In the competition between the manufacturers of harvester-threshers, the quality of the separation between straw and grain behind the thresher drum is the main criterion of performance, alongside the output per unit of area. The farmer is primarily concerned with losing as few grains as possible behind the shaker trays. This is the point where the straw and grain go different ways. Straw presses for attachment to harvester-threshers are still being used. Otherwise, the straw is either chopped by means of simple devices on the harvester-thresher and spread as widely as possible over the soil by means of deflectors, or laid in loose swaths for subsequent collection. The follow-up machines in the first case are disc harrows, spade harrows, or cutters, which mix the straw with the soil, or the field cutter with collector truck, or the pick-up press.

Although disc harrows are relatively expensive, they only work satisfactorily with straw-recovery on soils that are not too heavy. Wherever the soil is heavy, spade harrows or cutters with direct transmission are necessary. They are rather expensive, however, and having a maximum operating width of only 2.50 m. they are also expensive in relation to productivity per unit of area.

Farmers who use the straw for their stock connect a chaff-cutter or long-straw harvester as they do with the fodder-harvester developed later. The swaths of straw are generally picked up by the precision cutter and loaded on to carts with attached cutters. The straw from the long-straw harvester is pressed into bales. These bale presses are classified as low-pressure, medium-pressure, and high-pressure presses. Low-pressure and medium-pressure presses use binder twine, but some high-pressure presses use wire. The bales are either transferred to the attached cart on chutes, with one man on the cart for stacking, or "fired" onto the cart with the built-on bale-sling. This eliminates the need for a second man. But this is offset by the fact that the bales lie very unevenly on the cart, the loading capacity of which is thus not used to the full. In both methods, unloading in the farmyard is done in the same way as in the case of fodder-harvesting.

The grain is today transported via the bunkers almost always in the loose state. Bagging stands for transport in sacks are now supplied only by special request with all types of harvester-thresher, including self-propelled ones. The grain screw-conveyor that is always built on to the grain bunker of the harvester-thresher, conveys the grain either to simple farm carts with awnings or foils, to lorries (because of the one-sided tax concessions in West Germany it has hardly made any headway here), or to an intermediate plastic storage bunker at the edge of the field. These plastic bunkers are a standby in cases where the transport space is inadequate or where it is desirable to extract the maximum advantage from a period of fine weather. In the farmyard the grain is tipped into the grain pit through a grating over which movement is possible, and from there it is conveyed by a screw or blower through a primary cleaner into the drier.

Drying installations are classified as continuous driers, in which the grain is dried in a continuous flow generally with the help of hot-air blowers, and batch driers, where the grain is blown while at rest in square or round bins. The abundance of implements and machines on offer and the fact that a great deal can be achieved with relatively simple means by do-it-yourself methods, necessitate that adequate information be obtained, advice sought from impartial sources and, above all, accurate calculations made before this final link is added to the harvesting chain. It is not unusual to find variations from DM 12,000 to DM 60,000 in calculations of this kind from the grain centre.

Maize-harvesting is an offshoot of corn-harvesting. While corn-picking implements have developed in Europe on the same lines as in the United States—the heads are harvested and later stripped with special machinery—there has lately been a tendency to thresh the heads direct, with maize-picking attachments before the harvester-thresher. To this end, all the threshing and screening elements of the harvester-thresher must be of particularly robust construction, and the distance between the bin and the blades on the cylinder must be adjusted to the thickness of the head. The prerequisite for this type of threshing is a grain humidity of less than 20%, which is the rule only in the southern regions of West Gernamy, the centre and south of France, and Italy south of the plain of the Po. It is of course true that maize has been threshed in West Germany even in frost. All the follow-up implements and machines after the harvester-thresher are the same as those used for corn-harvesting.

L. GIL

Centre national d'études et d'éxpérimentation de machinisme agricole
Paris

Farm Machinery Maintenance and the Farm Workshop

(Translated from French)

Since farms have become mechanized, with the attendant influx of implements and harvesting machinery, farmers have been faced with a new problem. The new machines, with which they have equipped their farm, are unable to function properly without proper inspection, maintenance and supervision.

One of the advantages of mechanization is the ability to carry out various cultural and routine operations at the proper time, by means of specialized equipment.

To do thi: it is essential that the equipment should be in perfect mechanical condition to perform the desired function in the available time, which is often very short.

If inspection, adjustments or repairs are necessary to enable it to do this, they should not be left until the last moment, since this will cause delays which might be damaging and loss of time unacceptable to a well-run organization. Equipment should therefore be inspected well before the time when it will be required.

The best way is to check equipment as soon as it is finished with, cleaning and greasing it before it is laid up. At this moment, the troubles which have been experienced during the season can be noted down for rectification as soon as possible. If this is not done, some things are remembered, but others are forgotten and these are often the most important ones.

— Servicing

If extensive repairs are needed, or if, after several years' use, the equipment requires a complete overhaul by a mechanic, it is essential to tell the makers' representative the points that need particular attention. The specialist mechanic will check certain components, but may very well miss some major fault which has appeared during the season. It is therefore up to the farmer to indicate these points and to give his observations on them; nor should he forget to clean the machine thoroughly before he takes it to the dealer, since this will save him several hours of labour charges.

— The farmer's job

Apart from overhauls and major repairs, requiring skills and tools which the farmer rarely possesses, he can and should maintain and adjust the machine and carry out small repairs; for this he will need to set up a small workshop and equip it with a minimum kit of tools. Apart from this it is clear that rural craftsmen are disappearing rapidly and are not being replaced; for this reason it should be possible for the farm workshop to carry out small jobs of plumbing, carpentry and building which are essential for the maintenance, and alteration of buildings and for small building work on the farm.

Here, several questions arise:

What kind of repairs are within the farmer's scope?

Wat kind need the services of a specialist?

Where does the dividing line come?

To be able to reply to these questions the situation on the farm and the ability of the farmer must be considered.

— The situation on the farm

Apart from the size of the farm and the amount of equipment it carries, the main point to consider is its distance from a competent repair workshop.

If there is one close to the farm it will not be necessary to have such an extensive kit of tools as if the workshop were 20 or 30 kilometres away, at which distance considerable time will be lost in travelling.

The mechanical knowledge of the farmer and the tools he possesses should also be considered; these, together with his workshop facilities, will determine the extent of repairs and other work that he can carry out.

Young farmers to-day are far better able to drive a tractor than to groom a horse. Twenty years ago, the reverse was true and the size of a farm was judged by the number of teams, while to-day it is judged by the number of tractors and implements.

On farms which already possess a car, the purchase of a tractor does not mean any driving lessons or instruction in ordinary day-to-day maintenance. In both, the cleaning of the air filter, the fitting of a new oil filter element, checking batteries or lighting and even the dismantling of an injector on a diesel engine are not very complicated operations provided one has a few proper spanners or the necessary special tools.

The farmer should undertake all regular maintenance work; washing, greasing, checking tyres and batteries etc. He should also be able to make the necessary settings and adjustments for the various cultural or harvesting operations by referring to the instructions issued by the manufacturer.

Repairs to a tractor, for instance, should be confined to adjusting the valves. To fit new valves requires the removal of the cylinder head and is, in our opinion, beyond the capabilities of the ordinary farmer.

The farmer has to organize his work, plan his cropping, carry out his cultivations at the right time, decide what fertilizers are to be spread, what seeds or sprays to use and keep his books up-to-date and maintain his equipment; he already has plenty to do without undertaking mechanical work requiring special knowledge undisturbed concentration, time and so forth.

— The farm workshop

As a result of mechanization some farm buildings have changed their use; this applies particularly to stables and barns, which are often suitable for coversion to a workshop, on condition that:

- the space chosen is light and easily accessible,
- the door is as wide as possible and fairly high,
- there is an available supply of electricity with several lighting fittings and power points,
- there are means of heating and ventilation,
- there is storage for nuts and bolts and spare parts and space for a stock of metal,
- water supplies are installed.

The workshop should be light, pleasant and tidy and should provide good working conditions.

Any inventory of equipment, hand tools and machine tool. like that suggested below, must necessarily vary considerably. We have already mentioned the situation of the farm and the farmer's degree of mechanical knowledge, but the most important factor is the quantity of machinery on the farm and the type of farming carried out; an arable farm will have more equipment than a grass farm.

As a basis we have taken the example of an arable farm of 60 hectares, this being about the average size of farms which can maintain a workshop. We list the maintenance to be done, with the tools required opposite.

Washing	pressure hose giving a pressure of 10 to 15 kg.
Greasing	grease guns of the cartridge type with a pressure of 1 to 5 kg. — oilcans,
Oilchanging	sheet metal pan
Filling:	
— water	watering can with spout
— oil	stillage for oil drums — suction pump
— fuel	storage tank — filling pump
Tyres	pump (or wheeled compressor) — pressure gauge — repair kit — tools — valves for water inflation
Batteries	6 and 12 volt charger — hydrometer — volt meter

Painting	spray gun
Mower sections, etc.	sharpener — riveting and rivet removing tool
Essential tools:	
Measuring and setting out	rule — micrometer — straightedge — set square — scribers — compass — centre punch
Hand tools	hammers — cold chisels — files — screwdrivers — pincers — bolt cutters — hacksaw — breast drill — sets of spanners: adjustable, flat — open-ended — box — ring
Fixed tools	2 meter bench — anvil on stand — foot vice — bench vice — welding or oxy-acetylene kit
Special tools	box of taps and dies from 6 to 20 mm. for engines: feel gauges — hub drawer for electricity: electric soldering iron — insulated pliers and screwdriver for wood: handsaw — rasp — plane — chisels
Machine tools	rotary drill (up to 13 mm. diam) with bench stand and vice, sheet metal shear, lever-operated (up to 2 mm.) grinding wheel (2,200 mm. wheels) optional power-driven saw, heavy duty hole puncher
Maintenance	hoist, capacity 500 kg. lifting jack or movable hydraulic jack, pincers, crowbar — ropes — wedges — rollers
Safety	fire extinguishers — sand boxes and shovels — first aid chest (fully fitted)

Estimated cost on the whole, subject to considerable variation according to the tools selected and those already owned: about 6,000 FF.

—Stock of metal

Recently, at a conference requested by a CETA Study center on "The organization of the work-shop on the farm," the farmers present, farming some 150 hectares each on average, in view of the slight knowledge of the types and names of rolled steel products, asked if a basic list could be drawn up showing the sections currently available from stock.

The purpose of this idea was to have handy in reserve a selection of metal normally used for repairs and small blacksmith's work and for gates etc., and also for the conversion and maintenance of buildings.

It will perhaps be surprising that H-section (Gray) and threaded rod are included, but it was at their request that this was done.

H-section is frequently used on the farm as a slotted post to take plank walling in a silo or to construct enclosures in a building for the storage of grain, beet, potatoes etc.

—Statistics and summary

As may be seen, this basic list involves about one metric ton of metal. Some of the items on the list (on the basis of one 6 metre length of each type) will require renewing each year, while others will not have been used at all. But, generally speaking, the figure of one metric ton will involve turning over the stock once a year.
According to official statistics, the data for France are as follows:

1. Farm size and numbers:
   23,500 farms of more than 100 hectares
   84,000 farms of 50 to 100 hectares
   394,000 farms of between 20 and 50 hectares
2. Machinery numbers:
   1,050,000 tractors
   110,000 combine harvesters
   plus all the other machinery for tillage, cultivations, harvesting, transport and maintenance.

Stock of steel sections and plate (1 bar of about 6.00 m. in each size)

	Sizes / Weight						Total weight
Flat	20/5	30/5	40/7	60/7			50.
	6	11	13	20			
Round	8	10	12	14	16		27.200
	2.4	3.7	5.3	7.3	9.5		
Square	10	12	14				20.700
	4.7	6.5	9.5				
Angle	20	30	35	40	50	60	103.700
	5.3	8.1	11	14.4	22.5	42.4	
T-section	35	40	50	60			95.900
	14	17.8	26.7	37.4			
U-section	35	40	50	80	100		188.300
	14	17.2	23.1	51.8	82.2		
I-section	80	100	120				152.700
	35.7	49.8	67.2				
H-section	100	120					320.
	126	193.2					
Heating pipe	15/21	20/27	26/34	33/42			56.300
	6.5	11	16	22.8			
Sheet 1×2 m.	10/10	15/10	20/10	thickness in 1/10 mm.			70.600
	15.5	23.7	31.4				

Threaded rod 1 m.		5	6	8	10	12	14	16	5
Hex. nuts and bolts	25	8/25	10/30	10/60	12/60				
Round headed nuts and bolts (Japy or TREC)	25	8/30	9/50	10/60	10/80				20
Whitworth bolts	100	assorted							
Coach bolts	100	5/30	6/30	6/50	8/40				
Washers, flat	100	6	8	10	12	14			
Split pins	2	2.5	3	4	5	6			
								Total·	1,110.400 kg

Taking these figures into account, it may be estimated that:

a) the number of mechanized farms, owning one or two tractors and one combine harvester, is about one-third of the total number of tractors, i.e. 300,000 farms;
b) the number of farms with a maintenance and repair workshop, a welding set and a small stock of metal must be about 200,000;
c) the number of highly mechanized farms, having a well-equipped workshop with machine tools and a metal stock of one metric ton can be estimated at 50,000.

This represents a tonnage of metal of 50,000 tons for the last category, to which must be added those with smaller stocks, bringing the total tonnage up to the order of 60,000 tons.
It is this tonnage which has made the large hardware merchants in agricultural areas so important.

M. ZERMATTI

Fédération nationale des coopératives d'utilisation de matériel agricole
Paris

Co-operative Workshops for Agricultural Equipment

(Translated from French)

Present position

At present practically all repairs to agricultural equipment are carried out at workshops belonging to the trade (concessionnaires' or dealer-repairers' premises, fitters' shops, converted smithies). The concessionnaires for agricultural equipment include perhaps a score of big supply co-operatives under contract to industrial concerns (such as Renault, International Harvester, Claas, etc); these run repair shops in connection with their after-sales service.

It is customary in France for the concessionnaire, and the trade generally, to see to the maintenance of the equipment sold, whether to individual farmers or to farmers working in association (more especially through agricultural equipment pools). Also, the network of repair points has hitherto been reasonably adequate, which is no doubt why the pools, for example, have not been very keen to set up shops of their own.

However, there are about a hundred such shops owned by the pools in France. Some, most in fact, are small establishments dealing solely with maintenance, not with actual repairs. They do not employ a permanent workshop staff, but have the jobs done by the machine operators themselves, in order to keep them in employment for as large a part of the year as possible.

The others, about fifteen in number in France, are much bigger affairs, which carry out not only maintenance, but also pre-repairs and sometimes repairs proper. "Pre-repairs" include detection of the trouble, dismantling of the machine, replacement of the parts repaired, e.g. by welding, and reassembly, in shops run on commercial lines. This is done by a permanent staff who are at the same time machine operators—a reasonably remunerative job. This disassembly and reassembly work is the part that takes the most man-hours and represents the largest item in the actual repairs bill.

Most of these shops are some distance from the trade-owned repair points, and help to save time in the repairing not only of the equipment belonging to the pool concerned (of which there is always a great deal) but also of that privately owned by the individual farmers affiliated to the pool. Take for instance the diesel tractor fuel-pump: in the event of a breakdown it is removed from the tractor at the pool's shop, and subsequently re-fitted there after going back to the concessionnaire's shop to be adjusted and calibrated.

The pools' shops, of whatever type and size, have all the usual apparatus required for such operations, and in some cases even bigger installations such as overhead cranes and trackage. A few—they are rather the exception—have secured second-hand lathes, but these are used only for extremely urgent jobs.

We have endeavoured to provide both these larger shops and the tiny pool-owned maintenance shops with portable welding apparatus to enable emergency welding jobs to be carried out, sometimes as a temporary measure pending the arrival of the spare part.

It is hard to say just what equipment these shops have at their disposal.

Future outlook

The French agricultural-equipment park is growing all the time. In five years'time the number of tractors, for example, is likely to have risen to 1,300,000 or 1,350,000 and of combine harvesters to over 140,000 or even 150,000 as against 110,000 today.

Moreover, the range of equipment in use is increasing steadily: in addition to the normal items just mentioned there are all sorts of new and highly specialized forms which are essential to the application of the new farming techniques now appearing year by year.

On the other hand, it is by no means certain that the trade will be able to keep up with this expansion and to install the necessary number of new repair points with appropriate equipment and skilled personnel. I do not wish to talk out of turn, but it is a fact that the dealers in agricultural machinery have already been in trouble for some years both financially (insufficient liquid funds to maintain stocks of spare parts, for instance) and organizationally (with the very great difficulty of obtaining and keeping good skilled workmen, owing to the disparity between agricultural and industrial wage levels).

It seems pretty certain that these problems will become more and more serious in the course of the next five years, and that as regards both numbers and apparatus the repair points will fail to keep pace with the rapid expansion in the amount of machinery in use on the farms.

To help make good these inadequacies, we have for some time been urging the pools to link up, in order not only in their turn to pool their increasingly numerous and costly items of machinery, but also to open joint workshops provided with the necessary basic installations and appliances for the maintenance and repair of their machines and those, if any, that are privately owned by their members.

There is no knowing at this stage how far such arrangements are likely to be introduced. But of course they will be adopted only where the trade is not able to cope with requirements: we much prefer to help the trade rather than compete with it. So action will be taken in this direction only if we find the trade is really not managing to give the necessary service.

Anyway, it seems probable that in the next five years something like a hundred shops of this kind will be started, sufficiently well fitted up to do pre-repairs and cetrain routine repairs. Unfortunately, there are two problems — securing skilled labour prepared to work there on a permanent basis (like the concessionnaires, dealer-repairers and craftsmen), and obtaining spare parts (for the shops could not keep the necessary stocks themselves, as they have nothing like enough cash; moveorer, to pay their way they would need to be able to buy the parts very nearly at trade prices).

A third problem — supposing the first two were overcome — would be the shops' break-even point as regards turnover, that is to say, the amount of repairs they would need to do over the year in order to make them worth-while: in other words, the number of vehicles and machines to be dealt with.

The board of management of the Tractor and Agricultural Machinery Repair Shop Equipment Fund some years ago put the minimum number of tractors needed to make a small shop a paying proposition at 20. I am sure we can now safely reckon it at twice that figure, i.e. 40 tractors plus appurtenances (tractors or other equipment expressed in terms of tractors, that is).

The idea of thus "concentrating" the agricultural-equipment pools with a view to setting up repair shops is quite accepted by now, but so far it is only just beginning to be put into effect. If the process does go ahead normally, the shops' requirements of steel and other metal installations and appliances, large and small, though not enormous, will be substantial: in this field the demand for steel in the agricultural sector will expand in line with the equipment park itself.

Francis DURAND,
Ingénieur agronome

Association pour l'encouragement à la productivité agricole
Reims

Agricultural Haulage Equipment

(Translated from French)

The introduction of the tractor has enabled farmers to mechanize their transport either by temporarily adapting former animal-drawn vehicles or by obtaining new ones specifically intended to be tractor-drawn.

In effect, therefore, transport can be regarded as already mechanized on all farms possessing a tractor. This has so enormously speeded up farming operations as to alter them out of recognition: we need only think back a moment to the heavy horse-drawn carts that used to ply back and forth in the surroundings of Paris from the beet farms to the sugar mills, often making only two or three trips a day before the early autumn dusk.

Yet even so the design and construction of motorized farm vehicles is changing fast.

I shall deal in my paper with two aspects — firstly the actual farm vehicles used to carry the different types of product, and secondly the role of the motor car in farming.

Farm vehicles

Farm transport has to take into account the following specific factors.

- Range of products, ect., carried
  - Fertilizing agents (chemical fertilizers, manure, soil conditioners)
  - Seed, treatment products, water for spraying
  - Crops (grain, hay, grass, roots, tubers)
  - Animal feedstuffs (beet pulp, concentrates, meal)
  - Livestock (fat stock, breeding stock)
- Tonnages carried

  On a grain-, beet- and cattle-raising farm the average amount carried is from 25 to 35 tons per hectare per annum, and on a grazing farm from 20 to 30 tons.
- Terrain and roads

  The design of farm trailers, the pull they require, and their useful load and capacity vary considerably according as they are to be used on sound or moist soils, on plain or hill farms, and on unprepared earth tracks or wide, firm roads.
- Distances covered

  By increasing the efficiency of farm haulage, motorization has made distance a less important business consideration. Some farmers are nowadays working fields six or seven miles away from the main farm.
  Nevertheless, other things being equal, the amount of time consumed in transport can vary appreciably according to the distances to be covered. We have here to distinguish between
  - on-farm transport, i.e. from steading to field (loads of fertilizer, seed, manure, etc.) and from field to steading (cereals, potatoes, hay, beet, etc.). These trips are frequent but short. Land consolidation and rationalization of farm roadways is cutting them by an average 20%;
  - off-farm transport, i.e. where the tractor and trailer do the job of a lorry, taking out wheat to the silo, beet to the sugar-mill, livestock to the slaughterhouse, potatoes to the starch works or the railway station and, so on, and bringing in fertilizer, seed, animal feedstuffs and various other products.
    For the purposes of this low-pull road haulage the farmer needs a large-capacity trailer, to be drawn by his tractor in top gear.

On major highways this involves a serious safety problem. The difficulty could, however, be largely overcome by preparing wide, firm earth-tracks alongside the main roads, for the use of farm vehicles only (tractors with trailers or machinery, combine harvesters and so on). This sensible arrangement has been adopted in a number of French Departments, and effected with little trouble in conjunction with land consolidation operations; it is much to be hoped that the example will be followed elsewhere.

What part does transport play in farming?

It is usually claimed that transport accounts on an average for 50% of the tractor's operating time. This is, however, putting it too high: a scrutiny of the regulation "tractor log-books" shows that on mixed grain/beet farm the figure is about 30%, and on mainly grazing farms about 40%.

The capital ratios (residual) on a 100-hectare mixed-crop farm also rearing cattle and/or sheep work out roughly as follows:

— Dead stock capital (exclusive of installations)	100
— Tractors	35
— Farm vehicles (trailers, liquid-manure, tank, 2 h.p. van)	16

If the tractors are used 30% for transport purposes, the real proportion of capital going on the latter thus amounts to 27% of the farm's dead stock.

The farm vehicles most used are the trailers drawn by the farm's tractors. Lorries are not usual, being found only on large farms where they are employed solely for road haulage proper. The American Army surplus G.M.C.s were popular at one time, as they were comparatively cheap and lent themselves admirably to both field and road use; nothing, however, has taken its place, the manufacturers apparently finding it hard to offer the farmers a lorry with comparable advantages at a price they could afford.

The possession of trailers suitable for on-farm (field) and for off-farm (road) use is only really possible on ultra-large farms, which are in a position to own a range of trailers for different types of freight and destination; what the small farm needs is a multi-purpose trailer the design, capacity and useful load of which offer a compromise between freight and destination considerations.

Trailers are of two kinds, four-wheeled and two-wheeled.

The four-wheeled type was the first to be marketed. The older wooden body is giving place more and more to the steel body. These trailers have a large capacity and run well on roads or good tracks. To improve the tractor's wheel gripping power in field work, efforts have been made to distribute the weight by means of chains or jacks between the tow-bar delta and the front wheels.

The two-wheeled trailers may be of the "balanced" type (for small loads of 2-3 tons, drawn by low-powered tractors) or of the "semi-carried" variety with the axle at the rear. The latter model is coming more and more into general use by reason of the greatly-improved wheel grip resulting from the fact that the load is transferred to the rear of the tractor. The manufacturers have had to make provision for this by strengthening the rear wheels of their tractors and the lifting device, often used for hitching.

There are also some p.t.o.-driven trailers requiring the tractor's p.t.o. speed to be synchronized with that of the driving wheels. As these are costly to produce, they can be used only for unloading.

I should also like to mention the metal loading bins for loads of 300-500 kg. fixed to the three-point hitches.

Specialized trailers include:

— water tanks for supplying pastures and treatment apparatus;
— liquid and semi-liquid manure tanks with spreading and filling appliance;
— livestock trailers.

The useful load of trailers has been increased in recent years. This trend will continue with the use of higher-powered tractors, which is itself linked with land consolidation and the increase in farm area.

In beet-growing areas they are now employing two-wheeled trailers with useful loads of 10 tons and capacities of 14 cubic m., hitched to 60 h.p. tractors. The manufacturers are trying to get the ratio of empty to loaded weight down as far as possible, to 1:5 or 1:6, by making all bodies of cold-reduced sheet, tubes and so on.

One thing farmers are most anxious to have is mechanical and automatic loading and unloading, and also coupling and uncoupling, of trailers.

Bulk unloading is done:

1. with tipping wagons, whose jacks are operated either by the tractor's hydraulic system or, increasingly, by a pump on the trailer driven independently from the p.t.o. The manufacturers are now working on automatic two- and three-way locking and opening of the tailgate;
2. with moving-floor trailers, usually operated by pawl and chain and run from the p.t.o. These are more in demand on small farms and in stockbreeding areas, as they are more versatile than the other type: with a movable appliance attached at the rear, they can also be used for manure spreading.

Automatic loading is also coming in in the case of hay and grass, with the development of "self-loading" trailers, very often German-made, and fitted with a loading device at the front or rear.

The farmers greatly value the various automatic contrivances for coupling and uncoupling trailers quickly without action by hand, especially in the case of two-wheeled vehicles. In their desire for multi-purpose equipment, they also want readily-adjustable silage slides, rails, forage ladders and so on.

As regards safety, it is regrettable that there are not at present any definitely fixed European standards. Heavy-duty suspension, requiring no maintenance and not unduly raising the centre of gravity, is becoming necessary to cope with the higher speeds and loads and the vulnerable transmission which is liable to be impaired by jolting and vibration. This tendency is very marked.

For the same reasons, more and more attention needs to be given to brakes. These are usually hydraulic, but it is objected that this type requires maintenance, and above all that it is difficult to connect to the hydraulic system of the tractors, the oil pressures, flows and qualities of which vary widely according to the make. It seems likely, therefore, that for large-capacity trailers the manufacturers will prefer compressed-air transmission, as being separate from the tractor and much stronger.

The motor car in farming

With the disappearance of draught animals, farmers have had to cease using wagons for getting about and for light carting, and buy motor cars instead.

To start with they simply used the tractor to get the men out to the fields, or even to run minor errands to the nearest market town. Similarly, motor-cycles and mopeds began to be employed instead of ordinary bicycles. But very soon they found a car was absolutely essential to do these jobs faster and in greater safety and comfort.

Now a car involves quite a sizeable capital outlay and running expenses, which only a fairly big farm can afford. Nevertheless, more and more farmers now own one, as agriculture cannot continue indefinitely to lag behind a trend now developing in all walks of life. Owing to the farmers' comparatively limited means, they represent a large slice of the second-hand car market.

In France 57% of the farmers now have cars; and the proportion is bound to grow as agricultural living standards rise.

On the great majority of farms the car is primarily used for work, to take the men to the fields and to carry machine parts, small animals, seed and so on. But it is also needed to take the farmer to agricultural meetings and on study tours, in some cases to take the children to school every day, and occasionally simply for private outings.

On the land in particular, the motor car is an all-purpose asset, and so must be of appropriate design and construction. It must be sturdy and serviceable for country use, able to cope with all types of surface, cheap to run, properly capacious, and reasonably fast.

In my own view the small runabout will always be in demand for essentially utilitarian purposes; as time goes on, however, the farmer will very probably take to running a second car chosen more for comfort, speed and road behaviour.

Conclusion

Transport will always be a major production factor in agriculture. But its future development—and hence the demands on industry—will be very much bound up with the technical, economic and social structure of the farms themselves.

Land consolidation, improvement of farm roads and tracks, advancing mechanization of field work and handling operations, specialization of production and processing of the primary produce, formation of bigger units, the farmers' desire for technical information, for bigger markets and for affluence and leisure—all these are factors directly affecting the growing importance of transport in agriculture.
The march of civilization must always mean more and more active trade in goods and movement of individuals and interchange of ideas, and agriculture too, as it moves more fully into the modern age, will need steadily to improve and expand its various means of transport.

J. TERPSTRA

Instituut voor Landbouwtechniek en Rationalisatie
Wageningen

The Development and Potentialities of the Universal Self-unloading Trailer

(Translated from Dutch)

Transport has an important place in agriculture. Altogether between 40 and 60% of all activities in the farming industry consist of transport, and the lion's share falls to the farm trailer. Considering the wide variety of products to be found on most farms, it would be true to say that the modern trailer not only works the longest hours, but is also the most versatile tool the farmer has.
The present condition of agriculture, with rising wages, a shorter working week, and growing shortage of labour, make it imperative to increase productivity per man. As far as transport is concerned the only way to accomplish this is by bulk transport of crops, with the trailers being loaded by means of other implements. Transit and unloading must be carried out at a steady pace. For unloading there are two requirements:

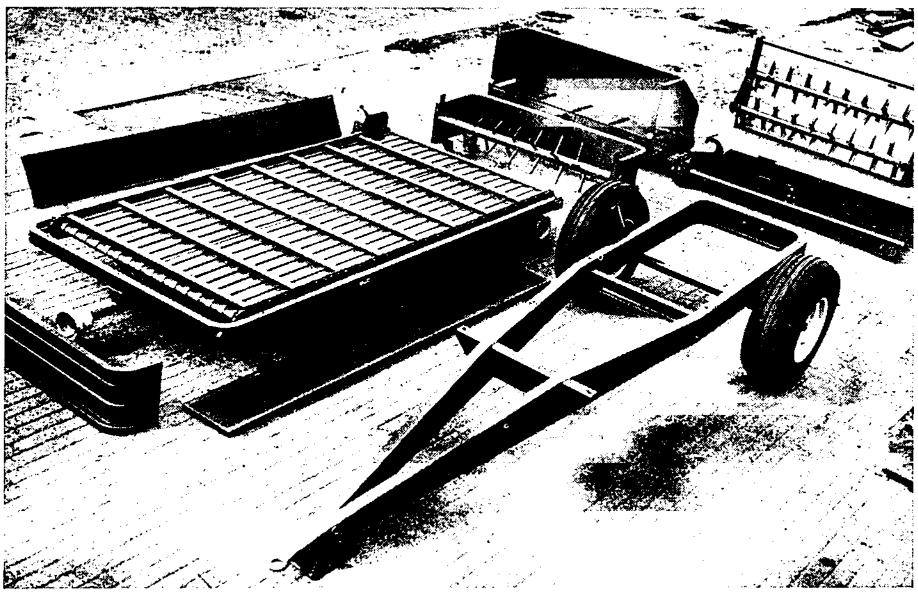
a) One man should take charge of this part of the work, without any other labour being necessary apart from regulation of the unloading mechanism.
b) Unloading capacity must be at least 1 ton per minute of fresh produce.

These requirements can only be met by a self-unloading trailer. The mechanisms of these trailers fall into two main groups according to the principle on which they work,

a) by tipping,
b) by moving floor.

With the moving floor system, discharge remains under the control of the operator, as it does not with tipping. The rate of unloading can be regulated within fairly wide limits. The system as such is suitable for unloading practically all farm produce. By using various detachable, interchangeable accessories, a moving floor trailer can be converted to a universal self-unloader, able to unload the product wherever it may be needed. These considerations have led our Institute (ILR) to undertake the developments of a universal self-unloading trailer in conjunction with a Dutch agricultural machine manufacturer.
In producing the trailer only steel has been used. Although a good deal of timber was incorporated in the first prototypes its use has been discontinued because it is not really suitable for mass production. Timber has the tiresome quality of swelling when it is wet and shrinking when it is dry. There are difficulties too in getting it clean.
If the trailer is to be mass-produced, steel is the indicated material. It can be shaped easily when cold, by rolling, punching, cutting, or bending. Rolling and bending play an important part in the construction of the trailer.

For conveyor belts another advantage of steel springs to mind, namely that it can be resistance welded. Spot, projection, multiple spot, and buttseam welding all offer possibilities not obtainable with other materials. If steel is the best material from the point of view of production, it has one big disadvantage in practice. If it corrodes, and particularly if it gets rusty, it will become unusable.
For the European Coal and Steel Community it is most important that an answer should be found to this problem. It is high time that corrosionresistant steels were available at a reasonable price. No-one can explain why deliveries of CORTEN to the European market should be so limited, nor why it should be so expensive. This holds up progress on the trailer's sectional bottom and side panels, which is a very great pity.
Another approach to the rust problem is to cover the steel with a protective layer. Bonding on zinc or cadmium has the disadvantage that these metals are too soft to withstand abrasion. Coating seems a better prospect, and epoxy powders seem particularly well able to withstand abrasion. Phosphate treatment is known in the motor industry. If steel is to have a proper place in agriculture, much depends on finding a way of protecting its surface from impact and abrasion. Whether the coating is applied electrostatically, by rotary process, or by electrophoresis is not very important. The thing is to find a process that prevents rust and is not too expensive in practice.
Modern tractor construction, with more power and less weight, has led to greater manoeuvrability, and this means that the trailer must have only one axle. With a low tow bar, and the wheels placed behind the centre of the load platform, the necessary weight transfer to the tractor's drive wheels will be achieved. With a coupling point under the rear axle of the trator, the low tow bar counteracts the tendency of the tractor wheels to spin. With the aid of its own hoisting mechanism and a pick-up hitch the trailer is readily coupled and uncoupled.
The trailer has an undercarriage on which its body is placed *(fig. 1)*. High strength low alloy steel is eminently suitable for the construction of both. Although EXTEN is widely used in America to cut down weight, this form of steel is too little used in Europe.



Trailers capable of carrying 3, 4 or 5 tons must obviously be fitted with good tires and 13-16, 13.5-17 and 16-20 tires have been produced for the purpose in conjunction with the Dutch/American motor tire factory. The 16 inch rim seems particularly suitable for adoption as the standard trailer tire. What is really needed for agricultural work, if breakdowns are to be avoided, is a 16-16 tire which, because of its large air chamber, is still load bearing at pressures down to about 1 kg. per square cm.
The trailer body is fitted with endless chains with sweep bars fixed between them. The chains are driven off the tractor's drive axle by means of a ratchet mechanism, which makes it possible to regulate the speed of unloading to a great extent while the operation is in progress.
Unloading capacity, however, depends on more than the speed at which the chains rotate. The shape of the sweep bars also plays an important part. Box-section bars about 3 or 4 cm. high give the best results. Extensive

trials with potatoes revealed no appreciable losses during unloading. It is also evident that the bars must be fixed so that they remain level while moving along the trailer floor.

The chain used is a long pitch bushing chain with a drawing power of 5.5 to 6 tons, this being a type that can be expected to last for the life of the trailer.

It should be possible to empty the trailer from either end. This can be done by mounting the body so that it can be reversed on the undercarriage to give the *right pull* on the chains for unloading. Except for stable manure and chopped grass for pit silos, a side delivery conveyor must be attached to deposit the load where it is needed. To have this conveyor attached to the front of the trailer speeds up the unloading operation, since it is easy to see what is happening. With a detachable extension belt produce can be stacked in heaps while the trailer is in motion. A 6 m. long elevator, driven off the trailer, makes it possible to unload higher and further.

The trailer's capacity is easily adopted to the product to be transported. Building up with interchangeable stacking panels each 40 cm. high gives the following variations:

1panel high: for spreading stable manure;

2panels high: for carrying cereals or roots;

3panels high: to carry silage or fresh material;

4panels high: for carrying chopped grass or hay.

Cereals can be unloaded at the back over the whole width of the trailer as well as via the side-delivery conveyor.

With a side-delivery conveyor and extension, beet can be unloaded into clamps from 2 to 2.50 m. high while the trailer is in motion. The trailer discharges either forward to the left or behind to the right, depending on the design of the lifter, so that the trailer's extension belt is not attached to the same side as the elevator of the lifter. By attaching the 6 m. elevator it is possible to unload straight into a barge.

Potatoes are unloaded at the front, to make it easy for the tractor driver to place the side-delivery conveyor above the bottom of the elevator. With a rubber extension belt it is possible to stack industrial potatoes perfectly in one operation.

Chopped grass can be unloaded into pit silos over a pick-up reel at the back of the trailer, without using the side-delivery conveyor. This provides an even spread over the pit, which can be filled with virtually no further manual work provided that it has been prepared properly in the first place. Circular concrete silos can be filled by unloading via the pick-up reel and side-delivery conveyor on to the 6 m. elevator.

Tower silos give unsatisfactory results if a blower, rather than an elevator, is used to fill them. Blowers cannot discharge the same volume, so they reduce the efficiency of the trailer and it becomes the weak link in the system. Hay that has been cut and loaded by a forage harvester can be handled easily with the help of an axial hay blower driven by a tractor. Fitted with pick-up reels and side-delivery conveyor, the trailer is equipped for transporting fresh chopped material and silage. When planning access to and doorways to new farm buildings, it is as well to bear this possibility in mind. Unloading at the back over manure shredders, the trailer reverts to the familiar function of muck spreader.

A vacuum tank can be placed on the undercarriage instead of the trailer body. This last modification enables the universal trailer to handle liquid manure as well.

Eugène DALLEINNE
Ingénieur agronome

Association pour l'encouragement à la productivité agricole
Paris

Tillage Equipment

(Translated from French)

A large proportion of the implements purchased by farmers consists of soil tillage equipment. In France the number of ploughs sold each year is practically the same as the number of tractors. According to statistics, plough sales exceed 60,000 per annum. The various other soil working implements represent an annual value of FF 135m.

Such implements are a vital necessity for the farmer. Although there are sometimes passing crazes for fashionable devices, sales are regular and less subject to annual fluctuations than other implements or even tractors. However, there might be some cause for worry concerning some recently introduced techniques such as cultivation without ploughing after weedkilling (sometimes referred to as chemical ploughing) or minimum tillage. So it is worthwhile to review the progress made in the use of these methods.

Tillage operations, like all other aspects of agriculture, will also be subject to the consequences of technical progress, of the need to increase the productivity of farm labour, and of the use on farms of increasingly powerful tractors. Implements will evolve as will also the materials used to make them.

Will new tillage techniques affect the implements used?

Sowing without ploughing after complete weed eradication has passed the mere testing stage. Fully effective herbicides, usually residue-free (such as "paraquat") have been used without prior tillage to sow maize after temporary pasture, barley after wheat, rape after barley, or to renovate pastures on grassland that has been allowed to deteriorate.

It would not seem likely that this technique will, in the future, obviate the use of conventional tillage equipment. Farmers have mainly used the method to tackle problems that would otherwise have been difficult to handle:

It is also hard to see how would such techniques enable farmers to bury plant residues, to control certain weeds, to avoid excessive compacting of soils having unstable structures, to allow satisfactory lateral drainage of water (sometimes necessary with moist loams), or to grow certain rotational crops in the loose soil that they require?

For a multi crop farm with normal or variable soils, "chemical ploughing" will, on the contrary, require the use of special sprayers, liquid fertilizer injection devices (which are often useful), special drills weighing up to 800 kg., or even special rotary drills, all this in addition to standard tillage equipment.

The same applies in the case of minimum tillage if the soil is worked on the surface only. Only deep working at regular intervals will solve the problems that arise from the repetition of these practices.

Nevertheless, certain minimum tillage techniques are necessary from time to time or at certain seasons to overcome difficulties at certain peak periods, since they require less labour or less tractor power.

Traditional equipment will continue to be used for tillage but alongside it equipment will be developed for rapid and very shallow tillage. Rotary machines such as rotary hoes and kneaders are those which appear to have the brightest future in France at present. Agronomic requirements however, make it necessary to have implements with variable rotation speeds obtained, for example, by changing gear-wheels.

Tillage implements will undergo evolution similar to that encountered in other fields. Gears, snafts and transmission systems will replace heavy shafts.

How will ploughs develop?

If traditional equipment survives, it will have to evolve. Mouldboard ploughs do not satisfy a scientific mind. The sideways movement and overturning of considerable quantities of earth by sliding over a metal surface (with a shape that is often difficult to define) is a considerable waste of energy.
But this is not the only reason. Increasingly powerful tractors are not very suitable for ploughs which have to be drawn at slow speeds. Increasing the number of shares makes it difficult to retain the popular reversible plough-share arrangements to which farmers have become accustomed for flat ploughing.
However, none of the answers are satisfactory, whether revolutionary or otherwise.
Despite improvements in digging machines, farmers regard them only as implements to fall back upon under difficult conditions.
Disc ploughs are exactly what is needed for abrasive, stony or rocky ground, but in heavy loamy soil, especially with autumn and winter ploughing, the soil structures obtained with disc ploughs are likely to be too friable or too compact depending on their moisture content.
Rotary devices associated with ploughs to varying degrees to complete the breaking up process are only suitable for soils with good structural stability and in situations where excessive moisture content is unlikely.
It can therefore be seen that ploughs are evolving gradually by slow modifications to traditional designs. Ploughing speeds are increasing, and plough bodies have had to be modified to make them more suitable for moving earth rapidly. However, more rapid wear of shares and mouldboards creates problems that go beyond the selection of stronger steels. One way of overcoming these problems consists of using two-part mouldboards. This is an old method which is being tried again. The front part of the mouldboard (the nose), which wears fastest, can be replaced independently of the rest of the plough body.
The problem of share wear cannot be solved by the traditional method of reforging, as qualified blacksmiths are fast disappearing. Various other methods have been proposed. Welding of worn shares has not become as widespread as expected. Using sharpened steel bars to take the main wear, and attaching them to shares made of particularly strong steel, is a method which many favour, but this type of share is not always suitable for soil which adheres to the mouldboard.
Thin and narrow shares can be used until they are nearly completely worn away by tilting over the plough body. These are scrapped when worn out. This represents another method of overcoming the problem of share wear for the future.
The problem of causing clayey soils to slide over mouldboards has yet to be solved. Apart from using extremely hard and very finely polished steels, and even using mouldboards consisting of several layers of metal, there would seem to be no completely satisfactory solution. Vibrating or teflon-coated mouldboards have not gone beyond the laboratory test stage. The formation of a film of water between the earth and the mouldboard is one method much used in clayey regions, but farmers prefer not to be bothered with the inconvenience of carrying water.
Traditional mouldboard ploughs, perhaps improved to varying degrees, wil doubtless remain the basic tillage implement for some time to come, and the ploughman's art will consist of knowing how to use them to best advantage according to the circumstances.

How will shallow tillage implements develop?

Tillers, cultivators, harrows, and light rollers were the implements most used when motorization began.
These traditional implements were modified to allow ground to be cultivated with the fewest number of operations, and the higher power of the tractors now used makes this possible. The growing use of twin tyres or cage wheels obviates certain operations the main purpose of which was to remove wheel impressions from the ground.
Tandem implements have now given way to two implements mounted on the same frame, thus allowing two tillage operations to be carried out simultaneously. Tillers have been modified to produce more break up of the soil in a single pass. They have more closely spaced tines, and more suitable vibratory modes have been developed for their operation. At the same time deeper tillage has been made possible, and the quality and strength of tines have thus become more and more important.

For many years now discs have been associated with traditional implements. Offset disc harrows (cover-crops) have come into general use and are particularly important for summer work. At present disc implements are practically the only type used for cleaning stubble in France.
Reservations must nevertheless be made regarding the use of disc implements for cleaning stubble. In fragile, heavy soils, disc stubble cleaning can be harmful by producing excessive amounts of fine soil, especially when several deep passes have had to be made in order completely to bury stubble. On the other hand, and thanks to the ease with which they can be used and to ensure better penetration, rotary hoes are beginning to be used for this purpose in soils with a stable structure.
Disc implements will nevertheless continue to form parc of the standard range of tillage equipment.
The development of agricultural techniques in recent years has increased the importance of soil compaction. Ploughs, and even some tools used for surface tillage, penetrate deeper. The regular use of herbicides eliminates the rank adventitious weed growth formerly encountered on finely tilled and compacted soil.
Heavy cross kill and cultipacker rollers have become indispensable on nearly every farm. Sometimes, when greater care is required in compaction, the "crosskillette" is used in addition to the crosskill. Of course, this will not oust lighter rollers made of smooth or corrugated steel plate from all superficial soil compaction operations.
In conclusion, the number of tillage implements now used on agricultural holdings is rather frightening, for the new implements to which we have referred are complementary to existing ones and do not replace them.
Agronomical factors become more and more important as higher yields are sought, since most other causes of bad harvests can to varying degrees be avoided as a result of fertilizers, pesticides, hardier varieties, irrigation and so on.
The major problem of crop farming is to obtain the maximum yield from the capital investment made, and to increase productivity per man.
Tillage implements have the dual objective of satisfying agronomical requirements and making farm work more efficient.

G.A. BENDERS

Instituut voor Landbouwtechniek en Rationalisatie
Wageningen

Construction and Development of Haymaking Machinery

(Translated from Dutch)

Compared with other crops, the forage harvest takes a lot of machinery, as the grass has to be mown, turned and loaded.
When it comes to construction and choice of material, machinery designers are faced with some difficult problems. Mowing, for example, must be carried out in conditions that are very hard on the machine. The grass is damp, or actually wet, and often full of sand. The plants frequently contain sharp fragments of stone, and the blades touch the ground whenever they meet a molehill or some slight irregularity in the soil. If there were no other factors to be taken into account, the most resistant steel would be the material to choose. For one thing, the grass to be cut is often mixed with bits of wire or other pieces of iron brought out on to the land with the farmyard manure, in addition to any small stones that may already be in the ground. The moving blades can very easily be damaged by these hard substances. If breaks are to be avoided, therefore,

the material the blades are made of must be neither brittle nor nor soft. At first sight, it seems as though a study should be made of the effects of abrasion. The institute, however, has not undertaken tnis, as the kinds of abrasion met witn in practice can differ so widely that research would only yield very limited information. For example, it would turn out that on one type of soil a mower blade might be good for several hectares, while on another soil it would need several blades to the hectare to acnieve an acceptable result.
Some plots with often quite small pebbles in them are notorious for heavy wear on mower blades.
The cutter bar, which has been in use since about 1830, has a great many moving parts, almost all of which are susceptible to wear. For this reason we are only moderately satisfied with this device.
The blade goes back and forth very quickly (10 to 12 times for every metre the mower advances), and must be held firmly in position by the clips if vibration is to be avoided, but it is continually being loosened by wear. It is therefore astonishing that no attempt was made until a few years ago to make a simpler moving machine. Even replacing the normal cutter bar, with its single blade mowing between fingers, by a pair of blades moving against each other would result in a considerable improvement. There would be no more clogging, and grass catching on the ends of the fingers. If the blades are well balanced and properly adjusted good work can be done, although the difficulty of wear is hardly overcome. The best solution to the mowing problem seems to be to replace the lateral by a rotary movement. Innumerable attempts have been made on these lines. A blade assembly rotating on a horizontal plane is even older than the cutter bar. For a long time the big problem with this type was how to remove the grass when it had been cut. Certainly the horizontal assembly did release it, but only after it had touched the blades several times, by when it was cut into too short lengths. However, this difficulty was overcome in time, by increasing the number of revolutions, among other innovations.
Blades rotating fast on a vertical plane discharge the cut grass upwards, and though it tends to be cut a little short, this is not serious. It may be considerably bruised, which can be an advantage, as it then dries more quickly in the field.
These two types of mowing machine, which cut the grass without any reciprocal movement, largely overcome the problem of wear. It can be expected that mowing machines will now develop with rotary movement and free cut.
Although these new machines have various advantages, the designer is still faced with other problems. The biggest worry is to keep the cutting part, which is under variable and sudden strain, free from vibration.
Fast rotating blades must be well balanced, with bearings to absorb vibration jolts. There is plenty of room for improvement on this point, while more thought might well be given to the position of the blades to minimize the spasmodic strain on them, and because plant juices (often damaging) and grit-laden water may penetrate the bearings.

Operation

If the mown grass is to dry in the field it must be worked with a rake or tedder. The function of the tedder is to pick the grass up and turn it over. On most machines this is done by tines, rotating either horizontally or vertically. The designer is faced with the difficulty that these tines will probably not be loaded at all evenly. Only on the most level soil is it possible to set the machine so that the tines rarely touch the ground. On most land this is not possible. The tines will then be heavily strained, and may be set in vibration by contact with uneven ground. A broken tine is a regular event with haymaking machinery, but this is not very troublesome, as they are cheaply and easily replaced. But the broken part may be left on the land to damage the mowing machine at the next haymaking, or when the hay is being loaded it may damage the baler or chopper. It is therefore desirable to avoid breaking tines as far as possible, without making them too expensive in the process.
However simple the machine in design, there is one requirement that tedders and rakes must meet. Half-dried hay has a particularly disagreeable way of winding itself round every possible part of the machine. This can have a very serious effect on the bearings. In the process, the grass becomes heated and disintegrates. Plant fibres get into the bearing casing and the bearings rapidly break up.
There are many different machines on the market for loading grass and hay. Having regard to the possibility of breakdown during the short time that the crop is ripe for harvesting, and the brief spells of fine weather

we can expect in Western Europe, it seems obvious that the simplest machinery would be the best. But since the form in which the crop is to be harvested also plays a part, complicated machinery, such as balers and choppers, will often be used. These present the same difficulties as we found in mowers. In particular, if a short cut is wanted, this makes heavy demands on the chopper blades.

They must be able to stand a great deal of wear, and must be tough enough to stay sharp a long time in spite of grass, sand, iron and stones. Up to now the material used has been anything but good. The blades of most choppers must be sharpened every four hours. The sharpening itself is not difficult, but removing the blades, replacing them, and adjusting them, is time-consuming and exacting work. More often than not the users will choose a chopper with a cutting cylinder, in which the blades can be sharpened without being removed and only the shear plate need be adjusted.

How complicated a machine is may often be judged by the number of greasing nipples. On some, they may number 50 or more. We sometimes wonder whether designers have any idea of what actually happens on the farm at harvest time. Using modern methods, it should be possible to reduce the number of lubrication points considerable.

Karl RÖBEN
Oberingenieur VDI,

Oelde

Steel as a Means to Progress in Agriculture, with Special Reference to its Use in Modern Milking Machines

(Translated from German)

There have been two distinct trends in the farming industry of Western Europe over the past twenty years, namely the motorization of field operations and the mechanization of at-farm work. The former process was not due solely to the advent of the tractor (which has since become and extremely reliable piece of equipment) but also to a whole series of useful implements which have come on to the market to be used in conjunction with the particular type of tractor employed. Higher returns for less physical exertion, together with a notable increase in *élan* on the farm are the happy result of this development.

Judicious mechanization of at-farm operations should always start with the electric power and water supplies; after that, it is also often necessary to purchase a milking machine of reliable make.

Though up to 1950 the desirability of milking machines was noth disputed, it was evident even then that probable one day all milking would be carried out by machine. Sure enough the machine came in more and more, as a help both to family and to hired milkers.

The enormous increase in the number of milking machines in West Germany the last 15 years—the total was estimated at about 440,000 at the end of 1965 (see *fig. 1*)—illustrates the important part they play in easing the load on farm workers and improving the quality of milk obtained. This rise is paralleled only by the similar continuous expansion in the tractor park with the progress of motorization.

Milking machines have now finally established themselves and have become an indispensable farm item.

The type of machine in most general use is that comprising a fixed power unit, a vacuum pipeline extending the length of the cow stalls in the shed, and milking devices which may be moved from one cow to the next. Technical progress has enabled milking efficiency to be increased without the slightest ill-effect on the udder, continual improvement resulted through the use of new materials and cleaning and disinfecting agents ensuring better-quality milk.

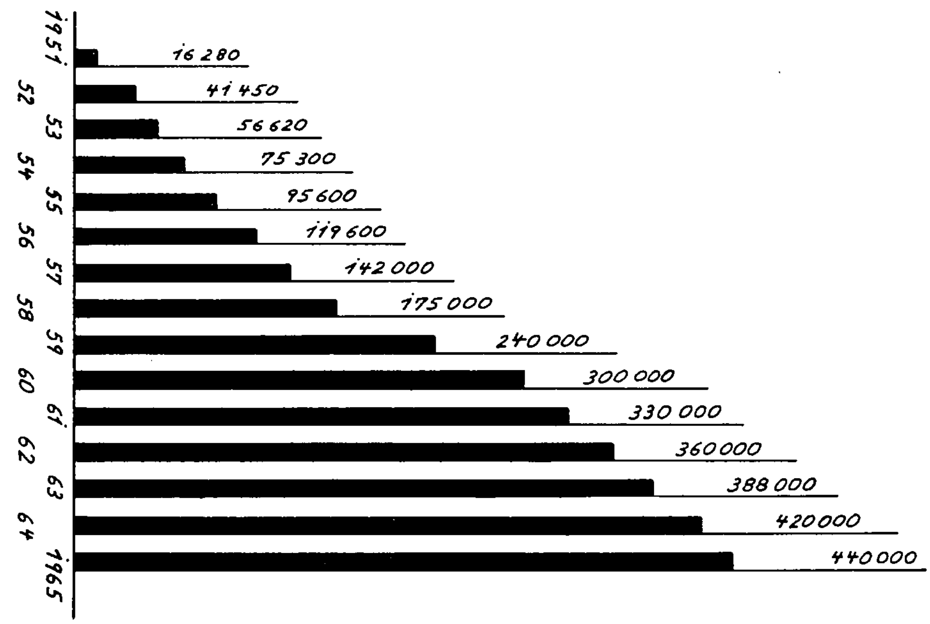


Fig. 1 — Increase in the number of milking machines in the Federal Republic

Milking machines are available for all sizes of farm and are notable for their simple design, great reliability in operation and high milking efficiency.

In the last ten years interest has been shown not only in the milking machines described above, but also in other more up-to-date types in which the milk is drawn out through special pipes and which are suitable for use both for stanchion stalls and milking parlours. Although milking as carried out with these machines is essentially the same process as the older mechanical milking with individual buckets, it does eliminate the need to remove buckets and churns and to strain the milk and transfer it to other containers. With these machines the milk flows automatically through a pipe made of stainless steel or Plexiglass to the adjacent milk handling room. The milk attachments connected to the udders receive activating pulses from generators housed in supports. Of course, these special milking machines retain those features which have proved successful in conventional machines.

Since experience is leading farmers more and more to demand automatic cleaning of milker connections located in the pipes, all special milking machines are nowadays provided with practical closure members of various types.

Another very important point is the automatic vacuum control system which ensures a constant vacuum and enables the cow located furthest from the source of vacuum to be milked dry just as quickly and efficiently as the first one.

A further step forward which is of great importance in the care and cleaning of these milk tubes and of the closure members mentioned above is the spiral flow rinsing system, so called because cleaning and disinfectant solutions are circulated through the milk tubes in a spiral flow which thoroughly rinses and disinfects them.

The decision whether to use a special pipe-milking machine in a stanchion shed or a milking stall in conjunction with a loose housing system will depend upon local geographical and working conditions and the type of building involved.

The milking parlours developed over the past 20 years are in many cases of the walk-through or tandem type. Both systems have produced good results and are still in demand. Walk-through milking stalls are often used for machine milking while cows are grazing.

The need to increase output still further has led to the development of the "herringbone" milking parlour (*fig. 2*). The rows of cows are milked alternately from the lower-level service passage so that cows are kept in the parlour for as short a time as possible. Many of these installations have proved highly successful in practice. It is nowadays by no means a rare occurrence for a trained milker to achieve a milking rate of between 35 and 40 cows per hour.

The "herringbone" system enables cows to be fed during milking with a quantity of hard food proportionate to their yield, since although the milking time is reduced the cows waiting time is still longer than is the case in walk-through or tandem milking parlours. Simple, reliable feed-portioning machines, which may be electrically or manually operated, are used to adjust the quantity of feed for each cow individually.

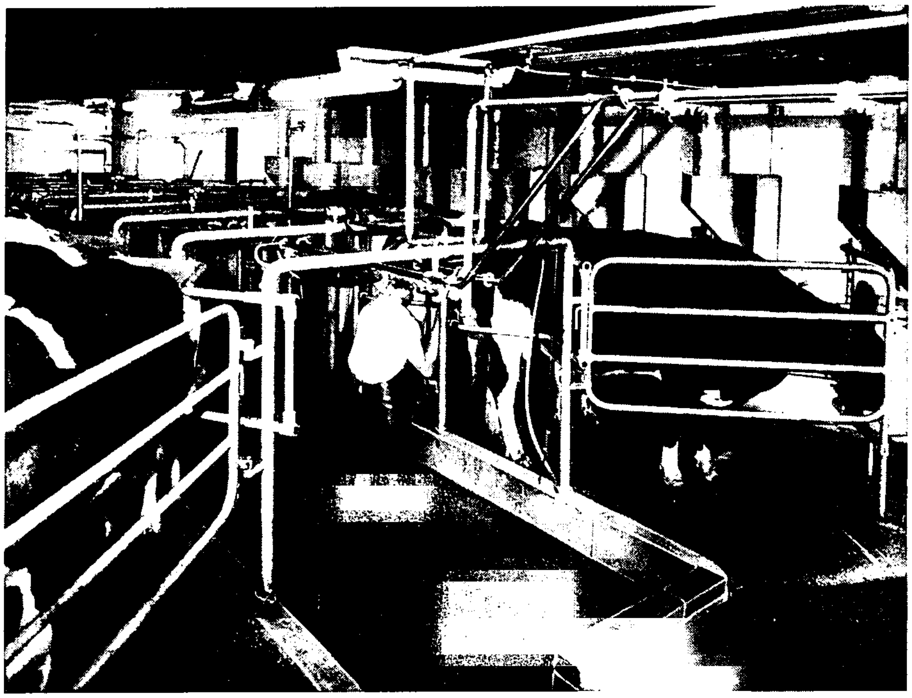


Fig. 2

There is thus in the first place the choice, depending on the type of farm, whether to install cowshed vacuum milking or a milking parlour. Whichever course is taken, there further remains a wide choice of cooling and storage tanks for holding the fresh milk af the farm's "milk terminal." The main deciding factor here is how the milk is to be used and whether the dairy collects it daily or very other day.

It is nowadays well known that to keep properly milk must be artificially cooled immediately after it is drawn from the cow. There are a number of well-known practical methods of cooling different quantities of milk and storing it until it is collected by the dairy milk tanker.

How about the relative amounts of iron and steel and of other materials used in manufacturing milking machines and equipment?

A considerable amount of grey cast iron was and still is used in most milking machines for the vacuum pumps and electric motor housings, rolled steel is used for rotary parts and pipe fasteners while galvanized tubes are used for the vacuum pipes laid through the cowshed. Steel sheet is also required for electric motors and containers. Churns are definitely tending more and more to be made of stainless steel instead of aluminium as hitherto. Non-ferrous metals and special composition rubber are, of course, also used in milking machines. There is an even greater demand for stainless steel in special milking machines where it is highly suitable for the milk tubes. It is quite usual to find several hundred meters of tubing in this type of large stanchion shed, since the rinsing tube in the automatic circulatory cleaning system is almost as long as the milk tube.

In milking parlours too there is a rapidly increasing demand for galvanized tubes which are used for the frames in which the cow stands during milking, while the amount of steel sheet used in such equipment as feed portioners is also not inconsiderable.

It is obvious that if suitable grades of steel had not been produced all these developments would never have been possible.

Finally a few details about the value of milk production in West Germany.

The *Bauernblatt fur Schleswig-Holstein*, No. 9/1964, records the value of agricultural food production for the financial year 1962-63 as amounting to approximately DM 25,600,000,000. The largest single item was cow's

milk, representing DM 6,500,000,000 or about 25% of the whole—just about equal to the figure for all plant crops together, including cereals, potatoes, sugar beet, fruit and vegetables.
Dr. F. Schönberg of Hannover in his book *Milchkunde und Milchhygiene* ("Dairy Science and Hygiene") makes the interesting point that "the total value of milk production in the Federal Republic of Germany is about four times that of total pig-iron production."
So milk and milk production in themselves constitute a field worth taking a look at.

F. MOLTZER

Instituut voor Tuinbouwtechniek
Wageningen

The Use of Steel in Fruit Growing Implements

(Translated from Dutch)

Implements used in fruit growing are generally constructed as lightly as possible without any sacrifice of strength.
There is considerable variation in the conditions under which implements are used in orchards, e.g. for tillage, mowing or spraying in all kinds of weather. High standards of dependability and operating reliability are therefore demanded.

—Rotary scythes

For this type of implement the main type of steel used is normal commercial quality steel 37 (V 1035), steel sections, steel sheet, structural shapes and tubing.
Steel 42 (V 1035) is used where better-quality material with improved strength and durability is required.
Axles are usually made from axle blanks of steel 42 (V 1035) but in specific instances steel 60 (V 1035) is occasionally used. Special types of steel are used in transmissions, knife blades and ball bearings.
Nuts and bolts are usally of ordinary commercial quality but exceptionally G-8 bolts are used.
At present there are five firms manufacturing rotary scythes in the Netherlands. These machines have been used increasingly in orchards during the current decade and many improvements have been made in design, including improvements to the rotors, offset operation, and improved distribution of cut herbage.
There is no trend towards using steels other than the above and consideration is not being given to replacing steel with plastics.
Cast iron is used for gear casings, bearings housings, etc., and cast or wrought steel for transmission components in universal joints.

—Mist blowers and high-velocity sprayers

The first mist blowers built in the Netherlands appeared about 1950 and permitted spray rates of 200-300 l. per hectare to be used instead of the 2000-3000 l. per hectare previously delivered by power sprayers. These

mist blowers were initially hand-operated but were replaced after a few years by automatic blowers with centrifugal fans. High-velocity sprayers with axial fans have also been introduced.
Mist blowers and high-velocity sprayers manufactured in the Netherlands have undergone repeated improvement and satisfy stringent requirements.
The various types of steel cited in the section on rotary scythes are also used in manufacturing mist blowers and high-velocity sprayers. There has, however, been a trend towards using materials other than sheet steel for making spray tanks (reservoirs) so as to save weight and avoid corrosion by reactive spray solutions. Plastics, including fibreglass-reinforced polyester, are already being used for the purpose.
Stainless steel is sometimes used in spray nozzles for orifice plates, regulators, etc.

—Tillage implements

In addition to ploughing, disc-harrowing and cultivating, tillage with offset rotary cultivators has shown a marked increase in popularity. Most of these rotary cultivators have tines consisting of angled steel blades, but these are imported.
Apart from the steels already mentioned, special-purpose steels are used for components subject to wear and tear from the soil, particularly in rotary cultivators and ploughshares.
Steel utilization in machinery for such land-improvement projects as earth-moving, drainage and building farm roads is outside the scope of this paper.

—Sprinkler installations

These are used in orchards in dry summers and for protection against night frost. Galvanized steel tubes with snap connectors are the main components used.
There is a relatively strong trend towards the use of aluminium and plastic tubes in these installations.

—Transport vehicles

Large numbers of low narrow two-wheeled carts are being manufactured for use in intensively managed plots. Increasing use is being made of sprung trailers with four wheels for conveying the fruit to the auction market.

—Fruit grading machines

These are predominantly of steel, though this depends on the make; some timber-framed ones are still made. They are made by a number of firms, some of which also manufacture for export.
Because of the trend towards centralized grading no increase in steel utilization is to be expected. Ordinary steels are generally used whilst certain components are made of plastic.

—Miscellaneous

Steel is also employed elsewhere in fruit growing for supports, fencing, hand tools, trolleys, nest-type storage boxes, box hoists, packaging machines, etc. The steels used are again the same.
Since reliable data on factory output of implements used in fruit growing are not available, we are unfortunately unable to assess the annual consumption ot steel by this industry.

P. SIBEN

Ingénieur en chef du Génie rural des eaux et des forêts f.f.
Coordinnateur des échelons du Midi du Centre national d'études et d'expérimentation de machinisme agricole
Nîmes

Mechanization in Arboriculture

(Translated from French)

In France, about 150,000 hectares of fruit-producing land is given over to intensive arboriculture, which traditionally takes the form of hard fruit production. For the purposes of this study, one can add to this figure a few hectares of high vines, though the potential here is over 500,000 hectares. To put this in perspective, in terms of orchards, tree plantations represent a potential gross turnover of around FF 2,000 million, while high vines could well add a further FF 5,000 million to this: this is equal to the figure for bread grains.

This intensive arboriculture, together with vines treated by the same methods, was developed only recently, and by people whose normal field was agriculture. This meant that the highest possible degree of mechanisation was pursued, even though it has not yet reached the scale common in cereal production.

Another feature of arboriculture is the high cost of investments of this kind, as the gross annual turnover never meets more than half the investment cost, if that, after five or seven years, depending on the crop in question; and writing-off must be extended over 15 or 20 years, even assuming there are no natural disasters to cause a drop in the tonnage harvested or in market prices.

These background details illustrate the scope of the problem.

We shall look at orchard cultivation in greater detail to show the amount of work required in this sector. The chief features of the annual cycle are pruning during dormancy, supervision of the fruiting period and frequent thinning and summer pruning, and the harvest. Arboriculture, according to the needs of the plant and the amount of attention it requires, involves basic dressing with phosphates and potash fertilizers, dressing for growth with nitrogen, and treatment for disease and pests. It also embraces methods for getting plants in peak condition, by compensating for climatic conditions such as frost, drought and humidity.

All these operations have to be performed in a very short space of time, during a period of only a few days or even a few hours of the plant's life. This means that the arboriculturalist must take swift and decisive action, of the sort that one usually attributes to a fire-fighter.

Another aspect of the matter is that, with only a few exceptions, such as aerial spraying and permanent irrigation lines all arboricultural work takes the form of on-the-spot manual labour, regardless of the state of the ground or the nature of the orchard. This means that the man who does this sort of work is going to attach great importance to the robustness and lightness of his tools. The sort of equipment used often combines a light but strong framework with light working parts, resistant to stresses and corrosion alike. For this reason, copper and copper alloys have in general given way to plastics, rather than stainless steel.

In practice, arboriculturalists use tractors of 50 h.p. and over in conjunction with the following tools:

- Manuring: Fertilizer injectors (ten to twelve cm.). Fertilizer distributors. Rotary hoes or cultivators.
- Compensating for Climate: Vibrating-time cultivators (vibrocultors). "Cover-crop" cultivators vineyard-type ploughs with hoes between the trees.
- Spraying: Air blast sprayers often with plastic reservoirs and pipes.
- Harvesting: Trailers, to some extent purpose built.

Most of these machines have working parts such as shares, knives and blades, which are fairly quickly worn out. Just how quickly depends mainly on the terrain, so that it is difficult to estimate how much steel a hectare of orchard consumes a year in terms of spare parts.

For some years now more and more machines have been coming into use for:

- Picking
  - Light, tubular steel portable tripods, which are easier to move than wooden or aluminium ones.

  - — Loader-elevators, or fork-lift trucks.
  - — Tractor-towed picking ladders with scaffolding or moveable platforms.
  - — Self-propelled picking ladders.
  - — Tree-shakers with built-in receiving trays.
  - — Receiving tray units.
- — Pruning: Traditional secateurs, which had to be replaced every two years, are now being abandoned for:
  - — Air-assisted, or mechanically-operated secateurs.
  - — Circular saws.
  - — Pulverizers for prunings.

These new machines, with the exception of those used for cutting operations, have no parts needing frequent replacement.

The main operations; pruning, thinning and picking, still remain mostly manual.

For picking on the industrial scale, the French, for some years now, have been using combined tree-shaking machines for plum-trees: the Americans use shakers and vibrators for canning fruits, whilst the Dutch only use vibrators for certain smaller fruits. Apparently, the Russians and Americans are also using harvesters for the wine crop, a method which is now being tried in the vineyards of Languedoc.

The idea that machines may prove satisfactory in themselves, either now or in the near future, does not necessarily hold true for their use in orchards or vineyards: as a general rule they serve to solve a simple problem, such as gathering fruit which has been removed from the plant by such means as shaking or vibration (other devices are electric knives with sensing probes and cutter bars), separating it from foreign matter such as leaves and stones, and feeding it into receiving trays, either as it is, or after it has been crushed for wine-making. Such methods, however, rarely allow fruit to get to the preserving or canning stage undamaged: often it is bruised by falling through branches or something of the sort, such that it has to be processed immediately, and only then if the damaged has not already induced fermentation or rot. This means that such scope as there is for mechanizing the fruit and wine harvest depends entirely on the genetic development of less fragile varieties better suited to mechanical handling, but without detracting from such qualities as flavour.

For hand picking, the arboriculturalist only uses small (10-500 l.) carriers made of canvas (the American picking bag), plastic (buckets), or wood (trays or bulk bins). Steel seems to have been ousted by plastic, which is both lighter and cheaper. At the same time, I have yet to see a metal tray or bin which needs any more plastic and protective foil lining than are used in wooden ones.

Orchard work calls for frequent runs with machinery which remains heavy, despite all the efforts made to lighten it. Low volume spraying in particular, calls for a three-axled unit, a four wheeled tractor and a two-wheeled trailer, which can exert a pressure of 10 tons, 7 or 8 of them from the trailer alone.This causes compression of the soil, choking the roots, and cutting down the cultivable area to around 40%, if not the entire area of the orchard. This wastage can be overcome by:

- — Using irrigation for spraying
- — By sowing ray grass, chich has deep roots
- — By laying runways, using light perforated steel plates, of the sort used on aerodromes.

Having looked at the work done in orchards, we shall consider the planting of them. This subject is rarely touched upon in arboriculture, as it concerns techniques which are only called for when the orchard is to be started or renewed: this takes place once every 15 years with peaches, and once every 30 at least with all other varieties, including grape-vines. But it is in this sector that we find that the heaviest machinery is used.

First of all, the orchard has to be planted, and here one is dealing with a suitable planned and ordered plot. There is no need to dwell upon the sort of machines the future arboriculturalist will use for this: bulldozers, angle dozers, profilers, scrapers and various other devices well known to civil engineers.

For drainage, there will be plant that is already used by rural engineers, such as mechanical shovels, hydraulic shovels, ditch-diggers, sub-soilers, drainers and so on.

One of these machines, however, the drainer, is worth saying a little more about: the average life of an orchard lies between 15 and 30 years, or longer, depending on what species have been planted, as this has a bearing on how long it takes before the roots become choked. Light drainage, using a subsoiler, is rarely suitable for orchards, as it ceases to be efficient after a few years (three of four in the very best conditions). What is needed is a drainage network of earthenware or plastic pipes, bedded in porous material which will not allow mud to seep through. Experiments conducted in France in 1963 seem to indicate that one good method is to lay PVC drainage tubes with a sub-soiler, following a predetermined slope, regardless of the surface contours of the soil. This process is very heavy on subsoiler blades. I would point out that one area is known to me where the ground was so abrasive, consisting of rough clay over a bed of shale, that five blades were used to cut 60 kilometres.

Future sites will always have built-in irrigation systems, of varying degrees of sophistication, which at all times will ensure optimum humidity for the health of the orchard or vineyard.

Arboriculturalists will, in future, combine the thorough cultivation of the site with the spreading of phosphate and potash dressings, either with one-way ploughs or with fertilizer-drilling sub-soilers, after which general planting will be done with tractor mounted augers.

According to the density of the plantation and the ultimate shape of the tree, planting is done either in open patterns or in hedges. The latter calls for wire trellises supported on posts, whose extent can be considerable. Here we should mention open-centre vines, which require a double V-section fence to ensure the speedy growth of the plant. The tension of the wires is obtained quite cheaply by using the device patented by Monsieur Faget. These fences should last as long as the plantation itself, and should be strong enough to support the weight of trees and bushes, plus that of the weight of ice which is built up when anti-frost sprays are operating.

Acacia posts are normally used for this in France and Yugoslavia, together with galvanized iron wire, whilst in the USA and Africa, acacia is replaced by ordinary sawn timber, to facilitate construction. Metal posts, correctly treated, would be sufficiently durable and rust-proof to fulfil this function, apart from which they could be used in conjunction with oblique supports, and thus provide an alternative to wood.

An orchard must also be protected against frost, and there are various methods for this: the most common is smudgepots, placed about 170 to 350 to the hectare around the site, and heated by domestic fuel oil, either gravity-fed by pipe, or supplied from mobile tanks.

One system which is being used increasingly in new irrigation networks is water spraying when there is frost about: this uses the latent heat of freezing water to warm the branches of the trees. Development of this method is being retarded by two things: the cost of installing a fixed irrigation network throughout the orchard, and the fact that it must give 100% coverage for this purpose, compared with the 20% of normal irrigation systems. Where there are fruit hedges, this network is mounted on the trellises, strengthened where necessary. It is also difficult to find sprinklers which can constantly deliver less than 3 mm. of water an hour (to avoid "drowning" the orchard), despite corrosion by water and the other liquids which may be passed through them.

Two other centralised processes which have been used in Italy and the USA for some time, and which are now being introduced in France, are normal and heated air circulation.

Air is circulated by a powerful blower to prevent it from stagnating in calm weather: a fan placed above the trees blows the warmer layers of air down towards the ground, where they prevent frost.

Heated air circulation can be used in all conditions: apparently heat is best utilized when concentrated at ground level. The machine in question is a turboreactor, that is, a fan with built-in-fuel-oil burners, which again is set up above the trees. Some parts, of course, will get too hot, but the rest of their metal can be protected by the usual coatings and paints.

Apart from fixed equipment, which, with only minor repairs, should last as long as the orchard itself, the arboriculturalist's tools can be written off in between five and ten years, an effective working life of between 1,000 and 2,000 hours (tractors excluded), and involving only such attention as the replacement of working parts (see above), such as secateur blades.

Here, as with all agricultural machinery, one must differentiate between new equipment and replacements and maintenance, particularly as recent official statements on the subject indicate that for the next two years, after the tremendous effort of the last decade, the traditional French apple, pear and peach orchards are unlikely to change very much. One would hope that the forward advance will pick up again when the Languedoc vineyards go over to mechanized harvesting.

Maurice AUDIBERT
Ingénieur

École nationale supérieure agronomique de Montpellier
Centre national d'études et d'expérimentation de machinisme agricole
Antony

Steel and the Development of Viticultural Equipment

(Translated from French)

At a time when more than ever before efficiency and profitability are not only desirable but essential, it may be helpful to outline the new features which should be introduced in viticultural techniques.
As in the past, steel will have a vital role to play in the production of modern viticultural equipment, but it is now expected to have a versatility which it did not have and which was not needed in the past.

—Preparing the soil for the planting of vines

The work of clearing the land and trenching and levelling the ground for the planting of vines can be done quite adequately with present-day civil-engineering equipment.
The mechanical laying of continuous drains of perforated plastic material by means of subsoiler mole diggers or trenchers making only a narrow cut ensures economical drainage of the plots to be cultivated.
The installation of a water supply system with underground or overhead metal pipes which can be used for many purposes (frost protection, irrigation, spraying with fertilizers, weedkillers or plant chemicals) is to be recommended since its advantages depend only on technical and economic considerations on which the engineer can make a decision on the basis of experiments and a calculation of profitability.
Organic chemistry has provided efficient and economical methods of ridding the ground of pests, predators and degeneration diseases, for example by the localised digging in of pesticides by means of special subsoil applicators.

—Preparation of plants for the planting of vineyards

Mechanization of the cutting of stock and grafts, their storage under refrigeration, mechanical bench grafting, the stratification of the grafts in heated premises, the mechanization of the planting of grafts with an incipient union for rooting and of their uprooting and packaging for shipment, already partially achieved, must be continued on an industrial scale.
Mechanized planting out, on which a half-hearted start has been made in France with equipment modelled on horticultural implements must be further developed.
The first tests undertaken on the "plastic mulching" of young plantations, still in its infancy, show that there are genuine possibilities of increasing rooting, development, early fruiting and the yield of the first harvests in this way. It can be done mechanically.

—Training of vines

Short training of young vines for subsequent "goblet" growing, and "wide and high" training of commercial vines intended to be cultivated by standard agricultural machinery and harvested mechanically, are opening the way to machines or tools for collective use for driving in metal stakes and posts and erecting and tensioning the metal supporting wires.

If a more detailed study shows that such training methods have technical or economic advantages, the supports might also be used for the transport of materials and power, *e.g.* multi-purpose sprinkler fluids rails for treatment and harvesting equipment, distribution of energy in the form of compressed air and electricity for treatment, pruning, and possibly also cultivating and harvesting machines.

—Fertilization of vineyards

For liquids sprinklers, sprayers or subsoil applicators may be used.
Fertilizer pellets or powders may be distributed by surface spreaders or localized subsoil applicator.. Standard centrifugal spreaders have various advantages, such as large working width, uniform distribution, and suitability for different crops, for collective use, and for conversion to subsoil applicators.
It is difficult to mechanize the spreading of organic manures in the existing confined vineyards, as the spreaders used for farm crops require much wider spacing between rows.
Trace elements to correct deficiency diseases may be distributed in liquid form with the equipment already in use, namely land and air-borne sprayers and sprinklers.

—Pruning the vines

Summer pruning of the vine vegetation can be done mechanically, particularly on trained vines, by heading and thinning devices with rotating and oscillating elements, circular saws, rotating blades or cutter blades driven by power take-off and auxiliary internal-combustion, hydraulic or electric motors.
Fully mechanized winter pruning of mellowed wood is not possible since this operation involves human judgment. The only progress that might be made in this direction would be to increase the productivity of each pruner by providing him with easily handled tools, operating continuously and actuated by compressed air, oil-hydraulic pressure or an electric motor, with the necessary power source or reserve coming from a fixed system or a crawling-speed tractor self-steered either by a pilot furrow or by a guide wire, with a remote-control stop available to the operator.

—Protection against weather conditions and disease prevention

Apart from spraying against frost and heating the air by smudge-pots, methods only compatible with a high income per hectare, little can be expected of smoke screens or ammonium bisulphide clouds in the way of frost prevention.
Insecticides and acaricides are chiefly applied in liquid form with a high volume per hectare (several hectolitres) when mechanical spray equipment with a spreader or solid jet is used, but may also have a lower volume per hectare (some tens of litres) when compressed-air spraying equipment is used.
For protection against fungi, when the pesticide must be well distributed over all parts of the plant, it is necessary to use spreader-jet compressed-air sprayers with a low per hectare volume to reduce idle time and the equipment and labour required. The treatment of the future will be the spraying of 10-15 litres per hectare of oily suspensions ready for use. Such treatment can be carried out indirectly by drifting application with air sprayers having a single nozzle or by means of air sprayers using air streams of differing characteristics.
In all this spraying equipment the metal parts must be chemically inert or suitably treated to prevent oxidation and corrosion and protect them against abrasion.
Because of its speed and high hourly performance, spraying from the air is ideal for general anti-parasite applications in vineyards. Thirty hectares per hour at 50 litres per hectare with mechanical spraying and from 30 to 60 hectares per hour at 10 or 15 litres per hectare with compressed-air spraying can be covered by helicopters and probably also by aircraft on larger and less congested plots.
Spraying from the air is the method of the future for treating vineyards, whatever difficulties are encountered at present as a result of the particularism of the vine growers and the stagnation on the wine market (where

prices are not keeping pace with wages and the cost of fungicides), since there is no other technique which enables from 100 to 200 vine plants per second to be sprayed after bad weather without damage to soil or vegetation, as often as once or twice a week if necessary. Additional work such as the spreading of fertilizers and weedkiller, the sowing of green manure or crop dusting, would make the use of aircraft in viticulture even more economical. As regards the components of the sprayers, crop dusters and spreaders to be mounted in agricultural aircraft, it must be remembered that weight is critical in flying.

—Destruction of weeds and working the soil

The problems involved in mechanizing and motorizing the vineyards arise from the need to cultivate the soil where the rows are closely spaced. This affects tractors in particular as they must be powerful, short, narrow, low, safe against overturning, directionally stable and light — qualities very difficult to combine, with the result that the specialised vineyard tractor is either practically custom-built or "retailored" from standard models, and in either case more costly in relation to its haulage performance than any other.

The search for an acceptable compromise between the quatilies required and the different spacing and growing methods encountered has resulted in an increasing diversity of models from the articulated mini-tractor and the small "caterpillar" to straddle vehicles of 4 tons, not forgetting the many types of asymetrical straddle vehicles and stabilized between-row chassis.

The multiplicity of models leads to confusion, small production runs, high prices, short-lived makes and unavailability of spares as engines change to suit the whims of the market.

The simplest method would be to use production-model agricultural tractors between rows with an adequate standard spacing (3 metres for example). If the height of the training supports was standardized at 1.5 metres the variable-track straddle tractor or stabilized between-row chassis could be used in all French vineyards. "Wide and high" training of vines also permits the use of the cultivating, fertilizing and treatment equipment used in orchards, thus eliminating the need for specialized tractors.

Weeding and working the soil along the rows are done with automatic vineyard ploughs but the most highly developed models which best protect the plants are fairly costly and require constant attention and frequent adjustment. Chemical weeding of the rows appears more convenient.

Chemical weedkilling may also be applied to the whole of the vineyard soil. Tests on non-cultivation carried out to date appear to indicate that for commercial viticulture it would reduce the fixed and proportional costs corresponding to the purchase price and running costs of traction and cultivation equipment.

To reduce the risk of the soil deteriorating if it is not cultivated and eliminate the need to work the soil in the rows, it may be advisable to combine chemical weedkilling in the rows with green manuring of the spaces between rows.

Non-cultivation and chemical weeding of the vineyard or chemical weeding of the row with controlled growth between the rows may be used for "wide and high" vines, as may also fully-mechanized working of the soil in and between the rows. In fact, as far as steel is concerned, traction and cultivating equipment and machinery for viticulture do not present any greater design problems than their agricultural counterparts.

—Destruction or disposal of prunings

For "goblet"-trained pruning can be facilitated by a mechanical *espoudasseuse* which before pruning chops the standing into pieces of about 20 centimetres so that they can be left as they are on the ground.

With "wide and high" vines long shoots which cannot be pruned mechanically are pruned by hand. It appears preferable to collect them between every second row so that they may be raked up mechanically or ploughed in with a rotovator.

Harvesting

From the plant to the table, the vine grower, oenologist and wine merchant must always remember that grapes and wine are complex, fragile and living substances.

Comsequently it is essential to protect the grape, the must and ultimately the wine from
— contamination by foreign bodies;
— contamination by iron or any other metal;
— atmospheric oxidation;
— rough mechanical handling.

The grape must be cleanly harvested and all foreign bodies and vegetation removed. In many cases washing is useful.

To prevent contamination by iron or other metals after harvesting, grapes must be transported or stored in chemically-inert containers. As a substitute for the traditional wood or basketwork containers, plastics appear today to be exempt from the disadvantages of metal containers. The latter may be protected by an inert insulating layer but unfortunately this is all too often not sufficiently long-lasting. However, when metal containers are required to move large tonnages of an ordinary quality, some protective coating is essential. A high-quality plastic coating of the type now available on the market, which has high abrasion and impact resistance, would appear suitable for this purpose.

The need to reduce production costs and mechanize work in the face of the increasing scarcity and cost of manpower, which will soon be non-existent, is forcing European vine growers to seek methods of fully or partly mechanizing grape harvesting.

A partial solution is to facilitate removal of the grapes after they have been harvested by hand. This increases productivity but does not release much of the labour required.

Full mechanization of grape harvesting means the almost total abolition of pickers. The machine itself harvests the fruit either by shaking, by mechanical cutting of the stalks or by suction.

Whatever the methods used, the danger of foreign bodies and pieces of vegetation being mixed in with the grapes, or of the fruit coming into contact with metals and suffering increased oxidation is very much higher. Grape-harvesting machines must be provided with a cleaning, de-dusting and possibly washing device if they are to function efficiently. The many leaves picked with the grapes, particularly when suction machines are used, will probably be removed pneumatically. Whenever traditional oenological practices and the intended quality of the finished product permit, mechanical pressing will be effected in the vineyard. The disadvantages inherent in premature pressing of the harvest will be overcome by keeping the pulp in an anaerobic environment, transferring it directly from the machine to a mobile inert-gas tank. This machine is a harvester-presser-charger which operates continuously from harvesting to unloading, thus meeting the requirements for oenological quality and continuous working without "idle" times. Stainless steel should be first-class material for this type of machine.

Stainless steel in the transport and storage of wines

To solve the problem of obtaining impermeable, tight and non-toxic vat linings, stainless steel immediately springs to mind. Of the chromium-nickel stainless steels containing from 8 to 48% nickel, 17 to 25% chromium and 2 to 6% molybdenum, the ordinary 18/10 and molybdenum 18/10 stainless steels are the most suitable for the viticultural industry. They have almost the same mechanical properties,
— in the soft state: mechanical strength 65 kg/sq. mm., yield point 22 kg/sq.mm., elongation 40-50%, Brinell hardness about 140 kg./sq.m.
— in the cold-worked state: mechanical strength 150 kg./sq.mm. yield point 100 kg./sq.mm., elongation 5 to 11%, Brinell hardness over 300 kg./sq.m.

Their impact strength is excellent and the Mesnager notch impact strength varies from 20 to 30 kg./sq. cm. with a high cupping value making them suitable for deep drawing.

Although 18/10 stainless steels have a low thermal conductivity this disadvantage can be minimised by the reduction in thickness which their mechanical strength makes possible. The 14/10 and molybdenum 18/10 stainless steels also have an excellent corrosion resistance in the presence of oxidizing agents and organic acids and an excellent surface finish which facilitates maintenance.

18/10 stainless steel is resistant to dilute acetic solutions at ordinary temperature and molybdenum 18/10 to hot concentrated solutions.

18/10 stainless steel can be supplied solid or clad on steel. Pure stainless steel is supplied in all forms, strip, bars and tubes. Most designers are able to work stainless steel and produce very varied shapes.
Steel clad with stainless steel is produced by hotrolling a stainless sheet on to a steel sheet after preparing the surfaces. Steel clad with stainless steel in this way must not be confused with steel faced with stainless steel by spot or stitch welding.
There are also "sandwich" stainless steels consisting of a layer of a metal which is a good heat conductor, such as copper or aluminium, between two layers of stainless steel.
Clad stainless steels are useful for fairly thick plates of 4 to 5 mm. They are cheaper than solid stainless steel, although their price is nearer that of the latter than of steel. Their thermal conductivity is greater than that of the solid metal and is close to that of mild steel. Clad stainless steel must be welded in two stages, the mild steel and the stainless steel being welded separately.
The use of stainless steel prevents a harmful quantity of iron entering the wine and eliminates the need for copper. The main applications of stainless steel in the viticultural industry are for apparatus for sulphite treatment, evaporators for grape must, presses, filter pumps, cooling apparatus, tanks, containers, pneumatic bottling units, doors and traps in vats, piping, taps and wine tankers.

J. LAILLET

Syndicat général des constructeurs de tracteurs et de machines agricoles
Luisant

The French Agricultural Machinery Industry

(Translated from French)

In 1965, the French agricultural machinery industry employed more than 42,000 people and producted over 400,000 tons of machinery and plant.
Agricultural machinery must, by nature, be sturdy and serviceable; this implies both great strength and minimum weight, particularly where portable machinery is concerned; low price levels are also vital. The seven essential requirements for steel in agricultural equipment can, very briefly, be summarized as follows:

- — good resistance to atmospheric conditions;
- — good resistance to chemical agents arising, in particular from vegetable fermentation: manure, silage, etc. ;
- — good resistance to wear;
- — good bending strength;
- — good resistance to internal pressure stresses; for example, in the case of hydraulic jack tubes;
- — lightness in weight;
- — attractive price.

The problem here is to protect the metal; this is usually done either by painting, galvanizing (with or without an additional coat of paint), by means of plastic coating or by vitrification.
In the case of small components, protection can be provided by cadmium-plating, nickel-plating, chromium-plating, bonderizing, parkerizing, etc.
For spraying applications, very large quantities of light tubing are used; provided the metal is suitably protected and the price of the equipment satisfactory, steel tubing will solve the problem perfectly.

The problem of resistance to chemical agents affects the many agricultural machines used for handling vegetable matter and ranging from the simple corn mill and silage and manure loading equipment to silos in which damaging fermentation takes place; the principal components affected are the steel sheet (often protected with various coatings) and those mechanical parts which, after a very short working period, become surrounded by or immersed in corrosive matter.
It would, of course, be interesting to make comparative calculations of the cost price of ordinary sheet metal protected by means of various coatings and that of stainless steel sheet.
It is very likely that in certain cases the result would be in favour of stainless steel.
Here we are first concerned with the effect of abrasion resulting from the tool working in the soil; an important aspect of the problem is the wear suffered by the teeth of materials handling equipment. The normal grades of steels used for these purposes have a manganese content of 3 or 12%.
Consideration must also be given to the resistance to wear of moving parts, more particularly to spindles and shafts which are usually made of constructional steel alloyed with chrome and nickel steel treated by high-frequency processes.
This factor also can be divided into two parts:

a) the problem of piano wire and spring steel of various sections. A great number of spring-loaded tools are used in agricultural machinery and call for the use of hard carbon steels, silico-manganese steels, etc.;
b) the question of teeth and prongs used for manure, beetroot and fodder loading equipment.

These steels must comply with rigorous flexibility and toughness standards.
Hydraulically-operated plant is today being used in agricultural machinery and handling equipment to an ever-increasing extent.
The main feature of these items of equipment is the hydraulic jack. The tubes used in the manufacture of such jacks must also comply with special well-defined specifications.
It would therefore seem essential for tube dimensions to be standardized with a view to achieving some degree of European uniformity and the lowest possible production costs.
Provided that it can easily be welded, sheet steel with high strength properties should make it possible to achieve a considerable reduction in the weight of some types of agricultural machinery, particularly in the case of buckets and grabs used in association with handling equipment.
In addition, where steel framework is concerned, the maximum lightness in weight can be obtained by the judicious use of cold or hot-rolled sections, welded or not, and of tubes of various shapes corresponding to the most favourable moments of inertia.
If the use of agricultural machinery is to become more widespread, prices will have to be reduced as much as possible so as to ensure definite reductions in agricultural costs.
To achieve this, agricultural machinery manufacturers must aim at mass production, by making the fullest possible use of mechanically welded components and those that are cut out or pressed by cold or hot processes, forged or die-stamped components or steel castings. In each and every case the quality of the steel must be suitable for the individual purpose. Arc welding is frequently used in agricultural machinery manufacture and it is important to ensure that all metals involved can be easily welded.
Users of steel in the agricultural machinery industry are particularly hoping that the task of remodelling the French iron and steel standards, undertaken during the last few years will quickly be extended to the widest possible range of products, in accordance with current European standardization practice.
If manufacturers of agricultural machinery and plant are to make the best possible use of steel, it is essential for a specialist advisory service to be placed at their disposal, a service which should provide both information and technical advice.

Dr. rer. nat. H. J. KOPINECK
Dr. rer. nat. Bernd MEUTHEN

Hoesch AG Westfalenhütte
Dortmund

Composite Laminated Steel Sheets with Noise-absorbing Plastic Layers

(Translated from German)

A feature of agricultural development over the last few years is that machines have taken over much of the work previously done by hand. Mechanization has been an important aid in efforts to rationalize agriculture. It is impossible to imagine agriculture without machines such as combine harvesters, tractors, hydraulically operated machinery and cereal drying installations.

The harmony of the farmyard of the past has given way to the monotonous harassing noise of motors. The noise of industry is particularly unacceptable here because it still sounds strange in these surroundings and it can affect the health of the people, who still work extremely hard in agriculture.

In the search for materials which can effectively combat these sources of noise, one recent development warrants special attention. Industry has been successful in developing a noise-absorbing material in the form of a composite laminated steel sheet. This combination, consisting of two steel sheets separated by a plastic layer, has excellent properties with regard to reduction in sound transmission or sound absorption. Plastics have of late been used increasingly as vibration damping materials, mostly in the form of thick, sound-absorbing honeycombs.

As a result of theoretical work on acoustics new composite materials have been developed; knowledge of the physical laws of molecular relaxation behaviour in plastics has made it possible to obtain the optimum damping for use in particular frequency and temperature ranges. Such multi-layer systems are superior to sheets using single side sound damping systems. Sandwich components are relatively simple to produce and process and the composite material can usually be regarded technologically a single material.

The following remarks are devoted to this new material the types available, their properties, processing characteristics and applications.

Types available

There are two different types of steel/plastic/steel sandwich. These differ by the type and property of plastic used in the sandwich.

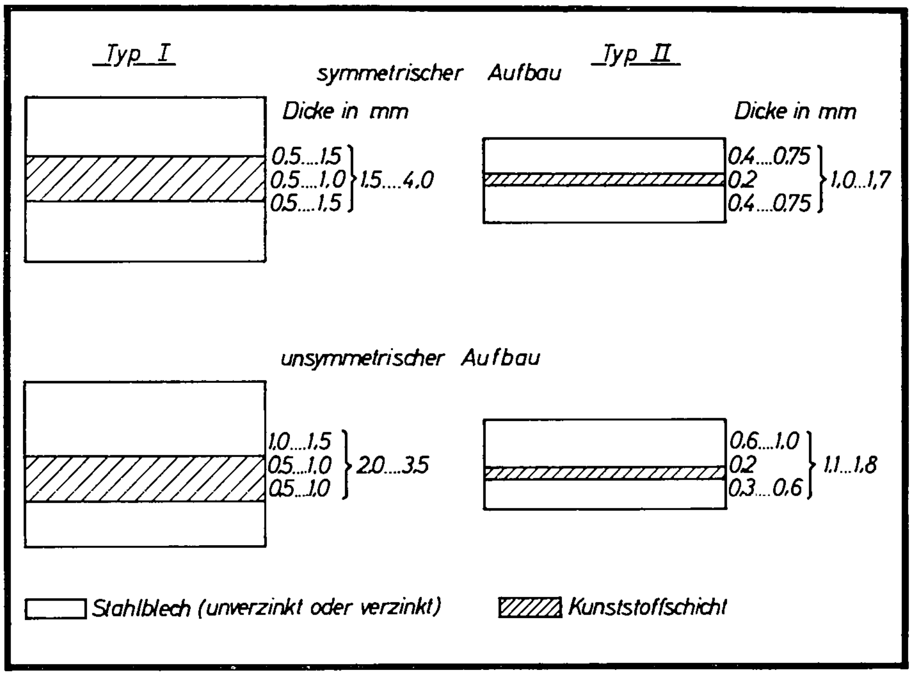
In type 1 the layer consists of a relatively thick, adherent, and barely compressible plastic and elastic foil consisting of vinyl chloride copolymers with a second component which has a low softening point.

Type 2 consists of a thin self-adhesive soft layer which is applied from a melt consisting of a modified vinyl acetate copolymer, and which has a softening range at ambient temperatures. By modifying the copolymers of both types the damping properties may be altered to some extent, particularly with respect to frequencies and temperatures.

The steel sheets used in the laminate are generally electro-galvanized, but may, however, be uncoated or even hot-dip (Sendzimir) galvanized. The outside surfaces of type 1 are lightly coated with a protective lacquer.

Figure 1 shows examples of the sandwich systems it is possible to produce. The individual sheets may either be equally thick (symmetrical sandwich construction) or they may have the thickness ratio of 1:2 (asymmetrical sandwich construction) since it is not uncommon that a high mechanical strength is only needed on one side. Fundamentally, other thickness ratios are also possible.

Usual sheet measurements are 1,000 × 2,000 mm.; the total thickness may very between 1.0 and 4.0 mm.



Typ I = *type I*
Typ II = *type II*
symmetrischer Aufbau = *symmetrical construction*
Dicke in mm = *thickness in mm.*
unsymmetrischer Aufbau = *unsymmetrical construction*
Stahlblech (unverzinkt oder verzinkt) = *steel sheet (ungalvanized, or galvanized)*
Kunstoffschicht = *plastic layer.*

Figure 1 — Schematic representation of the layer sequence for sandwich-composite sheets

Properties

— Temperature resistance

The highest working temperature is 70-80° C; for short periods exposures up to about 130° C are possible, although the plastic material used in *type* 2 tends to become fluid at this temperature and may ooze out at the edges.

— Bending strength

Although the plastic layer in *type* 2 has high adhesive properties, it will not transmit large tensions or loads. Above all, the strength of the individual sheets have to be taken as the starting point in calculations involving transverse forces (bending loads).
The bending rigidity B as well as indentation and buckling resistance are proportional to the third power of the thickness "d" of a solid sheet, or to the sum of the third power of the thicknesses d_1 and d_2 of the two sheets making up the sandwich system:

$$B \sim d^3 = d_1^3 + d_2^3$$

With a thickness ratio

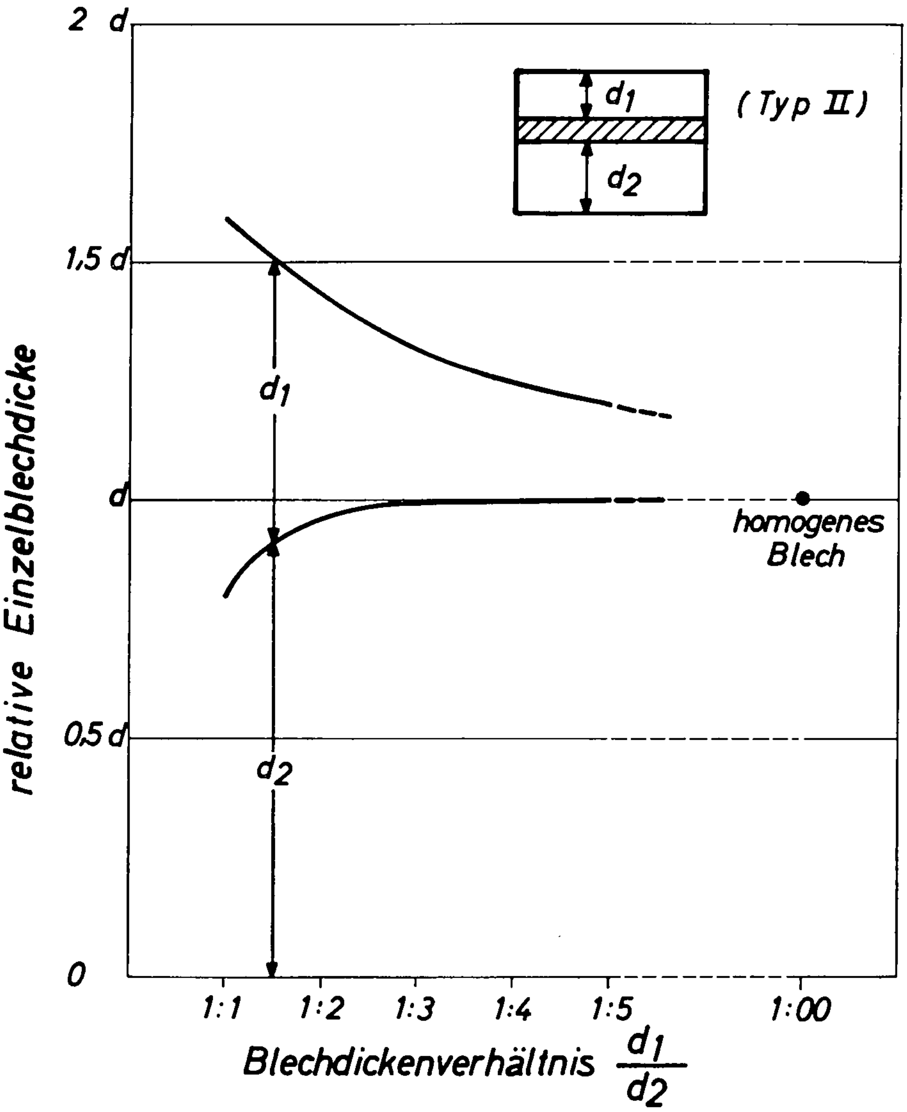
$$q = \frac{d_1}{d_2}$$

it follows that

$$d_2 = d\,(1 + q^3) - \frac{1}{3}$$

Figure 2 shows the required thicknesses of the single sheets if the rigidity of the sandwich system is to correspond to that of a solid sheet. The calculated values for d_1 and d_2 may be rounded off to the lowest figure. The thickness ratio of 1:4 should not however be exceeded because of increasing deterioration of damping properties.

Different conditions are relevant for *type 1* because of the rigid bond between the steel and the plastic foil and because of the higher internal rigidity of the latter, so that to a certain extent shear forces and tensions can be absorbed. By shifting the neutral axis the flexural bearing strength is increased substantially. Initial results of experiments which are still proceeding indicate that the overall rigidity of a symmetrical laminate corresponds roughly to that of a solid sheet 0.5 mm. thicker than the individual sheets making up the composite. This relationship is valid at least up to a single sheet thickness of 1.5 mm.



relative Einzelblechdicke = *relative individual sheet thickness*
homogenes Blech = *solid sheet*
Blechdickenverhältnis = *sheet thickness ratio*
Typ I = *type I*

Figure 2 — Relationship of the individual sheet thickness to sandwich construction, in comparison to a solid sheet of the same rigidity

With both types, the rigidity can of course be increased by corrugating and profiling etc. in the same manner as for a solid sheet.

Sound damping

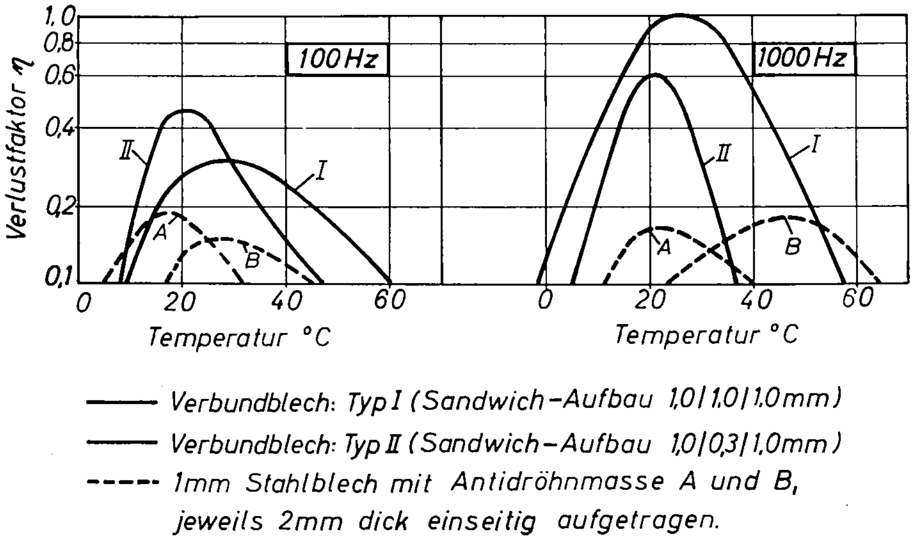
What are the special acoustic properties of such sandwich constructions?

"Sound damping" can be defined as the diminution of intensity of sound waves by the absorption of energy. In particular, sound attenuation of an object means the reduction of sound transmission from walls etc. into air, because the exciting vibration has already been largely destroyed in the wall itself.

Of decisive importance in the reduction of the sound reflection from a sheet is vibration damping, in particular the damping of flexural waves. This internal damping is described as the loss factor η. It is a measure of the absorption of vibrational energy and shows that fraction of energy which is absorbed per vibration, mainly by shearing strain of the plastic layer, is transformed into heat, and therefore, made useless for sound reflection.

The loss factor is dependent on temperature and frequency since the plastic materials which are used are thermoplastic. Apart from this, the magnitude and trend of the loss factor is influenced by geometry, i.e. the thickness ratio.

For an undamped steel sheet the value of the loss factor is of the order of $\eta = 0.001$, and under conditions of substantial edge damping can reach a maximum of $\eta = 0.01$. *Figure 3* shows the influence of temperature on the loss factor for the two types of sandwich. The left part of the figure refers to a frequency of 100 cycles/second and the right to a frequency of 1,000 cycles/second. For comparison the corresponding damping values for each of two 1 mm. thick steel sheets coated with good quality sound damping material (thickness 2 mm.) is also reproduced. The difference is remarkable.



Verlustfactor = *loss factor*
Hz = *cycles/second*
Temperatur = *temperature*

Verbundblech Typ I (Sandwich-Aufbau 1,0/1,0/1,0 mm)
= *composite sheet type I (sandwich-construction* 1.0/1.0/1.0 *mm.)*
Verbundblech Typ II (Sandwich-Aufbau 1,0/0,3/1,0 mm)
= *composite sheet type II (sandwich-construction* 1.0/0.3/1.0 *mm.)*
1 mm Stahlblech mit Antidröhnmasse A und B, jeweils 2 mm dick einseitig aufgetragen
= 1 *mm steel sheet with damping material A and B, each* 2 *mm. thick applied on one side.*

Figure 3 — Temperature dependence of the loss factor at frequencies of 100 and 1000 cycles/second

For rough calculation of the sound level difference ΔL (in db) of two sheets with almost identical elastic properties but different loss factors η_1 and η_2, he equation below can be used, with certain reservations

$$\Delta L = 20 \log \frac{\eta^1}{\eta^2}$$

For comparison a steel sheet witn clamped edges and a loss factor of $\eta_1 = 0.01$ and a composite sheet with loss factor $\eta_2 = 0.3$ can be considered. This gives a sound level reduction of about 30 db.

Workability

Composite sheets can be worked very much the same way as normal sheets, but some processes are limited because of the sandwich construction.

— Cutting

Hold-down pads should be used whereover possible when cutting on guillotines. With an asymmetrical construction it is best to cut with the thicker sheet uppermost. Using sharp tools the extrusion of the plastic layer at the edge can be largely eliminated; with larger sandwich sheets the drag over of the cutting edge does not appear to be detrimental for vibration damping. Similar recommendations hold for stamping and drilling.
The use of band saws is possible. Even cutting curves results in satisfactory cut edges. Flame cutting is not possible because of the destruction of the plastic layer.

— Forming

The usual forming presses and machines can be used for folding the sandwich sheet. It is of course possible for the inside sheet to stand proud a little so that an irregular sheet edge is formed. Bending, folding and rounding for more than 90° should be avoided if possible; furthermore, the inside radius should be at least 1.5 × thickness of sheet. When it is required to make several folds in the same bending direction it is best to start in the middle and work outwards.
For flanging and corrugating, the process used is as that for solid sheets.
Drawing and deep-drawing with conventional tools is possible but the maximum drawing depth is limited and depends usually on the quality and thickness of the individual sheets. By accurate setting of the tool gap and by making an allowance of about 75% of the nominal thickness of the plastic layer it is possible to avoid wrinkling of the inside sheet. Also, the blank holding pressure should be at least double that used for normal sheets and the drawing speed should be as low as possible. Initial pre-heat of tools and dies is also helpful to the deformation process especially for *type 2* material.

— Fixing

For the fixing of sub-assemblies it is best to use self-tapping screws. In the presence of shocks and vibrations conventional lock washers have to be used. Each type of sandwich sheet behaves differently when additional weight apart from their own has to be transmitted. With *type 1* the plastic material flows under the screw head; the plastic layer must therefore be removed beforehand, if necessary milled out with special saw attachments and then replaced by a metal disc of equivalent thickness. With *type 2* the plastic layer is pressed sideways so that the solid joint is made.

— Welding

For welded joints on sandwich sheets the only processes which can be used are those which employ a very short limited localized heating. Fixing components such as profilos and brackets can be spot welded with double electrodes which are used on the same side. With this process low electrode pressure, short welding times, and increased current and voltages must be used. Screws and nuts can be attached by arc welding.

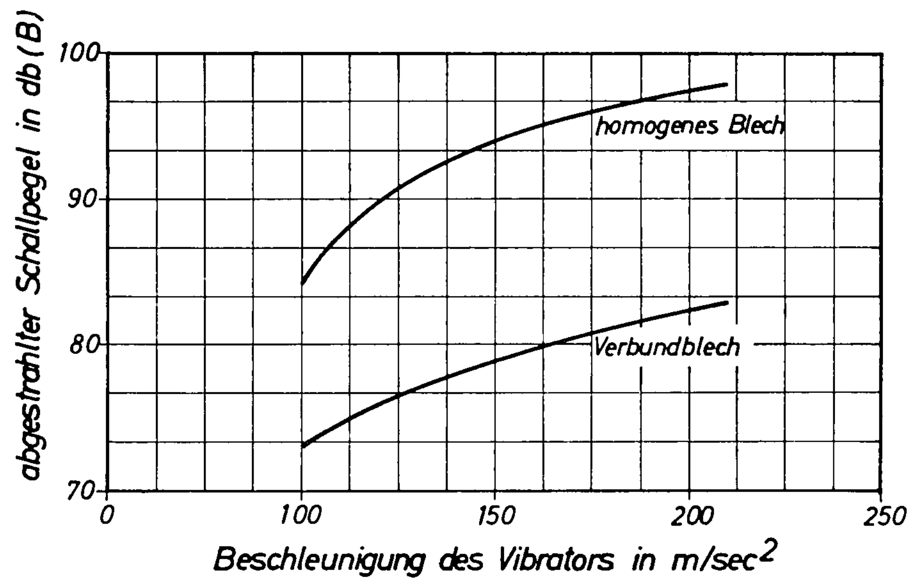
Spot welding on *type 2* can be carried out through the thin plastic layer as long as welding pressure and current strength are increased above the normal.
Special welding conditions have to be used with sandwich sheets of hot-dip galvanized steel.

— Applications

The applications for these new materials in agriculture are numerous in the cladding of noise producing motors and machines. Several examples may be mentioned:

— machines for the cutting up of daily food for live stock;
— installations for cereal drying (fans, hot air ducts as sound reflectors, and possibly silo parts);
— pump units for water supply from individual wells;
— parts of combine harvesters etc.

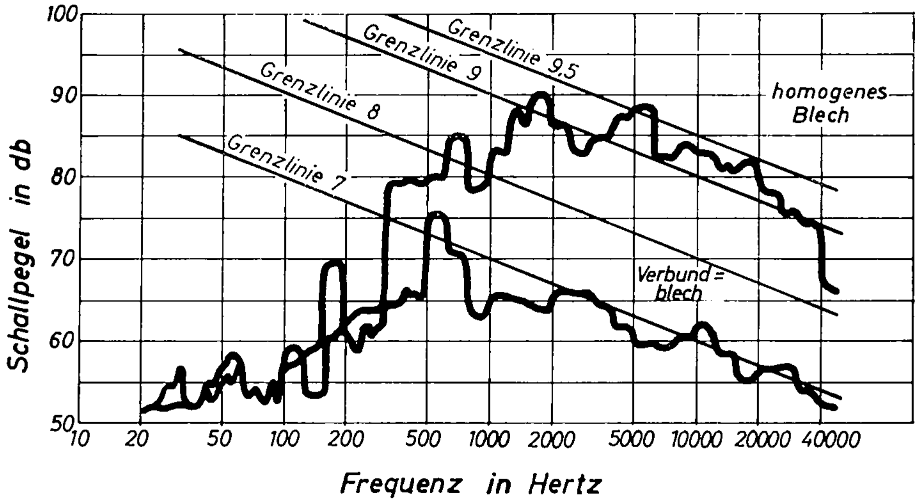
The main objective in the case of these examples is to encapsulate the machine parts and motors in such a way that the noise of the equipment is prevented from being radiated.
The following demonstration may clarify what the sandwich constructions are capable of:
In order to compare the radiation of sound through air for sandwich sheets and solid sheets, boxes out of the two materials were prepared and excited by a 50 cycle/second vibrator. The transmitted noise was measured at a distance of about 1 metre and was analysed in relation to its frequency.
Figure 4 shows the sound level of the solid sheets (upper curve) and of the composite sheets (lower curve) in relation to the intensity of the exciting vibrators. The solid sheet is always about 15 db higher than the sandwich sheet construction.



abgestrahlter Schallpegel in db = *emitted sound level in db*
homogenes Blech = *solid sheet*
Verbundblech = *composite sheet*
Beschleunigung des Vibrators in m/sec² = *acceleration of the vibrator in m./sec².*

Figure 4 — Sound emission from solid sheets and composite sheets at various degrees of acceleration of the vibrator

Figure 5 shows the sound level of these measurements in relation to the frequency. It can be seen that the sandwich construction is excited to resonance at 160 and 500 cycles/second; higher frequencies hardly appear. For solid sheet, however, apart from the almost equivalent resonances, a large number of higher frequency vibrations occur, which result in a very high sound emission.



Schallpegel = *sound level*
Frequenz in Hertz = *frequency in cycles/second*
Grenzlinie = *boundary line*
homogenes Blech = *solid sheet*
Verbundblech = *composite sheet*

Figure 5 — Comparison of the sound emitted through air for solid and composite sheets

An estimation of these measurements, according to Stahl-Eisen-Betriebsblatt SEB 905 001 gives values for the sheet test piece, which lie above the boundary line 9.5, whilst for the composite sheet type 1, all measured values remain below the boundary line 7.5. According to the Stahl-Eisen-Betriebsblatt SEB 905 002 intermittent noises in work places exceeding the boundary line 8 may be permitted provided they do not exceed a certain time period. Noise levels between the lines 9.5 and 10, however, must last no longer than 10 minutes per day.

Under the above conditions, therefore, it is not possible to remain close to the undamped test sheet pieces for any length of time. On the other hand it is both physically tolerable and also permissible according to the Betriebsblatt, to work at the lower noise level of the composite sheet all day.

The sound damping with steel-sandwich composites thus makes possible a considerable reduction of "industrial noise in agriculture."

Pierre MAILHOS

Chef du service des essais, S.A. des forges et aciéries du Saut-du-Tarn
Saint-Juéry

Tool Steels in Agriculture

(Translated from French)

Although over the past twenty years there has been no specific research into the steels used for the manufacture of agricultural implements or hand tools, they have nevertheless benefitted from the great progress achieved by the steel industry in the making, working and heat-treatment of steel.

There have been no revolutionary changes in these steels, but steady progress has been achieved in an effort to make them better suited to their intended purpose and more uniform in quality.

Which steels are these?

As we shall see, they are essentially plain carbon or low-alloy steels, the latter containing elements such as silicon, manganese and more rarely chromium. There are several reasons for this choice:
— Traditional loyalty to carbon steels;
— The demand for easy working. Carbon steels are less hard, both cold and hot, than alloy steels. They can be machined without prior softening; welding and hardening are generally easier.
— The progress made in heat treatment techniques means that their properties can be improved and there is no need for more refined alloys.

These factors together account for the continuing interest in what are known as carbon tool steels.

—High-carbon non-alloyed tool steels (C > 0.70%)

For thin tools with a high cutting power, when extreme hardness after quenching is required, manufacturers use high quality special steels made in the electric furnace from selected raw materials without residual elements, with sulphur and phosphorous contents of less than 0.020% and silicon and manganese contents of less than 0.30%.

These steels are generally treated to a Rockwell hardness of C.55 to 58 (e.g. secateur blades). The most common are the Y2 C 75 steels.

—Medium-carbon non-alloyed tool steels (C = 0.50 to 0.65%)

For thicker cutting tools (edge tools) or for parts subject to wear (ploughshares, knives, claws, teeth, etc.) which have to withstand bending stresses, torsion and heavy impact, steels with a lower carbon content are used, the most common content being 0.55%. These are the Y3 C 55 steels.

The C and Mn contents are selected to suit the tool and above all the final treatment it will undergo: contents of less than 0.60% for water quenching, contents of more than 0.60% for salt bath and oil quenching. The very great advantages of oil quenching and in particular of graduated quenching in salt baths in comparison to water quenching are well known: avoidance of quenching cracks and greater ductility with equal hardness.

These steels are generally treated to a Rockwell hardness of C.48 to 55.

—Low-carbon non-alloyed tool steels (C = 0.35 to 0.45%)

These steels were developed with a view to their conditions of service. When the tools wear, it must be possible to repair them easily and simply by reforging and hardening.

The carbon content is intentionally limited to a maximum of 0.50%:
— to provide a tough tool which is absolutely safe to use;
— to ensure that it can be forged and hardened without any risk of cracking and without special precautions.

This category includes steels for picks, pick-axes, axes, ploughshares, sweeps, etc.

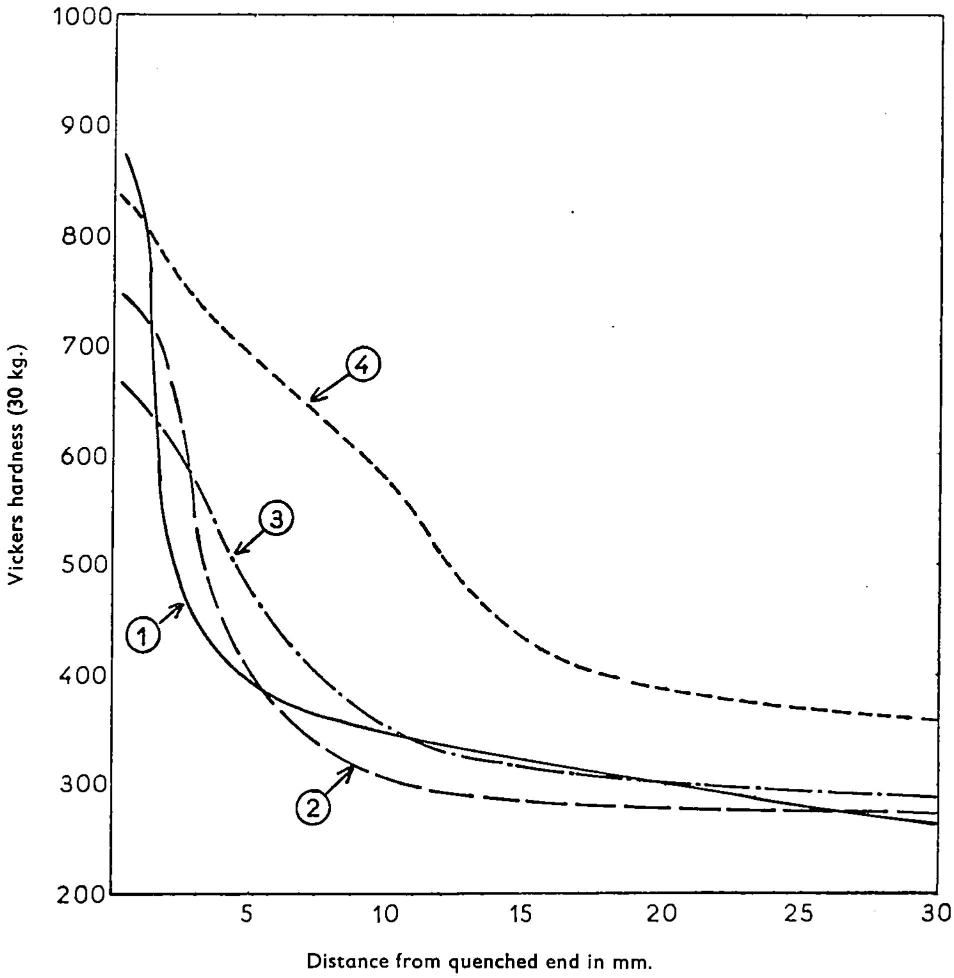
Steels with the higher carbon contents (0.42 to 0.50%) are generally alloyed with the lowest manganese contents (< 0.75%).

Steels containing less carbon (0.35 to 0.42%) can take higher manganese contents (0.75 to 1%) which give improved hardness penetration.

They are normally water-quenched and tempered at low temperatures to a Rockwell hardness of C.40 to 50. These steels are often made with a silicon content of less than 0.25% in order to extend their range of application. They can then be welded easily merely by bringing them together after heating in a forge fire, a property which was at one time greatly appreciated.

— Tool steels alloyed with silicon

Steels containing 1.80% silicon are often used for tools such as: rotavator teeth, ploughshares, scrapers, blades for secateurs and hedge clippers, etc.
To give increased hardness and resistance to abrasion while ensuring adequate toughness.
As in the case of plain carbon steels, the other elements, in particular carbon and manganese, are selected as a function of the quenching method envisaged and the desired hardness.
When their analysis is well balanced, they can safely be treated by oil or salt bath quenching to a Rockwell hardness of C.55 to 60 (blades with sharp cutting edge) (C about 0.55% Mn about 0.8%).



	C	Si	Mn
1 — Y2C75	075	020	020
2 — Y3C45	045	020	050
3 — Y3C35	035	025	090
4 — Y55S7	055	180	075

Typical curves for some Agricultural Tool Steels

Jominy tests

For tools subject to greater stress, manufacturers use lower carbon steels, C about 0.45%, Mn about 0.6%, the hardness of which after quenching varies from Rockwell C.48 to 55.
At these high hardness levels, the surface condition prior to quenching is most important, and in the heating process great care must be taken to avoid any decarburization to which these steels are very prone.

— Quality of the rolled product

The problem of the quality of an agricultural tool steel is not limited to the purely metallurgical aspect of the chemical analysis and physical properties of a grade of steel.
It also extends to the equally-important aspect of dimensional properties and the surface condition of the rolled products.
Problems relating to tolerance on cross-sections, the straightening of bars and the absence of torsion are often difficult to solve because of the special shapes of the sections.
The question of surface condition is extremely important for tool steels since they will be subjected to drastic quenching.
At the high hardness levels to which they are brought, any surface rolling defect or any surface defect in the ingot (double skin) may start a quenching crack or fatigue crack in service.
The surfaces of semi-finished products are therefore carefully prepared by grinding to remove any defects, and the techniques of magnetic flaw detection, micrography and macrography are used to inspect the finished products.
In brief, the steel industry can now supply agricultural implement and tool manufacturers with products of uniform quality, of sound surface and core, made from steel with a chemical analysis specially selected for the problem involved, with the dual object of facilitating its working and obtaining the desired service properties after treatment. (See *graph.*)

Marcel NEPPER
Ingénieur en Chef

S.A. Cockerill-Ougrée
Seraing

Galvanized Steel in Agriculture

(Translated from French)

Steel can be well protected against atmospheric corrosion by a zinc coating, the point being that in this way it is the zinc and not the steel itself that oxidizes, and does so much more slowly. Hence the corrosion resistance of galvanized steel depends on the thickness of the zinc coating. In a rural atmosphere, galvanized steel generally withstands weather conditions for several decades.
The two steel products most commonly used in agriculture are galvanized steel sheet and galvanized wire.

Galvanized Steel Sheet

The agricultural industry is a major user of galvanized sheeting. Its many applications include:
— roofs and outside walls of farm buildings. These are generally of corrugated galvanized sheeting, but flat or ribbed sheet or sheet in the form of self-supporting pantiles may also be used;

— steel frameworks in cold-formed galvanized sections;
— silos for grain or forage and barns. Research in the USA has shown that galvanized steel roofing effectively traps the heat of the sun so that hay drying times are reduced and the protein content increased;
— open and enclosed cattle sheds, animal shelters;
— feeding and drinking troughs, feeders and all sorts of troughs, vats, tanks, containers, buckets, pans, guttering, grain bins and bunkers, seed beds, glasshouses;
— wind mills;
— various devices such as elevators, chutes, loaders, single-chain conveyors for feeding stuffs, wheelbarrows, trolleys and certain machine parts (galvanized sheet protecting the blades of harvesters);
— poultry houses, incubators and laying houses. We hear from the USA of the advantage of using sandwich panels formed of two galvanized sheets separated by an insulating layer of rigid plastic foam, to ensure constant maintenance of a suitable temperature for breeding purposes in these buildings;
— rural slaughter houses (the building itself, containers, troughs, tables, floor and wall cladding).

Depending on requirements, flat, corrugated or ribbed galvanized sheet may be used for all these applications without any other coating. However, in the United States increasing use is being made of painted galvanized sheet, which combines added corrosion-resistance with an even more attractive appearance.

The sheeting may be painted in the works on continuous production lines or at the construction-site, after forming and assembly.

As the above list shows, galvanized steel sheet has numerous and varied applications. This is due to the useful properties of steel, of zinc and of the two together, i.e. of zinc-coated sheet. These include
— tensile strength of 30 to 45 kg. sq.mm. (considerably better than that of aluminium or plastics), and of up to 65 kg./sq.mm. for cold-rolled galvanized steel (unannealed);
— stiffness, measured by Young's modulus, also far above that of rival materials, enabling longer spans to be used without intermediate supports;
— excellent formability without risk of flaking, varying with the quality ordered: galvanized sheets can be bent, profiled, seamed and drawn.

Provided certain precautions are observed in the process, galvanized sheet may be welded or bronze welded.

The corrosion resistance of the zinc coating increases with its thickness. Higher coating weights are therefore selected for outside use.

Galvanized wire

Galvanized steel wire, used for so many purposes in different fields, is of great importance in agriculture. Barbed wire fences immediately come to mind, but these are not suitable for all purposes and do not solve every fencing problem. For livestock in particular, woven-wire fencing such as Ursus forms a wall of steel behind which the stock is perfectly safe. Light Ursus and single or triple-twist wire netting are ideal fencing materials for poultry.

Gardens, like farms, must be fenced to suit the type of plants grown.

Nurserymen who want to offer their customers straight-stemmed flowers such as carnations, freesias, roses or chrysanthemums, train them through the large meshes of a suitable type of welded netting.

Welded training wire to support the young branches and prevent them from sagging down when laden with fruit are invaluable to modern fruit farmers.

A hop field is a vast network of heavily galvanized wire, without which it would be impossible to grow this fine climbing plant economically.

Vegetables such as peas, runner beans or even gherkins climb along netting or single strands of wire, which help them to grow and makes them easy to pick.

The fashion of raising poultry and rabbits in batteries involves the intensive use of welded netting and wire to provide strength and long life.

We must not forget the vineyards, where very thick galvanized wire is widely used.

These enumerations are far from complete, either for galvanized sheet or for galvanized wire. Galvanized steel has turned ont to be ideally adapted to today's requirements in all sorts of connections.

The corrosion-resistant properties of zinc, the mechanical strength of steel, the low cost of galvanized-steel

products and the ease with which they can be transported and assembled make them most attractive for agricultural use.
What is more, I consider the potentialities of galvanized steel sheet and wire have not yet been anything like fully exploited, and I feel certain their agricultural applications will increase considerably in the future.

Winfried SÜSSMAN
Gewerbe-Oberlehrer

Walsrode

Hardened Steels for Ground Cultivations

(Translated from German)

The main uses of hardened steel are for the cutting parts of agricultural machinery, for instance plough shares, cultivator blades and tines, harrow tines and mowing machine knife blades. If these parts are to fulfil their function properly, they must possess the following characteristics:

1. they must be hard-wearing, i.e. keep their cutting edge as long as possible,
2. they must be hard right through and not just on the surface, so that they can be re-sharpened and remain hard even when worn,
3. they must not be brittle, so that they can resist shocks.

Steel acquires these qualities through hardening.
Ploughshares, cultivator tines and blades and harrow tines are among the cutting tools used to work the soil. But their tasks are so different and they have such a wide range of applications that a special steel is required for each type of tool. In modern cultivation techniques one type of steel is not enough. A type of steel must be used which is most suited to working conditions in each case. The steel must be designed to meet these conditions.
Compromise cannot be avoided in suiting the type of steel to its special uses, since the article being worked, that is, the soil, has no fixed or constant characteristics. The laws that operate here are fixed by nature and man can do little to influence them. External influences, such as sun, wind, rain and frost combine with the qualities inherent in the soil to produce soil conditions. The task of ground cultivation implements is to work the soil so that it can be made as fertile as possible.
It would be too much to ask that a steel should be suited to each type of soil, since in Germany alone there are about 60 soil types. In Germany the variation in the steel is limited to the function that it has to perform—ploughing, cultivating or harrowing.

Steel for ploughshares

Very great attention has been paid to ploughshares for a long time; firstly, because the plough is the main instrument of ground cultivation and so far no substitute has been found for it, and secondly, because the strain put upon this tool is very great and the questions of price and wear are correspondingly important. Good quality hardened steel is used in the attempt to combat wear. But it must be remembered that the degree of hardness cannot be pushed up so high, in an attempt to increase wear, that resistance to shock and impact stress is reduced. The materials used for ploughshares are treated in such a way as to aim at a balance between maximum hardness and adequate resistance to shock and impact.

Rests are held within economic limits by constituting the steel in such a way that the agricultural artisan can re-sharpen, forge and harden worn shares with simple equipment. He only has an open hearth for forging and the steel must consequently not be sensitive to this type of forging. Only water is available for quenching and the steel must be able to tolerate this equipment. It is much to be regretted that smithing in the country has so declined. Because less and less work is available for smiths, the new generation has not the feeling for steel in the fire and on the anvil which characterized the skilled smith. As a result unpardonable mistakes are made in the heat treatment and smithing of steel. It is only remarkable how much of this bad treatment steel can actually tolerate.

—Share steel to German Standard (DIN) 11 100

This standard requires that steel should be capable of being re-heated in an open-hearth furnace and quenched in water. Its composition is therefore required to have at least 0.34 to 0.43% C and at least 1.4% Mn and Si where at least 0.6% of Si must be present. The degree of hardness required is 500 to 700 kp./mm². The share should be quenched at temperatures of 200 to 300° C.

—High quality steel German Standard (DIN) 17 221

Ploughing today is done at a higher speed than 20 years ago. More powerful tractors and improved design of plough bodies permit speeds of over 5 km./hour. The strain on the share increases correspondingly. Share steel to DIN 11 100 dated February 1949 is no longer adequate.

German manufacturers of ploughshares today use a spring steel in accordance with 38 Si 6 DIN 17 221. The composition of this steel shows about the same content of C and Mn as the share steel of DIN 11 100 but a considerably higher content of Si. This means that the steel is subject to the same heat treatment requirements as share steel but has a better resistance to shock and impact.

This uniformity in heat treatment is particularly convenient for repair workshops. They can treat all steels in the same way as far as forging, quenching and tempering are concerned. Although the steel is not sensitive to mistakes in heat treatment, it is advisable to keep to the maker's recommendations if the best results are to be achieved.

—Surface-hardened ploughshare steels

Wear tests have been made en hard-metal surface hardened and hard chromium plated ploughshares. (Ewald Becker: Hartmetall-armierte Pflugschare. Landtechnische Forschung 12 (1962) pp. 129-133. DIN Leaflets 11 090, 11 100, 11 112, 11 113, 17 100, 17 221). These have shown that the full-hardened ploughshare showed less wear than the surface-hardened shares. No hard chromium-plated steel for ploughshares has yet been produced in Germany.

—Long-lasting ploughshares

These shares are designed to reduce costs and to compensate for the lack of skilled smiths, being so designed that they remain sharp until they are completely worn out. This, however, is not a question of the material used, but of the shape.

Cultivator tine and blade steel German Standard DIN 11 112 and DIN 11 113

Tines and blades for multi-purpose cultivators and hoeing machinery are exposed to very considerable impact stress and a high rate of wear through the speed of traction.

Owing to their good cutting power the cutting angles are very small. In order to avoid too high quenching stresses, with the consequent risk of the edges of the blades fracturing, the standard requires oil quenching to a tensile stress of 140 to 160 kp./mm² = HRC 42 to 48 for duckfoot tines and 150 to 170 kp./mm² = HRC 45 to 49 for chisel tines. For duckfoot tines DIN 11 112 requires the use of a spring steel of quality 51 Si 7. The steel has a 0.5% C content and thus lies on the border between water and oil quenching. The Si and Mn content is about the same as for share steel. The new DIN 11 113 for chisel tines requires quality 55 Si 7, and is a pure oil quenched steel with higher contents of C and Mn.

— Steel for harrow tines

Harrow tines to German Standard (DIN) 11 090 are made from constructional alloy steel of quality St 50 or St 50-2. According to DIN 17 100 this steel has a C content of about 0.30%. It may be quenched without difficulty in water. The standard requires a hardness of HV 320 to 500 kp./mm².

Conclusions

Steel for ground cultivation must be hard-wearing, full-hardened and tough. Only hardened steels meet those requirements.

The quality of steel is selected in accordance with the work it has to do, ploughing, cultivating or harrowing. Any differentiation according to soil type is uneconomic, since there are 60 different types of soil in Germany alone.

Ploughshare steel consists of spring steel of quality 38 Si 6 (DIN) 17 221. The steel in full hardened, may be quenched in water and can be heat treated by agricultural artisans with simple equipment. It is not sensitive to faults in heat treatment.

Surface-hardened steels are less hard-wearing than full-hardened steels, irrespective of whether they are hard-metal surface-hardened or hard chromium-plated.

Steel for cultivator blades and tines are oil-quenched 51 Si 7 and 55 Si 7 to (DIN) 17 221. They have the same properties as steel 38 Si 6. As they are oil-quenched the tools made from them are tougner.

Steel for harrow tines consists of constructional alloy steel St 50 or St 50-2 (DIN) 17 100. This is a water-quenched steel.

A. RABEY

Société des aciéries de Pompey
Paris

Special Steels

(Translated from French)

Farm mechanization and the role of special steels

According to figures issued by the Syndicat général de constructeurs de tracteurs et machines agricoles (May 1966) a total of 401,000 metric tons of tractors and other agricultural machinery was manufactured in France in 1965, the overall turnover being FF 2,400,000,000 (the 1964 figure for all six Common Market countries was FF 8,300,000,000.

Manufacturers of tractors and similar machines (walking tractors, mowers, rotary hoes) are the main consumers of special steels and delivered 130,000 tons, the turnover being slightly more than FF 1,100,000,000. According to our own estimate, based on a survey carried out in March 1964 by the Statistical and Economic Affairs Departments of the Federation of High-Carbon and Special Steel Manufacturers, tractors and agricultural machinery accounted in 1964 for a total consumption of about 50,000 metric tons of special steels. This is only a very rough approximation as it is difficult to obtain information on indirect deliveries to forges, pressing and stamping works, bolt-and-nut manufacturers, wire-drawing works, etc., and sales via stockholders and steel merchants.

A further complication arises out of the international arrangement under which certain leading manufacturers exchange parts or assemblies with their subsidiaries in various European countries, more particularly in the United Kingdom and Germany.

The tractor industry takes over half the total consumption of special steels, i.e. 26,400 metric tons, most of the balance going on such soil-working machines as mouldboard and disc ploughs, cultivators and harrows, and such harvesting machines as mowers and combines.

The following *table* shows the approximate tonnages of high-carbon and special steels used in the manufacture of the main types of agricultural machines in 1964.

Table 1 — Approximate tonnages of high-carbon and special steels used in the manufacture of agricultural machines

Type of machine	Non-alloy steels (C, XC and triplex)	Alloy steels, including silico-manganese steels	Total
Tractors, etc.	15,100	11,300	26,400
Soil-working equipment	13,600	4,400 (¹)	18,000
Harvesting equipment	3,200	1,700	4,900
Total	31,900	17,400	49,300

(¹) silico-manganese.

Some minor tonnages are used in drills, fertilizing, processing and packaging machines, and dairy machines (stainless steel cream separators and milking machines).

The use of special steels in farm tractors

The proportion of special steels used in farm tractors varies considerably from one manufacturer to another. Some cut it down to 10%-20% of the total weight to save material, their argument being that the poorer mechanical properties of the metal used can be offset by a corresponding increase in the size and weight of machine parts.

Most manufacturers use a higher proportion of alloy and non-alloy special steels, and sometimes as much as 25% or more of the unweighted weight of the tractor (i.e. not increased by weights or by filling the wheels with water).

According to a survey carried out in 1957 by the Office Technique pour l'Utilisation de l'Acier, the proportion of high-carbon and special steels used was 18%, but the notable increase in recent years in tractor power and performance has probably led to a greater use of special steels; 20% of the unweighted weight of the tractor would probably be nearer the mark. More or less the same figure is arrived at by comparing the tonnage of tractors manufactured in 1964 with the industry's consumption of special steel.

Table 2 shows the amounts of different grades of steel used in the manufacture of a 30 hp Diesel tractor weighing about 1,600 kg.

Table 2 — Weight of special steels used in the manufacture of a 1,600 kg tractor

Merchant bars, forging semis and flats:	
Non-alloy case-hardening steels	5 kg.
Non-alloy heat treatable steels	120 kg.
Total non-alloy steels	125 kg.
Alloy case-hardening steels	43 kg.
Alloy heat treatable steels	170 kg.
Total alloy steels	213 kg.
Tubes:	
Non-alloy case-hardening steels	18 kg.
Non-alloy heat treatable steels	21 kg.
Total tubes	39 kg.
Wire (for bolts and nuts, rivets, screws, rods, springs, etc.):	
Non-alloy steels	5 kg.
Alloy steels	3 kg.
Total wire	8 kg.
Total non-alloy steels	169 kg.
Total alloy steels	216 kg.
Total special steels	385 kg.
or 24% of the tractor weight.	

Different grades of steel used in farm tractors

The following is a brief conspectus of the steels used for the various parts of farm tractors and machines and the main types of tractor-drawn implements, exclusive of hand tools.

—Case-hardening steels.

For pinions, gears, spur and bevel crown-wheels, bevel gears.

— Non-alloy steels

XC 10 and XC 18 steels are generally used for small parts or parts subject to medium stresses. One leading manufacturer told us he preferred XC 12 steel, a variant containing 0.60-0-90 of Mn, as it permtis oil quenching of small parts. XC 18 steel is occasionally subjected to a carbonitriding treatment followed by an oil quench. Carbonitriding is applied at 840° for case depths of from 0.25 to 0.50 and at 810° for lesser thicknesses.

— Alloy steels

Two types of steel are chiefly used:

a) Nickel-chromium (two grades):

16 NC 6 for small and medium-size parts (planet pinions, planetary differential gears, etc.)

20 NC 6 for large parts (bevel gears, pinions and p.t.o. shafts, differentials, etc.)

b) Ni-Cr-Mo (one grade):
20 NCD 2, The same as AISI 8620 with guaranteed Jominy hardenability. One manufacturer employs the 8622 variant for large parts.

One manufacturer also uses AISI 4118 chromium-molybdenum steel with an average composition of C 0.20, Mn 0.80, Cr 0.50 and Mo 0.12 for gearbox pinions subject to moderate stresses. Tests have also been made with 20 Mo-Cr 4 steel containing 0.45 of molybdenum and 0.40 of chromium.

Some parts, e.g. 20 NC 6 steel bevel gears, are sometimes cold finished after hardening so as to decompose the residual austenite.

—Steels for full and surface induction hardening

— Non-alloy steels
The main grades used are XC 38—XC 42 and XC 48. The latter is used for steering shafts and is subjected to a mild nitriding treatment (soft nitriding) for steel parts requiring better mechanical properties. One manufacturer occasionally uses case-hardened, oil-quenched XC 32 steel. C 35 steel is used for tubes and lightly loaded parts. The post-treatment mechanical properties required of these carbon steels are sometimes difficult to reconcile with the thin cases of larger parts. The forthcoming French standard PNA 35-551 to 554 for heat-treatable steels and the corresponding Euronorms will provide French manufacturers with accurate data so that their specifications need no longer be incompatible with the potentialities of these steels. All manufacturers apply induction hardening to many different parts, e.g. clutch shafts, p.t.o. shafts, crown wheels, spindles, etc. The most commonly used grades in the carbon-steel category are XC 42 and XC 48 for case depths of 3 to 5 mm. Use is sometimes made of AISI 1046 steel which has a higher Mn content and hardenability. For gear-wheels with hardened teeth, or large pinions, some manufacturers use an XC 52 steel of a special formula giving the metal a very uniform hardenability and an extremely fine grain. Some very good results can now be obtained thanks to the improvement in induction hardening techniques and in particular to the proper use of preheating and precise, programmed automatic control of the holding time in the inductor, so that tne same part, for instance a gear shaft, can be given different case depths to suit the different mechanical stresses it undergoes.

— Alloy steels
The more highly stressed or larger parts (shafted pinions, p.t.o. shafts, axles, pins, spindles, coupling sleeves bolts and nuts treated to a resilience of over 80 kg./mm^2) are made of alloy steels. The commonest grades are 38 C 4, 35 CD 4, 42 CD 4 and 40 NCD 2, the choice being largely determined by the mechanical properties required and the size of the parts. In most cases the hardenability of these steels is specified. Manufacturers can raise the degree of hardenability of 35 CD 4 steel by adding a small amount of nickel. 35 CD 4 steel is sometimes given a surface-carbonitriding treatment to improve the wear resistance of the teeth and impart good compressive strengths. Several manufacturers give alloy-steel parts a local surface hardening after full hardening and tempering. The greater hardenability of alloy steels ensures good full-hardening properties and induction hardening depths of 7 to 10 mm.

— Special free-cutting steels
Some manufacturers use these steels for making moderately stressed parts which require a considerable amount of machining.
Grades 10 F 2 and 15 F 2 are used for case hardening. In the full-hardening treatment grade 35 MF 6 is used for heat-treated nuts and for pressure-pipe couplings. Some manufacturers also use small amounts of leaded steels. One of the latest standards, Afnor Pr A 35-562, defines the grades of free-cutting steels used for heat treatments.

Special steels used in soil-working equipment

Special steels are used in the manufacture of such soil-working implements as mouldboard and disc ploughs, and the tines of cultivators and harrows, etc. The mouldboard plough has a coulter or jointer which used to be made of A 70 steel, but owing to the inadequate wear and deformation resistance of this material it is now being replaced more and more by 45 S 7 or even 42 CD 4 steel, both being heat-treated. The skimmer sometimes fitted in front of the plough is made of treated 45 S 7 steel. The bill-headed ploughshare is made of XC 80 steel and sometimes of XC 45 forge-weldable steel. Plough beams are made of hardened and tempered XC 42 carbon steel or of silico-manganese steel. Plough mouldboards are made of Triplex steel, consisting of three successive layers of XC 70, XC 10 and XC 70 steels, each 2 mm thick. The mouldboards are water-quenched in a press to a Rockwell hardness of 60 and over, and acquire a fine gloss with use. French plough, tiller and drill discs are made of 45 S 7 water-quenched steel, or 55 and 60 S 7 oil-quenched steel, and occasionally of XC 80 steel. The type most commonly used in the U.S. is AISI 1085, which is similar to XC 80. 38 Mn Si 6 steel is also used in Germany. Discs supplied to the U.S. are painted without prepolishing. French farmers demand a polished surface, which puts up the cost unnecessarily. Cultivator tines are made of non-alloy XC 65—XC 80 steels, or of 55 S 7 silico-manganese steels tipped with XC 80. 50 CV 4 steel is also occasionally used.

Hard-surfacing alloys known as stellites are a very useful weapon in the control of abrasion which greatly reduces the life of soil-working equipment on certain types of soil.

Surfacing may be done with a blowpipe or electric arc, and can be applied to any tool used in farm machinery, e.g. shares of ploughs and flexible tine cultivators, shares with detachable tips, mouldboards, coulters, the blades of fixed or rotating hoes, plough and tiller discs, etc.

The best results are obtained by applying the surfacing to the most exposed parts of the new tools whose life is thereby increased three to tenfold.

Special steels used in harvesting equipment

The tonnage of special steels used in harvesting equipment is only a fourth or fifth of that used in the manufacture of tractors and soil-working equipment.

The main types used are:

- hard carbon steels of the XC 70—XC 80 type in special sections for tedder-rakers;
- silico-manganese steels for cutter bars made of straight or bulb-bars;
- blade rods or knife backs of the same steel;
- XC 70 steel strip for triangular mower sections with the two layers hardened by high-frequency treatment or blowpipe;
- mower tines made of XC 38 steel with an inserted blade, or of XC 75 steel with a hardened cutting edge;
- transmission gears of combine harvesters, for which both non-alloy and alloy heat-treatable steels, are used, and more especially induction-hardenable steels, e.g. special XC 45 carbon steels for a shaft treated to a resilience of 80-100 kg./mm.^{2}, and an XC 52 steel for a 67-tooth first-gear pinion of a combine harvester

Harvesting machines, particularly combine harvesters and binders, also use considerable amounts of hard wire, either drawn and patented, or hardened and tempered, for making springs.

Henry LEJAY

Société des forges et ateliers du Creusot
Paris

Special Wear-resistant Steel for Use in Agriculture and the Agricultural Industries

(Translated from French)

Agriculture and the agricultural industries often run the risk of wear which can cause costly equipment to break down at any time and lead to high repair costs.

Moreover, with the ever higher productivity of this equipment and its intensive use, the demands made on these implements have increased and thus the amount of wear has risen.

Special steels have often provided valuable solutions to these problems.

Up to now chief examples have been, on one hand, tilling, and, on the other, in handling for transportation and for the storing of cereals; and there are, no doubt, other examples.

Composite steel sheet, which combines core flexibility with surface layer hardness, represents the answer for furrowing equipment.

Silicomanganese steels give excellent results with implements made from bar steel, e.g. cultivator or rotary hoe blades, manure loader teeth, ploughshares, plough coulters etc. However, they do have the disadvantage of having to be heat treated after forming and they are difficult to weld.

Thus, I would emphasize the possibilities afforded to agricultural equipment designers by grades of steel wich have already proved their wear-resistance and easier applicability in other industries and are now being used for certain purposes in the field of agriculture, for example in the scoops and blades of potato lifters, rotary hoe blades, subsoilers, rotavators, root-cutters etc.

These steels are used mainly in the form of sheet or sections therefrom.

These steels are alloys with a low carbon content for easy welding but still capable, thanks to the alloying elements, of being heat-treated for a high degree of hardness. The heat treatment can, moreover, be carried out by the manufacturer rather than the customer. They remain flexible enough to take the impact from stones met in some soils without damage, and their good weldability facilitates repairs to worn parts.

The highest level of hardness is usually the result of a compromise between maximum wear-resistance and the quest for other qualities. One grade of MnCrMo steel, which has a hardness of HB320 after normalization, is suitable for coldformed parts (as long as the bending radius is high enough in ratio to the cross-section or the tickness of the product). A hardness of HB 400 can easily be achieved while maintaining sufficient weldability and good impact-resistance with an NiCrMo grade after hardening and annealing.

NiCrMo low carbon alloy steels which have been hardened and annealed to a strength of ca. 100 kg./mm.^{2} are best for equipment on which considerable mechanical demands are also made, since they have good ductility and thus better impact-resistance.

The handling and storing of abrasive grains is very similar to that of ores. The same grades as those mentioned above give excellent results in this field. They are most often in sheet form, and usually delivered ready for use so that the customer does not have to bother with heat treatment. They can be easily cut with a blow lamp; the polish acquired in service helps the passage of the grains, and they are good enough for chutes with relatively shallow gradients.

The steels can be used for tubes for pneumatic transport as well as chutes, hoppers and return valves beneath silos.

These same steels are just as suitable for many implements which have to undergo hard wear: chaff cutters, fodder pulpers etc. If damage is likely from impact with, for example, "foreign bodies," the NiCrMo grade, hardened and annealed to a strength of almost 100 kg./mm.^{2}, should be used.

Finally, the various qualities mean that, when used on the same scale as ordinary steels, the strength of the equipment is increased, even if thickness is reduced to obtain a weightgain.

However, in contrast to other industries, weight saving is hardly ever the subject of research, since agricultural implements are very often already of light-weight design. Nevertheless, I shall mention the example of the use of wear-resistant steel for stanchions in log carrier trailers designed for the tropics; in this case the saving in weight was such that the stanchions' weight was halved, thus enabling them to be handled by one man instead of the two needed for ordinary steel stanchions.
It is, however, in the field of wear-resistance that I believe weldable special steels, especially in sheet form, will give most service to agriculture and its associated industries.

Special wear-resistant steels used in agriculture

Type	App. chemical composition						Usual delivery state	Usual state in use
	C	Mn	Si	Cr	Ni	Mo		
Silicomanganese	0.45	0.60	2				annealed: HB = 230	heat-treated: HB = 500
MnCrMo weldable	0.20	1.2	0.25	1.30		0.25	normalized : HB = 320	
Alloy NiCrMo	0.28	0.75	0.30	1.40	1.50	0.40	heat-treated: HB = 400	
Specially weldable low carbon NiCrMo	0.16	1.40	0.30	0.80	0.80	0.20	E $\geqq$ 70 kg./mm^2. R $\geqq$ 80 kg./mm^2. KCV — 10° C $\geqq$ 6 kg./cm^2.	

Prof. Dr.-Ing. Wolfgang BAADER

Institut für Landmachinenforschung
Braunschweig-Völkenrode

Closing Remarks

(Translated from German)

Now that we have come to the end of the Working Party's second and concluding meeting, I should like to round off our discussions with one or two observations on the matters we have been dealing with.

Our main theme at both meetings has really been a slightly expanded version of the theme set for the first: Requirements for ensuring increased consumption of steel in the mechanization of agricultural production. On this I would like to make a few particular points.

First, agricultural mechanization should be stepped up with machinery and appliances thoroughly suited to the user's requirements. The manufacturer can contribute by

a) designing machinery with improved properties and a higher performance, with an eye to ensuring a higher-quality product with the minimum of loss;
b) making it stronger, and in particular more resistant to continuous stress and to vibration and impact. Mechanical engineering for agriculture is a field in which, owing to the exceptional conditions under which the machinery is used, there is a very wide range of stresses, necessitating special attention in design;
c) devoting more intensive efforts to reduce the amount of maintenance and servicing required and making the contrivance easier and more convenient to operate, so that it will involve less physical and mental strain on the operator;
d) designing for easy repair, in consideration of the commonly rather primitive and unprofessional facilities available at farms and in country repair shops;
e) supplying the equipment at a fair price for what it is expected to do.

Now the farm equipment manufacturer can only do all this if he has the right materials to work with. So here the object must be to ensure, by the fullest consultations between the manufacturers and the steelmakers, that there is the maximum of agreement between what the agricultural end wants and what the producing end can supply. Ultimately this always involves some kind of compromise.

The steel industry should devote still more careful study to the farm equipment industry's concerns and provide more information, through specialized engineering publications, on what it is itself in a position to offer. Also, the steelmakers could work for better mutual understanding by organizing seminars or courses in the different sectors and firms.

Another point to be mentioned is the desirability of more being done with regard to standardization. This will mean that the manufacturer will have to forgo quite a lot of his own pet preferences: he will need to think more in terms of obtaining his procurements in the form they are offered—provided they meet the purpose, that is—and of going over increasingly to materials in general use. Unfortunately it is still the case that many firms quite fail to grasp the need for standardization: they put their own business considerations first, not realizing that judicious standardization and co-operation could enable them to operate more economically and so increase their production. The High Authority, by the way, could well exert greater influence on both the producers and the consumers by emphasizing this in literature on the subject.

Very careful attention indeed needs to be given to the training of farm machinery designers to design machines that wil be economic. For in this sector in particular there are still a good many models about of a design that makes them really hardly a paying proposition at all. Getting designers educated in this respect is a very important matter, requiring to be tackled not only by technical colleges but also by individual firms that have designers on their staff. Here again the steelmakers can be of considerable assistance, by issuing their information in the necessary technical and scientific form and sending more of it to the designers.

The papers and debates at our two meetings have dealt mainly with questions of steel utilization. But we have been given hardly any clear, scientific facts and figures. It is not just due to chance, or to misunderstanding, that nobody submitted any: the fact is, I am afraid, that there *is* only the merest handful of accurate data concerning the farm implement and machinery sector. It is of the utmost importance to organize and finance further studies and research in this field. So I would urge the steel industry for its own sake, along with the implement and machinery manufacturers, to give still more support than it has been doing to research on agricultural engineering.

WORKING PARTY III

Steel

in the Storage and Marketing of Agricultural Produce

Chairman	*R. Brunotte*
Rapporteur	*C. Ricci*
Introductory Papers by	*A. Tosello*
	P. Nehring

Prof. André TOSELLO

Director del Centro Tropical de Pesquisas y Tecnologia de Alimentos
Campinas

Storage and Packaging as Means of Ensuring a Steady Flow of Agricultural Produce to the Markets

(Translated from Italian)

The majority of agricultural products are directly or indirectly intended to sustain human life either in the form of fresh or processed foods, or as feedstuff for working animals or animals for human consumption. And of course agriculture provides the materials necessary to clothe man and fit him for civilized society. In spite of the enormous advances in the development of plastics, most of our clothes are still made from vegetable yarns and fibres and the skins of animals. This prime characteristic of agricultural products implies certain basic problems in their treatment and use. These are products directly used and experienced by man, whatever his social condition. So any change in availability, quality and price is immediately apparent. Hence their enormous social and political significance. This explains why many countries give special treatment to agricultural products: they are not regulated by "supply and demand" but come under "political" and "special protection" price schedules.

Another important factor is the way in which they are produced. The first point here is that production occurs only during part of the year while consumption occurs throughout the year. This applies mainly to products of vegetable origin, which are distinguished by their short cycle of production: they are harvested in two or three months of the year, which means that production takes 15-20% of the year while consumption takes 100% of the same period. Production occurs in one particular period of the year and only during that period, subject to seasonal weather changes unforeseeable even today. This can mean that circumstances beyond human control are liable to affect the quality and quantity of production. Such variations in weather conditions can be greater in tropical regions than in regions with sub-tropical or temperate climates.

Another important factor is the nature of the agricultural product, which is wholly or partly living, and therefore subject to continual transformation, not only during its effective life but afterwards. The changes undergone by these products, whether as fresh or processed foods or as raw materials for clothing or other purposes, are so considerable that they can cause fundamental differences in the quality and quantity of the resulting products.

Another point is that most agricultural products, compared with those of other origins, are both bulky and dissimilar and therefore require special processing and handling techniques, not to mention the fact that agricultural activity as such is limited to the area being exploited and the degree of technological progress. And in most cases, further progress is the only means of increasing the productive area.

Technological progress is the principal factor, but this depends on development of the region. This in turn depends on a series of factors which are not always easy to evaluate.

Besides, the use of technology in agriculture is by its nature a slow process and one which does not give very startling results.

It must also be said that agricultural technology cannot be transferred from one region to another because it generally possesses local characteristics. Each region requires special agricultural techniques and these can only be worked out over a period of time and in relation to the overall development of the area.

This explains some well-known failures in the agricultural planning of certain underdeveloped areas, which were studied in the light of techniques used in other highly developed regions.

Production and consumption

An analysis of agricultural production and consumption in the last ten years, given by the FAO in its 1965 publication, brings to light some important facts.

We should first of all take a look at world population trends. There has been a distinct population explosion in the under-developed or developing countries. The world's population has increased by 20% a year, which means that the total population has increased by over 20% in the last 10 years. This is the largest percentage increase in history. In some countries there has been an increase of 3% or more per year. Future prospects indicate an even greater increase, due to a lower infant mortality rate and a longer period of maturity in proportion to the remainder of the average life-span. The current population of the world is 3,300 million and it is reckoned that by the end of this century, that is in 35 years time, it will have topped the 6,000 million mark. Of these people 4,800 million will be born in countries at present in the process of development and short of food.

The remarkable development of communications (radio, television, etc.) throughout the world has meant that progress in one region is immediately brought to the notice of other regions. So when the inhabitants of less favoured regions become aware of the comfort and well-being of those living in other areas, they tend to feel that an improvement is not a necessity but a right. Apart from all this, a large proportion of the world's population is still badly and inadequately fed.

If the estimated population increase becomes a reality and if the world food situation does not improve, both in quality and quantity, then by the end of this century we shall be left needing double the present amount of food. Taking into account that 15% of the present population cannot get enough food and that 50% is badly nourished, the conclusion must be that by the end of the century agricultural production will have to be four times greater, and animal production six times greater than at present, if the world's inhabitants are to be adequately fed. This means that, while at present the average man's diet consists of 78% vegetable products and 22% animal products and the total amount of food available is 600 kg per head per year, by the end of the century this total should be increased to 1,200 kg per head if the standard of food is to be improved.

At first sight this might seem an impossible task in just 35 years, but there are some grounds for optimism. The technical progress of the last ten years gives some encouraging indications of how it could be done. Constant increases of the areas under cultivation and constant progress in agricultural technology have considerably improved agricultural productivity. Apart from these traditional means, other new methods are being introduced which offer great possibilities for expansion.

The use of atomic energy in agriculture, the development of new sources of food, modern fishing methods, the use of micro-organisms to transform organic substances into food, etc., all show enormous possibilities for obtaining food.

A more detailed analysis of agricultural production in the different regions of the globe indicates that availability per head is greater in developed countries than in developing countries. This is due to the fact that in developing countries the population has increased at a faster rate than has technical progress.

Although in latter years there have been significant changes in food production methods, with ever-growing use of technology, there have also been major changes in the pattern of consumption. And this is still going on. We are in the middle, not only of a population explosion, but also of a radical transformation in the distribution of population. The movement of the rural population into towns and cities has already occured in industrialized countries and is now becoming apparent in developing countries as well. Urban concentrations are increasing all the time. Even in the tropics, cities with millions of inhabitants are springing up. These factors cause considerable changes in the distribution, prices and marketing of agricultural products. Production sources are becoming further and further removed from areas of consumption. Distribution is concentrated in the big population centres. Eating habits are changing and improvements in the standard of living tend to increase the amount and quality of food consumed.

In developed countries there is a rise in the consumption of animal products, which cost more but, in the long run, do not increase overall expenditure on food. In the developing countries, however, the increase in quantitative consumption is reflected by a corresponding increase in individual expenditure. And in some of them the rate of increase in food consumption is higher than that of production.
The selling price of agricultural produce is rising steadily throughout the world; and relatively faster in the developing countries. In these countries food prices are kept at an artificially lower level, which has tended to discourage producers from entering the less profitable sectors of production. Instead they have turned to areas offering greater profit margins. These are products which are not essential to life. Consequently we find a production surplus of essential foods in the developed countries, while the developing countries, which have a greater need of such products, tend to produce a surplus of non-essential agricultural products.

Distribution of production

Taking the total food production of 1965 at 1,738 million metric tons we find that 60% is accounted for by grain and potatoes: 28% consisted of products of animal origin: milk, eggs, fish and meat; 3.6% fruit; 3.5% sugar and 1.6% wine. These products can be divided into 72% of vegetable origin and 28% of animal origin and they correspond to an average availability per person of 600 kg. a year, or 432 kg. of vegetables and 168 kg. of animal products. If we take out the last group of products which are available throughout the year, we can see that the remaining 432 kg. must be produced in 1/5th of the year and stored for 4/5th of the year.
One curious fact about world stocks of surplus agricultural products, which we have already pointed out, is that the highly developed countries have the largest stocks of essential products: USA and Canada have around 95 million tons of surplus grain, while under-developed countries like Brazil and Cuba have surpluses of coffee and sugar. At first sight it would appear that conditions in the more highly-developed countries, which are situated in the temperate regions of the world, are more favourable for producing essential agricultural products, while the developing countries, situated in tropical and sub-tropical regions, are more suited to the production of non-essential commodities like coffee, tea, sugar, cocoa, coconuts, etc. In fact there are also other additional factors which are becoming increasingly important. In the developed countries, industrial production has now reached a sufficiently high level to force an expansionist policy on agricultural production, whereas in the developing countries, the reverse is the case. The latter countries take the view that a country's development depends on industrial progress. They therefore adopt expansionist policies for industrial production at the expense of agriculture. They encourage the production of commodities for export—which have a greater economic value because they support industrial investment—to the detriment of vital agricultural products.
The geographical distribution of agricultural products in 1964 was such that around 160 million tons were exported to various parts of the globe. About 38% of the total came from North America and 16% from Latin America; 54% from the two Americas. After that came Europe with around 21%, Asia and the Pacific with 18% and Africa with 7%.
These figures show that approximately 75% of the total was produced in regions with a temperate or cold climate and 25% in regions with a tropical or sub-tropical climate.
Fortunately the harvesting periods do not coincide, which increases the production period and therefore benefits both the consumption and marketing of these products.

The variety of agricultural products

If we omit forestry production, we find that more than 95% of all agricultural production is intended for food. These products must be harvested and stored in such a way that they can be offered throughout the year, daily and in the proportion of 1,640 grams per head of the population (600 kg. per head per year). This entails maintaining an average stock of 325 kg. per person during the entire year or an average stock of 1,000 million tons of food for the entire population of the world.

Taking into account qualitative differences between agricultural products which must be considered in making up stocks, they should first be divided into categories. These can be largely grouped into deteriorative foods and perishable foods. In the first category come products which can be stored under more or less natural surroundings, not specially constructed, for a given time, or with few modifications. With a few simple precautions these products can be stored for a considerable period of time, even for years without any significant alteration in their chemical and organic composition. These products are said to deteriorate slowly and only become unfit for human consumption under adverse conditions. On the whole, few precautions are required in storing these foods, apart from reducing their moisture content by 10-15%. Under this heading come grain, hard vegetables and oilseeds. These products represent 43% of the total. The annual consumption in this category is 745 million tons and, on an average throughout the year, 400 million tons have to be kept in stock.

In the second category, the perishable foods, come products which deteriorate quickly and become unfit for human consumption in a short time. In general these require special treatment to keep them in a totally artificial environment, with rigid control of the temperature and relative humidity of the air. Under such conditions and according to the length of time for which these products can remain in such an environment without considerable damage and deterioration, they can be classified as slightly perishable, moderately perishable or highly perishable foods. The first subcategory includes products requiring very little chilling which can sometimes, and in some areas, be achieved by natural ventilation or slight refrigeration. These are products which merely require a surrounding temperature of between 5° and 15° C., as for example, potatoes which represent more than 20% in volume of the total agricultural products consumed by man, or 356 million tons a year.

Under the heading of moderately perishable foods come those which require refrigeration to between—5° and + 5° C. These foods require refrigerated storage. They include fruit and vegetables in general, dairy products and eggs, and they represent approximately 25% of all agricultural food products or almost 432 million tons a year.

Under the sub-heading of highly perishable foods come those needing deep refrigeration or freezing at temperatures of—10° C such as meat, fish, fruit juices, etc. which represent around 120 million tons a year.

Storage as a factor in reducing loss and wastage

Studies made of grain losses due to the lack of or inadequate storage show that a large proportion of these products are lost to consumers each year. In tropical countries these losses can be as high as 20% in some areas.

We can quote a survey carried out in England on losses caused by rats to stored grain: numerically these rodents are equal to the human population of the country, around 50 millions, and each year they cause damage estimated at £12 million. In other developed countries such as France, Germany and the United States, the losses are around 200 million francs, 200 million marks and 1,000 million dollars respectively.

Insects also cause considerable damage to stored grain, but unfortunately there are no precise details available. Most of these insects come from regions with a humid tropical climate. It is a well-known fact that insects are capable of devouring more than their own weight in food every week and that the larvae can eat a quantity equivalent to several times their own weight during metamorphosis.

By improving the storage conditions of the above-mentioned products, it should be possible to ensure greater availability of food and so contribute to improving the structure of prices and distribution to the consumer.

There is no information available on losses of perishable foods, but we do know that, in some parts of the world where the food industry is backward and marketing is haphazard, these losses can be very high indeed.

Although good results can be obtained by simply improving storage conditions in the case of the deteriorative foods, such improvement should be supplemented by advances in processing and packing in the case of perishable foods.

The need to improve storage and preservation conditions for food stocks in a large section of the globe is in inverse ratio to food resources in these regions, because improvements require greater investment and better technology.

The effect of preserving stocks on the nutritive value of the product

Although preservation has an immediate and direct influence on the quantity of the product, it also has an effect on quality and therefore on its nutritive content. Here the effect should be distinguished in relation to the two food categories.

The damage caused by insects to the quality of the grains is due to their attacking the most nutritive part, the germ, by changing its chemical composition and nutritive value. The presence of a large insect population in a mass of grain causes an increase in respiration and temperature and this increases the moisture content of the mass.

Such variations cause an increase in the grain's metabolism which means speeding up the breakdown of its carbohydrate content. In the worst cases bacteria and germination are present, which renders the grain unfit for human consumption.

The residue left by chemical sprays used to control insects can also cause changes in the quality of the product. Some of these chemical products can leave residue containing ethylene bromide which can be responsible for making the protein useless by forming inorganic bromide. This is a persistent, spreading residue which is difficult to eliminate. And if it is present in excess it produces a distinctive odour in milling grain which lessens its value for consumption.

Inadequate preservation of oilseeds causes fungi which can be highly poisonous.

Experiments in England and Canada on feedstuff containing traces of oilseeds infected by the fungus "Aspergilus flavus" showed that these contained a poisonous substance called "Aflatoxin" of a cancerous nature for certain animals such as turkeys, ducks and in-calf cows.

As regards the storage of perishable foods, it is well-known that these are subject to constant change from the very moment of harvesting. These changes gradually destroy the nutritional value of the food. After harvesting, fruit and vegetables continue their physiological activity and their catalytic and respiratory processes cause transformations in the product which are often uncontrollable. Although reduced temperatures bring a corresponding reduction in the metabolic activity of the product, which helps in preserving them, prolonged storage in such conditions causes modifications of their structure, nutritional value and organic quality.

The principal effect on the nutritive value of fruit caused by storage conditions is the gradual reduction of ascorbic acid which can be controlled by a corresponding reduction in temperature. The percentage loss of sugar which occurs when certain types of fruit are stored, should also be considered. The banana, for example, is apt to lose its smell and flavour under refrigeration. Changes occuring during storage of perishable goods in relation to vitamin content need further study. The most familiar change is the loss of ascorbic acid, especially at ordinary temperatures.

Products of animal origin are usually classified as highly perishable and are open to attack from bacteria, some of which are highly dangerous. These products are also subject to other transformations, such as oxidization of the fats, and enzymatic activity which can change their colour and smell.

Reduced temperatures are absolutely essential when storing these products if their nutritive and organic qualities are to be retained and bacteria are to be controlled. This type of storage can cause some physical losses, such as a decrease in weight, due to reduction of the moisture content, which at times can produce soluble solids affecting the flavour of the products. Changes also occur in the nutritive value of processed foods during storage. It is a well-known fact that vitamin losses occur when fruit and vegetables are stored in tins over a period of time.

In order of severity, the losses are as fellows: scorbic acid, followed by thiamine and to a lesser degree riboflavin, niacin and carotin. The loss in nutritive content during prolonged storage of canned meats has not yet been adequately studied. Prolonged storage of deep-frozen products cause other important changes apart from loss of vitamin content. Fish for example, are subject to physical changes mainly of a negative nature. These include desiccation, destruction of the muscle protein, and rancidity of the fatty substances. Although the effect on nutritive value is not yet fully known, there is no doubt that the organic qualities alter considerably, resulting in a less acceptable product. Loss of vitamin content, flavour and aroma can also occur in the case of dehydrated foods when stored for long periods.

Modern storage and packing methods

Current advances in science and technology offer new storage and packing techniques, which can guarantee considerable safety in keeping and preserving food. The use of modern techniques can still raise problems, however, especially in developing countries. Lack of government guidance and the vested interests of financial groups in these countries have prevented the most deprived areas from catching up with modern progress. The often huge investment needed to equip these areas can also be a serious obstacle.

One of the primary objectives of any developing country is to ensure proper storage for cereals and other grain crops. Modern tower silos provide highly effective safety conditions against damage by rats, insects, germs, etc. These products can be stored for years in tower silos which have been fitted with equipment for drying, cleaning and for controlling grain temperature and moisture-content. Unfortunately this method of storage is not yet sufficiently well-known in the majority of developing countries. While in the USA for the past 15 years there have been available in agricultural districts 23,000 silos, this system is practically unknown in most tropical countries. In these countries, cereals and other vegetable grains are still stored in bags piled up in warehouses.

With the exception of some types of grain and certain ground or powdered products like coffee, sugar, salt, fertilizers, etc., storage in bags is reasonably acceptable. However for the majority of these products, the use of tower silos with modern equipment is recognized as a means of benefiting humanity as a whole.

In volumetric order of importance of foods for human consumption, we must first consider storage of potatoes. As we have already pointed out, these come under slightly perishable foods, suitable for storage under conditions of natural ventilation or slight refrigeration. Modern technology makes it possible to store potatoes for a comparatively long period without any harmful effects.

In modern underground, semi-underground or surface stores, built from insulating materials, in which the temperature and relative humidity of the air is controlled, the amount of light is carefully regulated and the products stored in cases or containers: this helps to keep the potatoes in good condition and offsets the constant changes in their chemical composition which occur during storage. It is a known fact that in this period, depending on temperature, the starch can change into sugar and vice versa. It is also known that the physical loss of weight can be reduced by increasing the relative humidity of the air and that germination and certain chemical processes can be controlled by lighting and the addition of chemical preservatives. By using CO_2 and nitrogen atmospheres and irradiation, better conditions can be obtained for preserving not only potatoes but also fruit. Wider use of this type of storage for potatoes and other root crops for human consumption can provide conditions suitable for producing these foods even in the most severe climates.

In recent years technology has created new storage methods, especially in the field of deep-freezing. In fact this field has become a separate science. Nevertheless experience has shown that it is extremely difficult to forecast the effects of refrigeration unless tests are first of all carried out on the products to be preserved. The conditions vary according to the product. It is sufficient to point out that the degree of respiration varies enormously from product to product; for instance the heat given off by the respiration of tomatoes is 146 calories per kilo per day, while that of peas is more than 2,000 calories. It is well-known that even under refrigeration some fresh foods will only keep for a very short time. Physical changes in their structure cause serious defects as in the case of strawberries and certain varieties of figs and grapes. Deep refrigeration or deep-freezing has opened a new area in food preservation. With deep-freezing new techniques have been developed to solve food problems, as for example foods which are cooked and then frozen and those which are dehydrated and frozen. These new techniques mean new demands for packaging, especially in the field of plastics. Let us also mention freezing and subsequent dehydration by the high vacuum method, through which the frozen water is transformed directly into vapour by sublimation. This is the lyophilization method which has attracted the interest of numerous experts.

Rapid freezing of the product has proved to be one of the most important means of ensuring a good product both for quality and structure, followed by a low and uniform storage temperature. Here use is made of a high-speed blast freezer. In the last few years technologists have concentrated on developing processes which consist of putting the canned or bottled products in the quickest possible contact with sufficient heat to destroy the pathogenic micro-organisms and to induce the enzymatic inaction necessary to preserve

canned foods. This requirement is due to the fact that the faster the heating and freezing processes are carried out, the greater the possibility of obtaining a product equal to the original.
Under these circumstances the containers are a fundamental part of the thermic process. Preference is still being given to rigid containers of metal or glass. The use of electrolytically-sealed sheet metal is a step forward for the industry and an important improvement in the quality of the container, as it ensures uniform distribution of the metal and consequently a better resistance against corrosion. The use of a differentiated electroplated sheet in which the sealing layer is thicker on the inside of the tin than on the outside is a further advance and makes it possible to produce cheaper tins. The use of thinner metal sheets to reduce the weight of the tin and allow greater penetration of heat during sterilization is another improvement in packaging methods. At the moment the use of aluminium is still in the early stages and it is likely that future technological progress will make it possible to use stainless steel tins.
Glass containers have also undergone substantial alteration with the progress of packaging techniques. They are much lighter, although still as strong as the older type.
Modern technologists are trying to produce a glass container which would do away with the returnable "empties" system and speed up filling. Research is being intensified to produce closures for glass jars so that they can be sealed, sterilized and kept in a vacuum.
So far, flexible plastic containers have not taken over from metal or glass because they are unable to stand up to sterilization and handling. However some progress has been made in the use of containers of this type for certain classes of products as for example, pasteurized milk, dehydrated products, and smoked or frozen animal products.

Future prospects

In the next decade man will have to devote greater attention to the problems of producing and distributing food. If the standard of living goes on rising and if all countries recognize the significance of the food problem and the essentials of life, the preservation and distribution of agricultural produce will be of paramount importance for the well-being of humanity just as much as, if not more than, production itself. If conditions for keeping stocks are satisfactory they will provide considerable stimulus for production, because they will be able to guarantee the safety standards required for foods intended for human use.
The need to preserve stocks under standard conditions should be one of the main concerns of food technology. In addition to improving preserving methods, additional means of storage must be anticipated.
If we consider that within three and a half decades man will require 1,200 kg. of food per head per year the total volume of food stored for 6,000 million inhabitants should be 7,000 million tons.
To this should be added the fact that population tends to be concentrated in cities, that production centres are becoming further and further removed from centres of consumption, while interchange of goods increases and man, although better fed, will be spending less and less of his total income on food.
The standardization of containers will play an important role in the movement of these goods from centres of production to those of consumption and in their distribution.
While one of the major needs of the present is storing cereals and other vegetable grains in tower silos, the preservation of perishable products will become relatively more important in the future.
There is no doubt that there will have to be a considerable increase in the amount of stocks being kept in air-conditioned and refrigerated stores and in refrigerators. Forecasts of increased consumption of meat and dairy products, and above all the need for bigger and better yields from deep-sea fishing, will make such provisions absolutely essential.
We must also take into account the fact that food-processing can contribute decisively towards solving the problem of world shortage.
If we remember that in some highly-developed areas of the world, California for instance, 80 % of food consumption is processed products and 20 % fresh; and that there are other regions where the proportions are exactly reversed, we can get some idea of future prospects regarding the packaging of processed products.

Dr. Peter NEHRING

Institut für Konserventechnologie
Braunschweig

Steel for the Preservation and Packaging of Agricultural Products

(Translated from German)

In most countries the development of agricultural production and the marketing of agricultural produce are closely connected with the expansion of the processing industry. The food industry has become increasingly concerned with converting basic farm products into a condition in which they will satisfy the rising demands of the largely urban consumers of the industrialized nations. This has become more and more the balancing factor between agricultural production with its inherent problems (amount, consistency and quality of supply) and the consumers' demands for consistent, high-quality supply. Moreover, it now plays the role of a service industry in that its products cut down the housewife's work. These manifold tasks are fulfilled:

1. by removing those parts from the basic products that are not immediately fit for human consumption;
2. by converting the basic products into a condition which takes the organoleptic requirements of the various population strata into account. Of course, in spite of nationally uniform supplies of basic farm products, the different regional eating habits and differences in social structure will result in an extensive range of processed products (characteristic for the nation in question);
3. by preservation of perishable farm produce;
4. by packing foods in such a way that they meet the demands of transportation, storage, shelf appeal and convenience; especially where supply of large cities is concerned.

None of these tasks could be fulfilled without using steel as the most important raw material. So far the requirements of the food industry are practically the same as those of all other branches of industry.

On the other hand, no other field shows such a marked peculiarity as that of food preservation and packaging, where steel has an important technological function and ensures a comparatively long shelf-life. Once used, it is thrown away.

This use of steel as a non-returnable packaging material is so characteristically different from its other typical applications, where it is under constant long-term stress or repeatedly used, that it is worthwhile investigating the reason for its wide use in food preservation and packaging.

Preservation by heat sterilization

Food preservation is one of the vital concerns of mankind. Like employment of mechanical devices and fire, it has, since primeval times, distinguished the evolution of Homo sapiens from that of the animals. Storing of winter supplies, and particularly the preservation of foods with high protein contents by drying, salting, pickling and smoking, were already generally known thousands of years ago and, along with guarding against invasion, constituted tasks of vital importance. Only in modern times, at the beginning of the 19th century, was a process developed by which foods could be preserved for extended periods under various storage conditions without radical changes in their organoleptic and other qualitative characteristics. This process was developed by the French cook Nicolas Appert at Napoleon's suggestion; Napoleon wanted to ensure supplies for his military forces at war. The method was first published in 1809 and was based on the simple heat treatment of foodstuffs in hermetically sealed containers. It was only many years after Appert's invention that microbiological research, especially by Pasteur and his contemporaries, provided the theoretical base for the process. Microbes, which are ubiquitous, are killed by heat action when occurring as spoilage organisms in the food. Hermetic sealing of the package prevents reinfection through entry of spoilage organisms after sterilization. Only at the beginning of this century did biochemistry succeed in showing clearly that enzymic food spoilage is interrupted by heat treatment.

The practical introduction of Appert's process, which is known as "canning" or "appertisation" and which now forms part of our everyday life, was due not so much to theoretical knowledge as to the lucky choice of the best packaging material. An Englishman, Peter Durand, applied Appert's process (for glass bottles) to containers made from tinned steel plate, so that food preservation on an industrial scale became possible. Since about 1860, flourishing food industries have developed especially in the USA, England, France and the other European countries. The annual production of canned vegetables, fruit, meat and fish at present amounts to 5-6 million t. in Western Europe (that of the EEC-countries to about 3.5 million t.). The annual USA production amounts to about 10 million t. The figures for per capita consumption of canned foods in the individual countries vary considerably. The figure for Germany, at about 25 kg. per annum, is far lower than that for England which is about 40 kg. per annum and for the USA at more than 50 kg. per annum. However, the consumption of preserved foods in West Germany amounts to about 10% of the total consumption of vegetables, fruit and milk, and to about 7% of the total consumption of meat.

By far the largest proportion of canned foods until now has been packed into containers of tinplate, i.e. tinned steel. About 75% of a world tinplate production of, at present, some 10.5 mill. t. is used for preservation and storage of foodstuffs. These figures gain in significance if we realize that in thin sheets of under 0.30 mm. thickness as normally used in the production of tinplate, it is not the ton units of production but the surface area that counts. The estimated surface area of annual world tinplate production is at present about 5500 km^2., which is more than twice the area of Luxembourg. About 100 milliard packing units (estimated on the basis of 1 million tins corresponding to 80 t.) such as tins, canisters and other containers are made from it per annum i.e. about 25 units per capita of the world's population.

How did food preservation and tinplate as a packaging material become of such outstanding importance? As compared to past centuries increasing urbanization of the industrial population has led to a drastic change in eating habits. Populations which had played an important part in agricultural production have now become consumers in towns which have to be supplied with food. With their physical work becoming less, their physiological food requirements have completely changed. The foremost food requirements of industrial society are less concerned with satisfying calorific needs than with the regular supply of sufficiently varied fare of high food value. This means increasing demand for "speciality" foodstuffs, which deteriorate rapidly because of their high nutrient content. This demand can only be satisfied if, irrespective of place and time of production and consumption, the necessary food commodities can be made available through preservation. Food preservation therefore plays a vital part in a nation's health.

Consequently, preservation (in the widest sense) of agricultural products which are available naturally for short periods only is an invaluable service to the urban consumer. The cycles of the seasonal products, due to their short periods of supply, are levelled out and stabilized (at least within certain limits) by the preserved food products which are always available in addition to the fresh market supply. This anticyclic effect of food preservation on the price of fresh produce is also of great benefit to agriculture. By, for example, contract growing of vegetables, the canning industry ensures steady sales for agriculture, that exceed the direct demand, and renders possible the absorption of e.g. unexpected agricultural surpluses (due to weather conditions).

Food preservation has become of increasing importance for food supply in a crisis. No doubt the Great Wars which have shaken the Western world have helped the development of canning techniques and the expansion of the canning industries. Supply of food to military forces and the civil population is still a decisive factor for the chance of survival in modern wars.

Owing to improved transport conditions, the supply of fresh produce shows increasingly greater variety in nearly all countries of the West, and, owing to multilateral relationships, has become more independent of the seasons. However, without a sound and vigorous food industry, and without reliable and economic preservation processes, serious crises would occur if difficulties of supply arose. Therefore it is not surprising that recently the canning industries have expanded considerably and expect, on the whole, to expand still further, though here and there difficulties will arise, which, in an industry that depends so much on agriculture, are necessarily bound up with problems of farming structure and policy. Signs of saturation have for example been observed in some canned food markets in the USA. However, there will not be saturation in other countries for some time to come. Many developing countries, being agricultural States, are greatly interested in the rapid setting up of modern canneries and industries to supply them with raw materials because canned foods, being processed agricultural products, are often the best commodities available for exchange against capital goods.

Appert's process of preservation by heat sterilization still plays the foremost part in this complex problem. As compared with other competitive processes it has the following advantages:

1. it can be applied to a very wide range of foodstuffs especially fruit and vegetable, meat, fish and milk products;
2. technically it is relatively simple, so that the cost of capital investment warrants the setting up of canneries in the farming areas;
3. no special arrangements with respect to transport and storage of the processed foods are required;
4. the heat-processed commodities can be stored for long periods without substantial loss of the physiologically important nutrients.

The modern developments of the sterilization technique, for example the determination of the optimum sterilization conditions (which on the basis of theoretical considerations has become possible), the improvement in retort technique, especially the introduction of continuous retort installations and the use of rotary retorts, have helped considerably to bring about economic mass-production of high-quality canned food packs.

Preservation by deep-freezing, drying and irradiation

Methods of food preservation apart from heat sterilization, deep-freezing (which is the only substitute process worth mentioning) and the more recent drying processes have found their own fields of application. As methods of food preservation that present special advantages for a relatively narrow range of foods, they can be used to supplement heat sterilization but not to replace it. Consumption of deep-frozen vegetables in the German Federal Republic has for example risen from a base index figure of 100 for 1961-62 to 207.5 for 1965, whilst the figure for canned vegetables over the same period has risen to 116.7 only. However, the tonnage figures show clearly the quantitative ratio of the two methods. During the last four years the consumption of canned vegetables has risen by 47.7 mill. 1/1 cans to 332.8 mill. During the same time and in spite of vast sums spent on advertising, consumption of deep-frozen vegetables has only increased by 25.9 to 50.0 mill. kg.

Conventional drying processes have played an important part especially during the wars. Under the normal conditions of the food market in peace time, they have a limited range of applications in which they are serious competitors to heat sterilization only in the field of soup manufacture. The still relatively new method of freeze-drying makes possible the preservation of foods with only slight loss of food value and of flavour characteristics. Because of the capital expenditure that is required for large installations, freeze-drying is not likely to replace heat sterilization for some time to come, but it will find its own applications, e.g. in the soup industry. Neither can modern methods of "instant food" production be applied to commodities which are usually canned. These methods do not therefore present a threat to heat sterilization.

Preservation by irradiation has been thoroughly investigated during the last 20 years. The extensive results available lead to the conclusion that it is practically impossible to develop it into a generally applicable method of preservation. The irradiation dosage necessary for the killing of micro-organisms is of the order of 1.5—3 Mrad. whereas in many meat and vegetable products appreciable changes in flavour are likely to occur at < 1 Mrad.

According to the present and foreseeable state of technical developments, one cannot expect Appert's process (through which steel in form of tinplate became of foremost importance as packaging material in food preservation) to be confronted by a substitute method equal to it in simplicity and in range of application.

Tinplate as packaging material for canned foods

What is the importance of the sterilizable package made from steel, particularly that of the food can made from tinplate, at present and in the future? What substitute materials has tinplate to face and what are their prospects?

Tinplate owes its eminent position in the market to a number of favourable properties:

1. economical manufacturing methods, especially since the introduction of cold rolling and electrolytic tinning before and during World War II, now permit the setting up of high-capacity plant as required by present day demands;
2. good formability and machinability which permit consistent mass-production of different designs and dimensions;
3. good mechanical stability, which allows economic filling and sterilization at high production speeds and high temperatures. Its relatively high resistance to chemical interaction with the various products, its physiological harmlessness and working safety;
4. the good eye-appeal properties of tinplate containers, particularly their excellent printability and their bright appearance which stimulate sales, the favourable price relationship of tinplate and pack, and the low requirements of tinplate containers as far as storage, packing and transport are concerned.

The historical development of tinplate from the hot-rolled, hot-dipped material with plate thicknesses of about 0.35 mm. and tin coatings of the order of about 60 g./m². to the present situation where it is possible to manufacture "double-reduced" tinplate with a plate thickness of 0.16 mm. and with an electrolytic tin coating, set according to the intended use, down to about 2.5 g./m²., is characterized by the aim of producing as cheap a material as possible which meets in its mechanical, chemical and machinability characteristics the particular requirements of the individual packs. Advances in tinplate technology, and developments in the packs themselves, have helped the further developments of tinplate. Many food products which are not, strictly speaking, preserves, notably beer and soft drinks, have been packed into tinplate containers since the end of World War II. These two outlets for packages made from very thin tinplate together constitute about 25% of the total tinplate consumption in the USA, about 43% of the total beer production and 47% of soft drink production being canned. So far they have played only a subordinate part in European countries, but they do show an upward trend. They are distinguished from heat-sterilized packs in that they are not exposed to thermal stress. Consequently, the requirements of mechanical resistance are different and new possibilities of can manufacture and the use of unconventional very thin plate (with very low plate thicknesses and extremely thin tin coatings) present themselves. However, a drastic reduction in tinplate thicknesses down to 0.18-0.20 mm is also possible in conventional container applications (made from very thin tinplate) for heat sterilization and is already carried out. Here the special properties of harder material have to be considered in can manufacture, as well as the higher susceptibility to denting and damage during filling and sterilization. In modern plants, control of both factors has proved satisfactory but great care has to be taken with the introduction of new materials into mass production and all the particular national circumstances must be taken into account.

The same applies to the reduction of tin coating weights on tinplate. Since the electrolytic tinning process was first developed on a fairly large scale in 1934 by a German rolling mill, it has almost completely superseded the old hot-dipping process in the USA and is used for about 75% of tinplate production in the ECSC countries.

In the Federal German Republic the percentage of electrolytic tinplate supplied for the home market has risen from 66.5% in 1961 to 86.1% in 1965. The advantages of electrolytic tinning as a continuous process to be carried out on the strip, during which the tin coatings can be set and kept within narrow limits and, if desired, of different thicknesses on both sides of the material in the form of differential coating, are obvious. Their contribution to the rationalization of tinplate manufacture and to making this material more competitive has been as decisive as the change-over from hot to cold rolling which took place at the beginning of the thirties. It was logical that, together with the use of hood type annealing of the cold-rolled strip as a continuous process, further development of annealing in the continuous furnace would take place.

In spite of the reduction of tin coating weights, it has become possible not only to control the chemical interaction between the tinplate and the pack, and its resistance to atmospheric influences, but also to improve them for many uses.

The principal factors which make this possible were:

1. theoretical studies of the corrosion behaviour of tinned steel plate;
2. advances in lacquering techniques;
3. development of the chemical or electrochemical surface treatment of electrolytic tinplate.

The date obtained from electrochemical research carried out on the tin-iron alloy, and on the relationship between continuity of the iron-tin boundary layer and corrosion behaviour, have made possible the use of particular properties of the material for certain packs such as for example, the use of a special material for making cans for citrus juices.

Many problems of measuring and manufacturing techniques connected with this development remain unsolved.

Thanks to the advances made in the techniques of surface protection, many past failures due to pitting, hydrogen swells or total detinning can now be largely controlled and they no longer present problems which might affect the use of containers made from very thin tinplate. Progress in surface protection has been due principally to advances in chemistry and in techniques of internal can lacquering. So far, three distinct stages are apparent: up to about 1940, the use of lacquers based almost exclusively on an oleo-resin; up to 1950, phenolic resin lacquers and since 1950, epoxy resin/phenolic resin combinations have been used. At present these three basic types coexist and each has its own special applications. The many variations found within these basic types, their modifications and the many ways in which lacquers, e.g. based on vinyl resins, provide internal protection to nonsterilizable packages, ensure the solution of all manufacturing and corrosion problems with which one is faced during the working of lacquered tinplate. Where particular corrosion conditions occur due to the nature of the pack, the combination of lacquered components, e.g. lids and bottom ends, with unlacquered components provides the best solution. Simultaneous use is made of the chemically almost inert lacquer film and the stabilizing influence of tin ions (going into solution during corrosion) on those properties of the pack which may cause oxidation.

Some foods cause relatively rapid detinning when in contact with tinplate. This phenomenon can usually be prevented by use of the appropriate lacquer. At the same time detinning raises the question of toxicity and food legislation. So far no toxic effect due to those amounts of tin ions which normally enter solution (from the tinplate) has ever been observed or described in the literature. The limits of 250 ppm. tin in the pack as recommended in the Anglo-Saxon countries and in the German Federal Republic, should certainly never be exceeded. According to the more recent food legislation of most countries, higher amounts would be considered undesirable and perhaps dangerous due to the passage of foreign matter into the pack.

During the sterilization of protinaceous foods such as meat, fish, milk and certain vegetables, dark sulphide layers form owing to the reaction between sulphorous decomposition products and the tinplate surface. This phenomenon, generally described as "marbling" (" sulphur staining") can largely be avoided in both hot-dipped and electrolytic tinplate by the application of suitable lacquers e.g. zinc oxide-pigmented lacquer (C-enamel) or by the combination of suitable lacquer types such as those with a high percentage of phenolic resin. A special technique for preventing the sulphur staining of electrolytic tinplate is available; it entails electrochemical after-treatment, by which passivation layers are produced on the tinned surface. Occupying the susceptible areas, these layers inhibit the formation of tin sulphide during protein denaturation (during or after heat sterilization). Sulphur staining is a physiologically harmless surface reaction of the tinplate. One tries to prevent it only because it looks unattractive.

The high production speeds of can manufacture make very high demands on the material from which the can is made. With the introduction of bodymakers (shortly before the outbreak of World War II) production speeds went up by leaps and bounds. The capacity of fully automatic lines of conventional design is now up to 400 cans per minute; that of modern lines on which several bodies can simultaneously be seamed, soldered and finally separated, is more than 1000 units per minute.This very high production speed requires uniform raw material and can be employed only where there is a demand for large numbers of standard size containers. Standardization of can dimensions is therefore of vital concern to the can manufacturers and would provide the consumer with a better idea of the market situation.

The logical development of an economical method of can making would be the use of coiled strip in place of sheets. Continuous strip naturally makes completely new demands on the can manufacturer, which, with respect to handling, transport and production control, lead to high capital expenditure. The use of strip became possible only after advances in the cold-rolling technique allowed the manufacture of broad strips with narrow tolerance ranges. Introduction of this new process is therefore very slow and for the time being, limited to the large manufacturers. Because of the high capital expenditure and increased technical investment required, greater effort is at present concentrated in the field of processing sheet.

Only by the utilization of all technical developments has it been possible to keep the price of cans in a favourable relation to the prices of packs. The growing number of competitive materials which confront tinplate in particular, and the increasing competition from alternative packages which faces tinplate containers, compel the sheet metal processing industry to continue in its efforts. When considering this competition from other materials and packages it should be remembered that the food can made from very thin tin sheet shows additional advantages of

(a) relatively low demands with respect to transport, filling and storage technique;
(b) good physical and chemical resistance;
(c) favourable relationship between weight and mechanical resistance which makes minimum demands on repacking;
(d) good storability and printability which make sales-promotion stacking possible (no shelving required);
(e) permitting, even during the rough filling operations sometimes encoutered in factories, reliable production runs with a reject level of the order of 0.1 % being considered normal.

However, we must not deceive ourselves. Some problems in making cans from steel sheet cannot be solved, or have not as yet been solved satisfactorily:

(i) In spite of many suggestions which are technically ingenious, but usually too complicated for mass production, ease of opening and reclosure of the cans remain problems. Here, possible combinations with other materials as for example aluminium, present themselves, and in some cases they may lead to low-priced solutions.

(ii) No doubt it would be useful if the consumer could be convinced by the appearance of the cans that they are chemically inert to the pack and to atmospheric influences. Internal corrosion and external rusting of the can are, even if they do not affect shelf life and keeping quality of the packs, always visible defects which quite simply affect the saleability of the container (made from very thin tinplate). Here, processes of chemical surface protection whose possibilities have not yet been fully exhausted could lead to new solutions.

(iii) Of course the aim should always be to improve still further the ratio of the price of can: pack. The development of thinner plate and plate with thinner tin coating and advances in the manufacture of tinplate containers promise success.

(iv) Finally it must be remembered that the future of the container made from tinplate and its price depend very largely on the future of that political metal tin. The vast amount of the world's tin reserves, estimated to be 4 mill. long tons, during the last few years annual consumption has risen only slowly from 170-180,000 long tons (about 45 % of which is used on tinplate), does not yet give grounds for immediate concern. However, the principal world tin reserves are in areas which the Western World cannot consider to be politically safe. Therefore research aimed at the development of a food container made from steel plate, but without using tin, has recently been intensified.

Substitutes for tin-plate, based on steel

The difficulties of introducing a substitute material for can making based on steel consist principally of:

(a) producing the side seam of the can bodies,
(b) ensuring sufficient protection against corrosion,
(c) (as experience in Germany during World War II has shown) obtaining an attractive appearance which appeals as much to the consumer as does tin-plate.

Though only at low speeds, the production of reliable welded seams in tinless and therefore unsolderable plate was already being practised on a large scale in World War II. Recently, automatic welding machines have been developed in the USA on which can bodies can be manufactured continuously at high speed. These machines have opened up entirely new prospects. The cementing of can body side seams (developed in the USA) has also a future. Other interesting developments concern the production of seamless lower can components by means of deep-drawing.

Black plate passivated in different ways and blackplate with electrolytic chromium plating in different finisher (whose properties vary only slightly) are other tinless materials, based on steel, available. Also, vapour-deposited aluminium coated plate has been tentatively used. The fullest information we have arises from war-time experiences with black plate. They show that mass production of a tinless container is quite possible. All the same, it remains doubtful whether present or future developments can or should be linked up with those of the past. The tinless container of the future should be technically satisfactory, but commercially feasible, too, and should be capable of competing with other materials. The prospects for chromium-plated sheet are good, partly to supplement tinplate in some applications. It has still to be established whether chromium-plated sheet can be used for sterilizable food packs, and whether it offers definite advantages as compared with (if possible, very slightly) tinned materials. Development is still in progress.
At the moment attempts are being made to develop a tinless container in most of the tinplate producing countries. Such a package must and will come if steel is to retain its eminent place in the preservation and storage of foods.
There will be entirely new possibilities for using steel in packaging if the development of steel foil, started in the USA, continues successfully. At the moment it cannot be seen whether flexible steel foil packaging presents real advantages over other packaging materials.

Tinplate substitutes on a non-steel basis

The importance of some substitute materials for steel being considered for the packing of foods, such as glass, aluminium and plastics has grown of late.
The glass container for preserves has become more attractive, particularly due to modern developments in glass container closures. Moreover, light weight glass containers which have surface treatments to reduce, even at higher filling speeds, the danger of scratches and breakage, have already increased their use in some fields, e.g. baby food preserves, which are almost exclusively packed in glass. Most of the small containers for gherkins and pickled vegetables are also made from glass. For the compote preserves produced in Europe the importance of glass is increasing. At present, about 35% of German fruit preserves are packed in glass. On the other hand, the proportion of glass-containers for vegetable preserves is well below 10%. It is here especially that the high demands of the glass container on the pack are felt. The proportion of glass containers used for fish- and meat-preserves is generally low though glass plays an important part with small packages for certain products e.g. sausages (a favourite pack in Germany).
In view of past developments, increased marketing of glass-packages may be expected, but we can also expect that the relative proportion of the total requirements of sterilizable packages will remain approximately constant. Both the can and the glass container have a right to exist side by side. Neither is a substitute for the other. There is a trend towards the increasing use of aluminium as a base material for can making. In Germany it is being used increasingly for fish products. In the USA deep-frozen citrus fruit concentrates especially are packed in aluminium. However, the quantity of aluminium used for the manufacture of food packages which compete directly with containers made from very thin tinplate is far lower than tinplate. In the Federal Republic of Germany the amount of aluminium plate used for can making in 1956 was 2050 tons, which was only 4 % of the total amount of aluminium used for packaging purposes (as foil, tubes, closures for glass containers) and corresponded (taking the difference in weight of material into account) to less than 4 % of the amount of very thin tinplate used for can making. The main reasons why only a relatively small proportion of the aluminium is used for can manufacture are the price differential between aluminium and tinplate which is of the order of at least 20 %, and the fact that large containers with sufficient mechanical and chemical resistance cannot be manufactured as economically from aluminium as from tinplate.
Flexible packages such as bags, made from plastics and rigid plastics packages such as cups or bottles, are growing in importance where preservation of farm products is concerned. However, their use is mainly confined to non-sterilizable packages e.g. for packaging edible oils and preserves, which are semi-sterile commodities, for immediate consumption. Plastic packages suitable for heat sterilization and long-term storage of foods, which could thus replace the conventional food can, have not yet been developed, because in such packaging materials the problems of flavour- and gas-permeability are difficult to solve. Nor can

sterilizable packages made from polyethylene- or polypropylene-coated aluminium, for example, be mass-produced as yet. Moreover, their use will remain confined to single unit, portion packs.

Critical evaluation of the present data and a realistic assessment of future possibilities do not lead us to expect that aluminium, plastic materials or a combination of both, will present a serious threat to steel in the mass production of food cans in the foreseeable future.

Sudden changes will certainly never occur; at best there will be a gradual shifting of trends. In spite of the many efforts to develop something better and cheaper, no other packaging material has attained in the food sector the overall excellence of properties to which the food can, made from very thin tinplate, owes its predominant position.

Preservation by heat sterilization, too, in which the food can has played such an important part and on whose prospects its development largely depends, has proved superior in many respects to other preservation processes. It is symptomatic how little deep-freezing processes, for example, have affected production and marketing of heat-sterilized foods in the 25 years and more since their introduction on the market. This, too, must be taken into account when further progress is considered.

If there is any "danger" to the future of steel in the preservation and keeping of foods, it can only be that of not exploiting the growing market to the full. Everything ingenious is simple (and Appert's sterilization process and the food can made from very thin tinplate are ingenious) and everything simple and obvious tends to be considered final.

Agriculture and the food-, packaging- and steel industries together should aim at preventing the food can and food preservation from being considered as final solutions. They should do this by making their importance clearer to the consumer and by vigorously expanding the range of applications of the food can. Many promising starts have been made, but the interests concerned, at least those in continental Europe, have not yet got over the hurdle of accepting the obvious as the final: the market possibilities are not fully exploited. Even agricultural packs in containers made from very thin tinplate will not sell automatically in competition with the greatly increased range of products available today; they require intensive and purposeful promotion by the trade.

The rolling mill and the package manufacturer, the food-technologist and the agriculturalist must further their efforts in developing the existing methods and in improving the good into the best, and in reducing what has proved useful to what is necessary.

There are still many possibilities for further technical development. The best way to ensure that steel keeps and expands its present market position, and to ensure that the marketing of processed farm products does likewise, will be by giving full support to this development. For here as in all fields of modern life: lack of progress means regression.

Delegates' Papers and Comments

Dipl.-Ing. Alfons BREUER
Dr.-Ing. Johannes SIEWERT

Rasselstein AG
Neuwied

Development Trends in the Preservation and Packaging of Agricultural Produce

(Translated from German)

In his paper Dr. Nehring said that for the preservation of foodstuffs no alternative process of equivalent value to sterilization by heat was known at present or was likely to be developed in the foreseeable future. This process is closely linked with the use of tinplate, which is essential for the economic use of the process on a large industrial scale. This material combines the necessary durability with the moderate price essential for packagings used only once. In addition tinplate has proved well able to meet the demands of a variety of other packagings for which it is used.

In the future we must make even better use of the technical possibilities of tinplate and promote the development of a steel packaging material in order to guarantee its competitiveness, not least because of the various substitute materials which have already been discussed by Dr. Nehring in his paper.

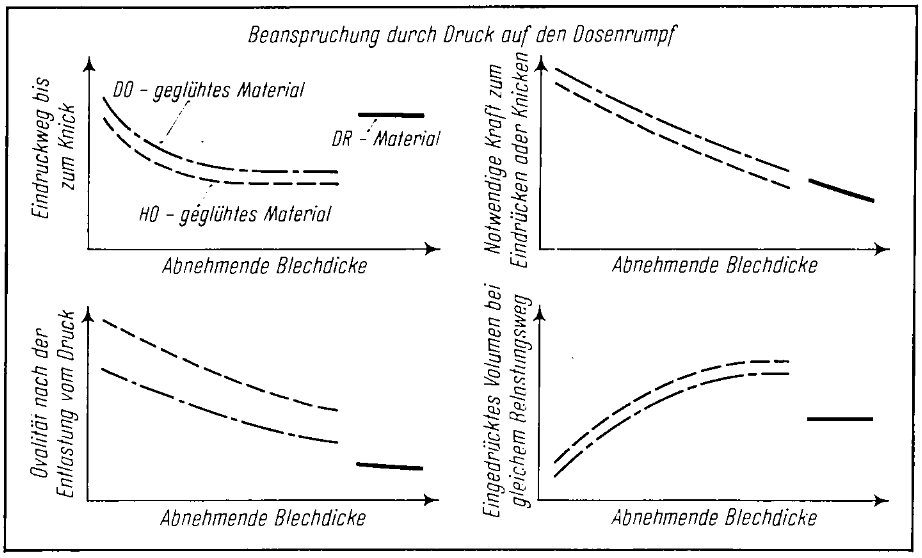
We should therefore like to give some indication of the progress made to date in the production of tinplate and the probable development trends in the future.

The development of steel sheet packaging is concentrated on the following features:

1. high uniformity in the properties of the material and in its dimensions as an important criterion of quality necessary for rational tin can production;
2. the thinnest possible sheet with high strength;
3. optimum surface protection to ensure long storage life.

As regard the first point, the improvement of large capacity plant for the production of cold rolled tinplate has led to a considerable reduction in the tolerances of the finished tinplate. This is the most important development in the production of tinplate since it enables the tin can manufacturer to produce thin sheet packagings of optimum quality and costs on high powered machines. Dr. Habenicht gives further details of this in his discussion paper.

As regard points 2 and 3, i.e. sheet thickness and protection against corrosion, the packaging sheet available today provides the tin can manufacturer with numerous possibilities of producing cans of optimum quality and costs. The available materials can be utilized to better advantage by correct selection. New trends in



— - — *continuously annealed material*
- - - - *box-annealed material*
——— *double-reduced material*

Beanspruchung durch Druck auf den Dosenrumpf	Notwendige Kraft zum Eindrücken oder Knicken
Compressive stress on the body	*force required to crush or buckle the body*
Einddrucksweg bis zum Knick	Eingedrücktes Volumen bei gleichem Belastungsweg
crushing action required to produce buckling	*crushed volume under the same loadpath*
Ovalität nach der Entlastung vom Druck	Abnehmende Blechdicke
ovality when loading is removed	*decreasing sheet thickness*

Fig. 1 — Sheet thickness and can stability

packaging sheet relate both to the mechanical properties of the sheet, which affect the stability of the finished can, and to its corrosion behaviour. In such developments it is not sufficient to achieve what is technically possible; it is also important to ensure that the development trend makes economic sense and thus helps to achieve the aim of making steel packing materials even more competitive.

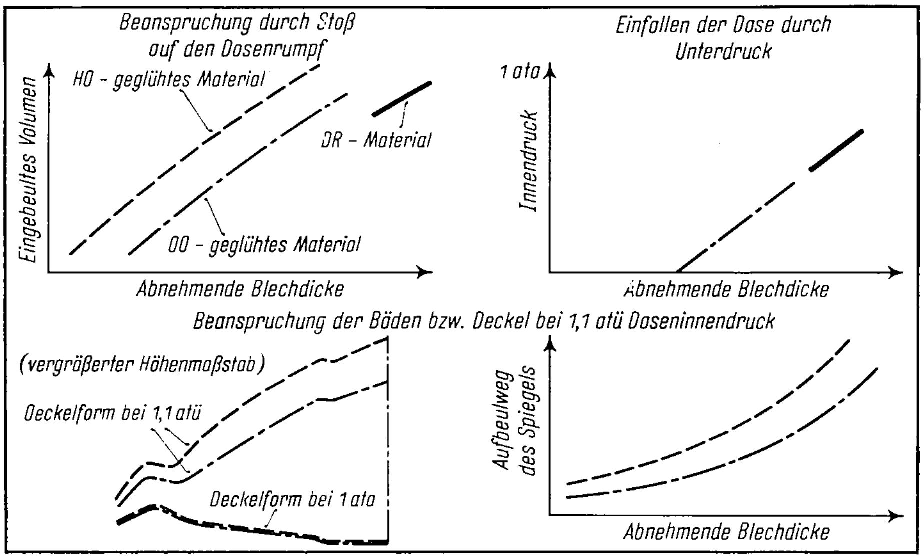
Sheet thickness, mechanical properties and can stability

The production of thin sheet is subject to limits imposed by the normal rolling process. However, in order to go beyond these limits a double-reduced tinplate combining greater strength with lesser thickness was developed some years ago.

The effect of the reduction in sheet thickness on the stability of the can was investigated by means of experiments involving examination of the can in the various production stages and simulation of the load on the empty can during despatch, during filling and at maximum stress during sterilization and finally the stability of the full can during transport.

During manufacture of the can it is, for example, possible that compressive stress on the body may cause buckling when thin sheet is used. Such compressive stress may also occur on an empty can with a base and on a filled can. *Figure 1* shows diagrammatically the crushing action to produce buckling and the force required to crush the body of the can with various sheet thicknesses and different materials. Likewise under the same loadpath the crushed volume of the can depends on the sheet thickness and the quality of the material. However, the ovality of a rounded edge after loading diminishes as the sheet thickness decreases, showing that a can body of thinner sheet springs back better.

Experience has shown that a tin can is subjected to strain as a result of impact during transport and storage. *Figure 2* shows that the extent of a dent resulting from impact is again affected by the thickness of the sheet and the quality of the material. Finally, the partial vacuum, in itself desirable in the filled can, at which a can tends to collapse can also be determined experimentally.



---- *box-annealed material*
—-— *continuously annealed material*
——— *double-reduced material*

Beanspruchung durch Stoß auf den Dosenrumpf
Impact stress on the body
Eingebeultes Volumen — *crushed volume*

Einfallen der Dose durch Unterdruck
Partial vacuum at which can collapses
Innendruck — *internal pressure*
ata — *1 atm. abs.*

Beanspruchung der Böden bzw. Deckel bei 1,1 atü Doseninnendruck
stress on lid and base at 1.1 atm. gauge internal pressure

(vergrößerter Höhenmaßstab)
(enlarged scale)
Deckelform bei 1,1 atü
shape of lid at 1.1 atm. gauge
Deckelform bei 1 ata — *shape of lid at 1 atm. abs.*

Aufbeulweg des Spiegels
buckling path of the polished section

Abnehmende Blechdicke — *decreasing sheet thickness*

Fig. 2 — Sheet thickness and can stability

Similar considerations on stability also apply to the lids of tin cans. The greatest strain here occurs as a result of excess pressure during sterilization when the lid bulges out slightly as a result of the internal pressure and returns again as it cools. *Figure 2* shows the various bulges of tin can lids with a standard section at an internal pressure of 1.1 atm. as a function of material quality and sheet thickness.

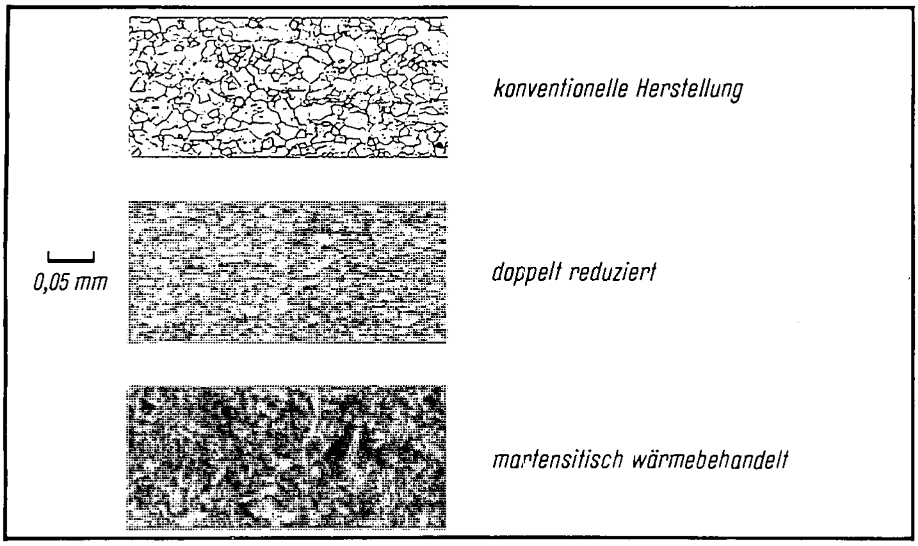
A reduction in can stability, which is bound to occur when the thickness of the sheet is reduced, can be offset either by the quality of the thin sheet or by the design strength of the can. In the diagrams the material properties are shown as parameters, viz. two different annealing processes for conventional tinplate and the double-reduced material. The effect of the material is clearly evident and it is possible for example to estimate the extent to which a reduction in stability as a result of reduced sheet thickness can be offset by the strength of the material.

Similar tests can also be made on the effects of design. In the case of the lid, design has deliberately been used to influence stability for some time. In the USA bright tin cans of reduced material thickness with body corrugations have been manufactured for some time. This method should also be promoted in Europe.

In addition to the question of can stability, that of workability is also of importance in the case of a new material. Practical experience has shown that the double-reduced material can be made into can bodies without difficulty on modern automatic can machines. However, in the production of lids and bases the anisotropy of the material causes difficulties which have not yet been surmounted. Possibly in the future the martensitic steels might prove more suitable in this case. In this material the necessary strength is obtained by a specially controlled annealing process. The polished section shows a structure similar to that of a hardened steel, which clearly differs from that of conventional and double-reduced tinplate (*Fig. 3*).

Corrosion behaviour

Another important factor which affects the quality and cost of a tin can is the coating of the steel sheet. Although in recent years hot-dip tinning with its high and uneconomic tin coating weight has been replaced by electrolytic tinning with lower tin consumption, a method of obtaining the optimum tin deposit really necessary has not yet been found in all cases. Electro-tinning has the advantage of much better control of the tin coating weight than is possible in hot-dip tinning, so that closer tolerances can be observed. According to Euronorm 77-63 hot-dip tinplate has no genuine quality advantage because of the lower tolerance limit. In addition the electrolytic process makes it easier to improve the tin surface by subsequent chemical or electro-chemical treatment, which improves the adhesion of lacquer and hence the protection against corrosion which it affords. Even sulphide discoloration, an optical effect not to be confused with genuine quality concepts, is considerably inhibited by the subsequent treatment possible with electro-tinning.



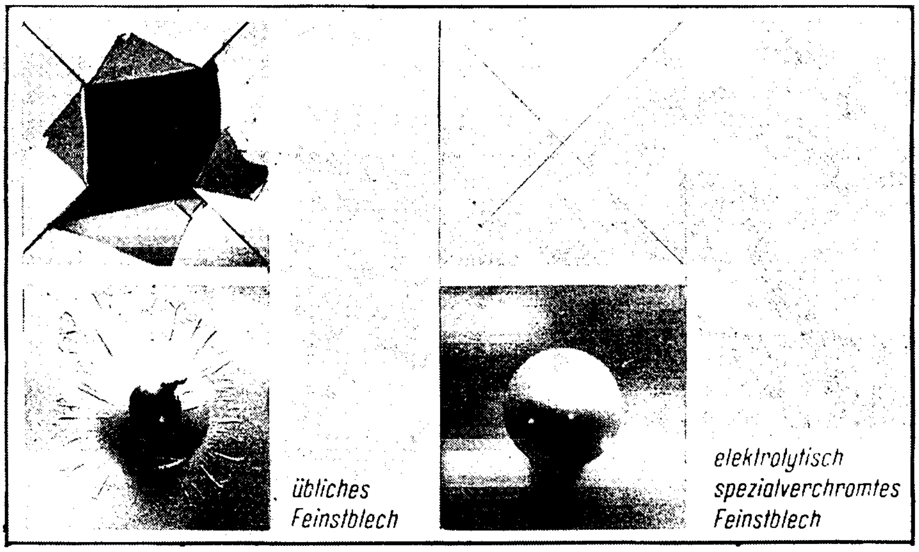
konventionelle Herstellung	*conventional method*
doppelt reduziert	*double-reduced*
martensitisch wärmebehandelt	*martensitic heat treatment*

Fig. 3 — Structure of thin sheet used for canning

A further advantage of electro-tinning is the possibility of coating each side with a different thickness of tin and producing differential tinplate which can be better adapted to suit the requirements of the can. Naturally the tin deposit cannot always be reduced to the thinnest commercial coating. Differential tinning makes it possible to give the inside surface of the can the maximum protection necessary for its contents while the outside can be protected with a thinner coat of tin, particularly if it is to be printed and lacquered. A simple distinguishing mark on one side will prevent any confusion.

Recently, there has again been much discussion about the tin-free can. Experience during and after the war in Germany showed that good cans could be produced without tinning by the use of suitable lacquers on black plate although costs would be high. It should also be remembered that in addition to the expensive lacquering process the really good cans were always made of thin sheet, which had been prepared by various chemical processes to provide an adhesive layer for the lacquer. However, new methods have recently become available in this respect. The first one which deserves mention is the electrolytic deposition of chromium and chromium oxides as well as hydroxides. This material is already produced industrially in Japan and Germany. In the rest of Europe and in the USA steelmakers are devoting close attention to the process.

This new packing sheet is chromized in a chromic acid electrolyte adapted to the requirements of the sheet packaging. It is possible to control the electrolysis so that layers of varying composition are formed and can be adapted to the respective application. No adequate experience is yet available on the production of sterilized canned goods. At present this material is used predominantly for the production of technical packing materials especially crown caps. The excellent lacquer adhesion compared with very thin sheet should later open up a market for it in the food industry. *Figure 4* shows the results of a comparative test to determine the lacquer adhesion on untreated thin sheet and on specially chromized thin sheet. A distinct difference is evident, even after boiling in acetic acid, considered one of the worst media for chromized sheet.



ordinary thin sheet *specially chromized thin sheet*

Fig. 4 — Difference in lacquer adhesion on thin sheet

The thickness of the protective coat is up to 0.05 μm, considerably lower than that of tin on tinplate. The use of chromium, which unlike tin is not considered a "political metal," gives certain advantages, not least as regards costs. Although because of a poor electrolytic efficiency the saving in cost is not as great as the ratio between the thicknesses of the coatings of tinplate and specially chromized thin sheet, it is nevertheless a factor. In due course this saving in costs will also have to be investigated for the packaging of foodstuffs. Although the plant engineering applicable to electrolytic tinning can largely be adopted unchanged for the chromizing process, the coating of thin sheet with other metals in principle requires different processes. For example the vapour-deposition of metals on steel strip has been in the experimental stage for some years and aluminium has been the main metal tested. A plant for the production of this material is to be commissioned this year in the USA. Consequently there is as yet no wide experience of this material. One advantage of the process is that a wider range of metals and metal alloys can be deposited than by electrolysis. In all the efforts to find a metal coating to replace tin in the production of thin sheet containers it must be remembered that the soldering technique now used in the production of cans cannot be used. New methods must be found and tested in practical use. The success of the large can manufacturers as reported from the USA gives hope that this problem can also be solved so that in Europe too we can expect a can without tin in the distant future. However, completely new production processes and long experience with the special contents will be required. As with the reduction of the tin coating weight, the individual products must be tested. This process is complicated by the European demand for a universal can. Consequently for a long time to come the reliable tinplate will remain the predominant packaging material for the long-term preservation of foodstuffs.

Dr. Wolfgang BENZINGER

Düsseldorf

Economic Aspects of Steel Utilization in Connection with the Preservation of Foodstuffs

(Translated from German)

My object in this contribution is to follow up the main paper by Dr. Nehring with an account of the present sales outlets for steel in the food-preserving industry, and a tentative estimate of the prospects during the next few years. When I speak of steel consumption in the preserving industry, I mean in fact the steel used to make the actual cans. The amount of steel needed for buildings and machinery is difficult to estimate but the amount needed for cans—meaning all sterilizable sealed containers (in this case naturally of metal, but not necessarily always so) ranging up to capacities of 10/1 litres—is so large as to merit discussion in its own right. For instance, in Federal Germany alone something like 160-165,000 tons of tinplate a year go on can manufacture. The relevant steel products are, then, tinplate and the ultra-fine variety known as blackplate, the standard qualities and characteristics of which are set forth in Euronorms 77 and 78.

There are several separate and specific difficulties involved in arriving at a more or less reliable estimate of the market outlook. In the first place, the market is an "incomplete" one. Cans rank as packaging, although, as we shall see, they are actually an integral part of the production process. Their sales potential is limited by the availabilities of their respective "fills"—the commodities that are to go into them—and by the canners' production programmes: the can manufacturers themselves are not as a rule able to influence the demand direct to any real extent. Pricing plays next to no part as a market regulator, taking the market overall. The well-known calculation "rationalization of production=more rational apportionment of production costs, distribution costs and overheads=lower prices=higher sales=further automation and rationalization of production, etc." does not apply in this case, if, as we must, we do not look at the individual producer firm but at the market as a whole. The price of the can *is* important, of course, from the point of view of potential competition from substitute types of container, and in relation to the potential market value of the contents. But the level of demand for unfilled cans depends primarily on the fill.

Again, it is difficult to make any estimate with regard to the different fills, since the crop or yield is to a great extent influenced by circumstances outside human control: the crop of such major fills as peas, beans, cucumbers and the like is governed by the distribution of sun and rain, the catch of saleable herring cannot be determined in advance. So forecasts as to the level of the demand for cans are bound, owing both to the nature of packaging—inherently dependent on the goods to be packaged—and to the uncertainty of the flow of raw materials to the canners, to be highly problematical.

However, the statistics available do afford useful indications of the trend in production and consumption, and if we then also take a look at the prospects regarding competition from substitutes it may help us to form a rather clearer idea of the future movement of the market.

The fuller, and so the more important, picture is that provided by the production figures for the main preserved foods. Unfortunately, these reflect only the movement in the sales of the major can-using groups: they tell us nothing as to the relative numbers of tinplate, glass and aluminium containers employed. They must therefore be treated with some reservation. However, it is only in certain sectors of the preserving industry that containers made from materials other than tinplate are being used on any scale to speak of. Only estimates are available. In Germany it is considered that glass containers have a big future only in the case of preserved fruit, though it is true that their share of this market has expanded very substantially in the last few years (approximately 9% in 1962, 19% in 1963, 28% in 1964 and 34% in 1965). In the much larger vegetable-preserving sector the experts definitely put the share of glass at less than 10%. In the meat sector it is probably about the same: in Germany, for example, sausages in small glass containers have been selling fairly well. Small lots of pickles are admittedly practically always marketed in glass jars:

the 10/1-litre vessels for gherkins and sterilized sauerkraut, on the other hand, are still made of printed tinplate, and it is estimated that the proportion of tinplate to glass in this sector is round about 60:40. In fish preserving tinplate is pretty well supreme, though aluminium cans are also used for this purpose in Germany.

So in seeking to assess the sales opportunities for rolled steels in this direction we must allow, as regards the canners' production figures for certain other factors, which moreover may vary from country to country according to consumer habits there. Moreover, the year-to-year changes are no guide: it is necessary to take longer periods, since crop losses in any one year affect the figures very considerably.

Figure 1 shows in diagram form the total production of preserved foods of all the Western European countries (it should be noted, by the way, that no figures for fish canning in Italy were available up to 1963; the first issued, for 1964, was 67,000 tons). As can be seen, the leading fill, vegetables, rose steadily from 1956 to 1963, from about 1,200,000 to about 2,400,000 tons, but fell back in 1964 to 2,360,000. Meat, too, increased from barely 200,000 tons in 1956 to something like 530,000 in 1963 and 600,000 in 1964. Milk, the second

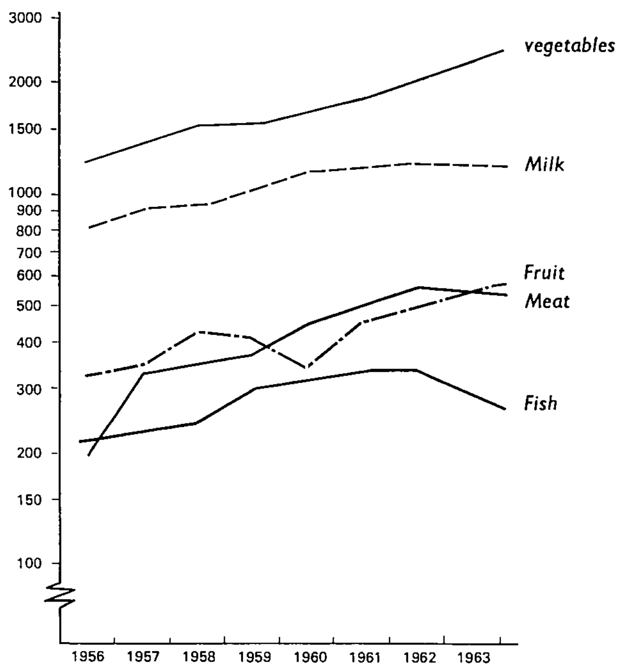


Fig. 1 — Total production of preserved foods (1,000 metr. t)

highest fill, moved from 800,000 tons in 1956 to just under 1,200,000 in 1963 and 1,240,000 in 1964. Fruit, after going up from 320,000 tons in 1956 to nearly 600,000 in 1963, dropped sharply in 1964 to 540,000; in this sector there have been a number of other setbacks over the years, as for instance in 1959-60.

As the output trends for the different canning sectors are anything but even and uniform in the individual producer regions, *Figures 2-5* show the movement of the main fills in the respective countries where they are principally produced. Generally speaking they have mostly been rising, but there have been various aberrations, for instance in France for meat in 1957-59, and in Germany for vegetables in 1963-64. These are striking inasmuch as they were not paralleled in the other producer countries: at the relevant times meat canning was continuing to rise in Germany, the Netherlands, Denmark and Britain, and vegetable canning in Britain, France and Italy. These contrasting developments in neighbouring countries serve to emphasize my earlier point that statistical data do not afford a reliable basis for forecasting.

Table 1

(*Note*: The figures and diagrams are taken from a study by messrs. J. A. Schmalbach AG, Braunschweig, Europa als Markt für konservierte Nahrungsmittel, February 1966.)

('000 *metric tons*)

Country	Year	Preserved fruit	Preserved vegetables	Preserved milk	Preserved fish	Preserved meat
Belgium	1938	3.1				
	1962	33.0	107.8	25.0	2.1	10.4
	1963	30.6	138.0	26.0	2.3	11.6
	1964	17.6	106.1	30.9	2.2	12.0
Denmark	1938	0.8	5.2	17.4	2.0	5.8
	1961	1.8	19.8	22.9	11.5	80.4
	1962	3.2	16.1	22.3	9.3	90.5
	1963	3.2	25.9	17.7	9.5	99.0
France	1938		158.0	24.8	13.0	
	1962	93.8	383.0	129.0	59.7	85.2
	1963	108.3	440.0	155.5	58.0	74.2
	1964	88.8	495.0	166.0	60.3	76.0
Germany (F.R.)	1938	46.3	107.4	60.0	28.0	65.0
	1962	87.8	286.5	414.0	47.0	129.9
	1963	85.0	344.0	448.0	49.0	131.0
	1964	84.0	275.0	450.0	50.0	162,0
Netherlands	1938	3.5	23.9	156.1		
	1962	21.4	90.1	365.0	18.0	104.6 (estimated)
	1963	17.9	101.0	358.0	15.3	93.0
	1964	23.0	90.1	381.0	14.4	100.0
Italy	1938		147.3	3.0		
	1962	58.5	385.0	10.0		21.1
	1963	60.0	433.0	10.0		23.8
	1964	65.0	461.0	10.0	67.0	28.1
Portugal	1964				82.1	
Spain	1962	100.9	113.1		37.0	
	1963	135.8	140.6		40.2	
	1964	156.3	158.0		37.6	
U.K.	1938	32.5	101.6	144.5	8.1	30.5
	1962	102.5	606.3	156.3	8.7	73.0
	1963	111.9	658.5	157.6	9.0	80.3
	1964	97.5	697.2	155.4	6.8	81.2

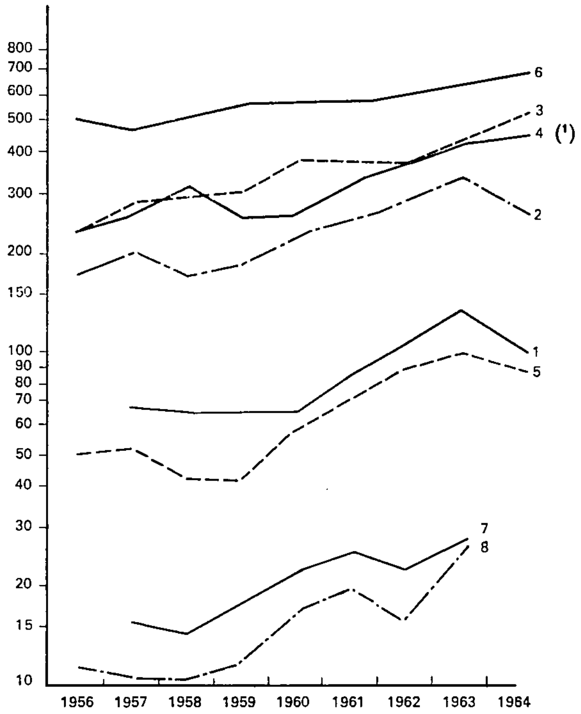
Of the above, the figures for fruit mostly do not include dried or deep-frozen produce; vegetables mostly do not include pickles or dried or deep-frozen produce; milk does not include powdered milk, dried milk products or sterilized cream or milk; fish does not include soused, kippered or salted herring or dried or frozen fish; meat does include sausages and preserved poultry, but not ready-cooked dishes (except in France).

These figures may not be entirely accurate here and there, or even mere estimates, but they give a reasonably clear idea of the main foci of production in relation to the individual countries, and bring out the very marked expansion since 1938.

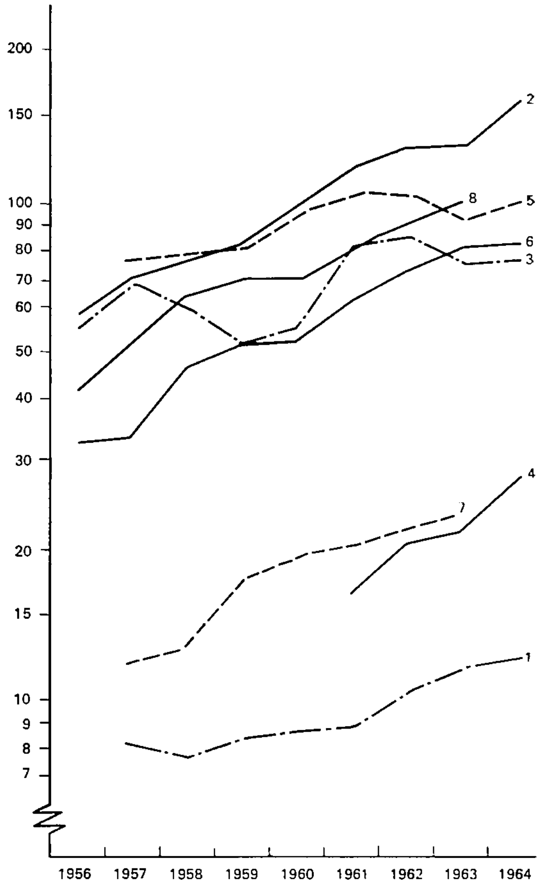
We need not concern ourselves with the export and import statistics for preserved foods. Exports are included in production; imports do not represent any consumption of the importing country's own tinplate, only at most an invasion of its canners' home market, and in any case consist very largely of tropical produce (such as pineapples) or of specialities. (Intra-Community trade exchanges of preserved foods are here disregarded as the Community market is taken as a single whole).

Within the Common Market, it would appear that statistics are kept of the production of the actual cans only in France and Germany. The French figures (obtained from the French Can Producers' Federation) include the tinplate consumption of the "integrated" firms; the German do not, so that various additional calculations have to be made. Incidentally, it may be noted that in Germany it is pretty well exclusively the condensed-milk canners who make their own cans: only one firm in the fruit and vegetable sector and a handful in the fish sector also do so in varying degree.

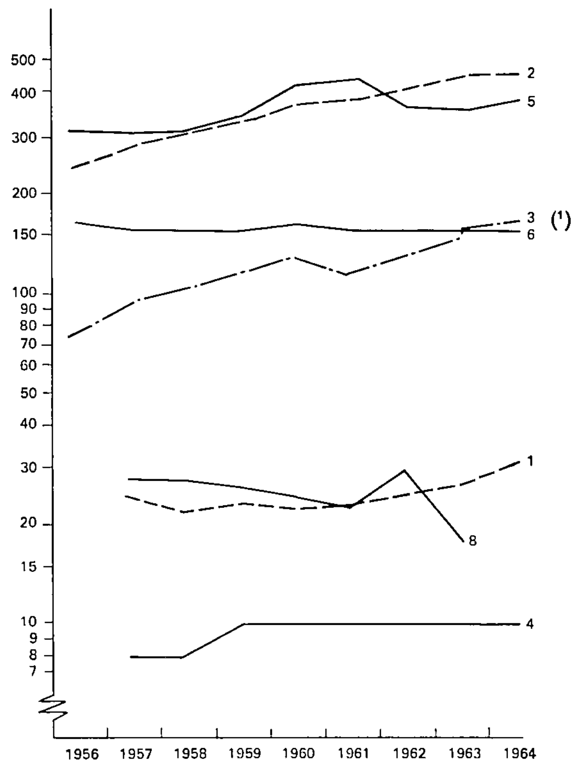
The relevant German figures for the last few years are as follows.

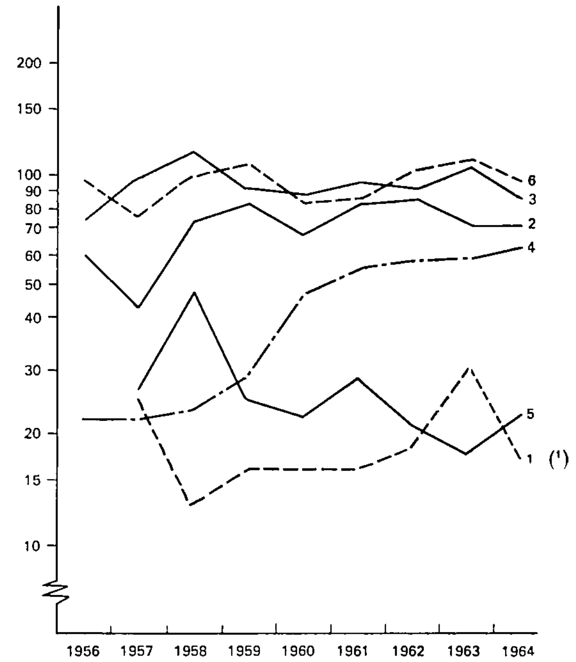


(¹) *Tomatoes only before 1960.*



Meat





(¹) *New basic figures for milk as from 1963.*

(¹) *Including marmelade in 1962 and 1963.*

Fig. 2,3,4 and 5 — Production of preserved vegetables, milk, meat and fruit ('000 metr. t.) — 1 Belgium, 2 Germany (F.R.), 3 France, 4 Italy, 5 Netherlands, 6 U.K., 7 Swedeń, 8 Denmark

Table 2 — Tinplate consumption

('000 metric tons)

Year	Total consumption for packaging (blackplate)	of which: for cans	of wich for fruit & vegetable	of which for meat	of wich for fish
1960	325.6	142.4	55.7	34.8	19.6
1961	338.5	141.2	61.8	38.5	17.1
1962	392.7	176.8	66.9	54.1	16.8
1963	400.9	174.3	79.1	40.0	13.9
1964	401.6	163,3	66.4	43.9	13.4
1965	413.8	165.3	63.6	49.3	14.0

Note: In addition, in 1965, approximately 15,000 tons for other preserved foods, 3,000 for home preserving, and 80-82,000 for milk cans, including the dairy industry's own can production.)

The following are the reported figures for tinplate consumption in can manufacture in France (aluminium consumption for the same purpose in parentheses) *('000 metric tons)*:

1960	162.6 (0.06)	1961	168.3 (0.08)	1962	188.4 (0.168)	1963	210.9 (0.065)
1964	209.6 (0.03)	1965	200.5 (0.025)				

The corresponding tinplate consumption in the Netherlands, including that of canners making their own cans, is put at: *('000 metric tons)*

1960	118	1961	118	1962	125	1963	133
1964	138	1965	122				

In Belgium: *('000 metric tons)*

1961	49	1962	59	1963	60	1964	49
1965	34						

These figures are inclusive of cans for condensed milk, powdered milk and beer. Aluminium consumption in can making in the Benelux countries is estimated at about 400 tons a year; aluminium cans are used there only for powdered milk.

In the long-term context all the figures indicate a continuing expansion in canning in the Western European market as a whole. It is true that in the last few years the rate of growth has slackened somewhat (with variations in individual countries and individual fills). In Germany indeed the outlook is viewed with some doubt, although German tinplate consumption for all packaging purposes in 1963 was only about 8.1 kg, per head of population, well below the figures for Britain (11.5 kg.) and the United States (25.7 kg.), so that there would appear to be still a good deal of scope for an increase in sales. The technical design of the tinplate can may be expected to be worked out with an eye more and more to the consumer's convenience, particularly as regards opening: recent developments include the body opener, tear off seal, and tear-off aluminium lid, to mention only a few.

The can itself, with its bright and colourful printed design will certainly become an important advertising aid in the self-service shop of the future. Quite a number of major trends now in prospect indicate that there will be a further sustained rise in sales of cans. Thus the steady growth of population will mean growing demand for groceries, including those traditionally packaged in tinplate. Fuller and fuller employment, lower and lower unemployment, continuous expansion in GNP and steadily-rising wages, salaries and pensions are bringing new strata of consumers into the market for high-grade tinplate-canned produce. Given for example a rise of only 4% p.a. in the national income, by 1976 the increase would work out at round about 50%. And consequently the market for packaged goods, and especially foodstuffs, will in a few years' time be substantially larger than it is now. Again, full employment will stimulate sales of packaged goods for other reasons than the mere fact of higher earnings: the saving of time represented by the use of ready-prepared products will be more and more of an attraction, particularly where both husband and wife are working. In commerce, in the hotel and restaurant business, in the home—everywhere labour is short. And so the prospects for the consumption of preserved, and especially precooked, foods are growing better and better.

Long-term storage is also a problem to which both Governments and, thanks to intensive publicization, householders in Western Europe are devoting a good deal of attention. For tnis purpose there is no better form of packaging than the tinplate can. I made the point earlier that sales of cans must be governed by the availabilities of the fill concerned and the production programmes of the canners, but both of these can actually be influenced in the right direction by appropriate action. If large-scale concentrated advertising succeeds in expanding the market for canned foods, the growers will react accordingly. The collective publicity drive which the French tinplate producers, can manufacturers and canners have been carrying on for some years has scored big successes; in Germany too such collective advertising and public relations work have had excellent results. These activities ought to be carried on intensively, and in countries where nothing much is as yet being done in this direction the same kind of co-operation should be instituted as soon as possible. The emphasis must of course be on tinplate packaging as sucn, especially since both glass and aluminium, and latterly plastics as well, have been making a push to enter the market. Large-scale publicity really could open up new outlets and expand existing ones, thereby helping to increase the consumption of steel in canning. The startling succes of the campaigns for canned delicatessen, liquid soups and beer in Britain, and recently also in Germany, shows the extent to which it is possible to influence consumer preferences.

Not all the fluctuations in the production figures are the effect of inherent problems. The steep drop in the production of canned vegetables from 1964 to 1965 (in Germany from 228,400 tons to 185,500, in Belgium from 110,400 to 76,100 in France from 543,600 to 464,400 and in the Netherlands from 103,300 to 66,800) was obviously due in considerable measure to overstocking, production having risen faster than sales. All the more important, then, to get rid of consumer prejudices by persuasion and expand the market by publicity.

Finally, a word about the substitute packaging materials. We occasionally hear it said that the can is unduly costly in relation to its inexpensive fill. But the pcint is that it is not just a piece of expendable packaging: it is an integral part of the production process, since thermal sterilization cannot be effected without it. Dr. Nehring's figures concerning the use of aluminium for the packaging of preserved foods in France, Benelux and Germany speak for themselves. It does not look as though tinplate has much to fear from that quarter in the foreseeable future.

Glass containers are extensively used for certain fills, notably fruit compotes. Incidentally, baby foods are now pretty well always sold in glass jars, as is instant coffee, and it is poor consolation that at any rate the cap is made of fine tinplate (or sometimes aluminium). However, it is a matter for doubt whether this method will continue to gain ground. Glass is heavy, light-admitting and easily broken, and many fills need to be specially treated in order to stand the light. In 1965 many manufacturers were impelled by worries about their sales to adopt different forms of packagings for their wares, partly because concerted publicity by the glassmakers was having some effect on the trade and the consumers. However, if normal sales conditions return the manifest drawbacks of glass will become more apparent.

As regards the prospects of plastic containers for preserved foods, Dr. Nehring has already told us all we need to know.

Dr. Gerd HABENICHT

J.A. Schmalbach AG
Braunschweig

The Techniques of Food Can Manufacture

(Translated from German)

In 1966 a paper which deals with the techniques of food can manufacture must emphasize present and future manufacturing processes. Our production methods must be brought right up to date, without using past methods as our starting-point.

As we are dealing with the subject of food can manufacture at a congress on steel, i.e. in front of an audience which is very well informed about developments in steel production and treatment, it should be discussed as far as possible in relation to the production of very thin tinplate. Modernization of tinplate manufacturing processes and parallel developments in food can manufacture are so closely interconnected that one can justifiably speak of interdependence.

The main problem in our industry, which is constantly presenting us with new tasks, is that of combining the finest precision work (within tolerances which lie in the field of light engineering) with exceptionally high speeds which in the most up to date installations make observation of the individual cans virtually impossible. A material which largely meets these requirements is now available, principally due to improvements in rolling techniques.

Modern techniques of can manufacture

(a) Raw materials

Modern processes of can manufacture begin with the economic utilization of the raw material. After rolling techniques had been developed to such a degree that very close thickness tolerances were attainable by means of electronic control devices, it became possible to use tinplate in the continuous form in which it leaves the rolling and tinning process. Processing from coil had become a fact. As far as the manufacturer of ends is concerned, processing from coil results in a significant saving of material. In contrast to working from sheet, in which the tinned strip is first cut into rectangular sheets from which the ends are stamped out with appreciable waste, when working from coil a scroll cut is made during the first operation. The sheets obtained in this way are scroll sheared once more in a second operation. Depending on the diameter of the end in question, up to about 12% material can be saved. This process also has the advantage that the technical properties of the ends produced are identical to those made from conventional sheets.

The slitting of the coil by the first operation scroll shear has to be carried out with greater precision than slitting into rectangular sheets. Because this process is slower, it is not carried out on fully automatic installations in the rolling mills but by the can manufacturers themselves. This process of course requires considerable capital expenditure.

As can manufacture must aim at becoming a continuous operation, the surface treatment of the base material by lacquering and printing must also be viewed from this angle. Techniques for the lacquering of wide strips ("coil coating") have been extensively investigated and continuous coil coating is now possible.

(b) Body making

Since the early days of can manufacture, body making techniques have changed considerably. Manual and semi-automatic production of soldered overlaps was soon replaced by the production of can bodies on the body maker. Over the past few years further development of body maker operation has been necessary due to the higher speeds required for can manufacture. When the upper speed limit for making individual bodies has been reached (in the most up to date plants this amounts to about 550 units per minute) the machines were so modified that two bodies could be seamed and soldered in one operation, the individual cylinders then being separated by a can separator. This technique is employed particularly in the manufacture of beer and soft drink cans, when up to 800 cans per minute may be produced. With small containers (e.g. for certain tomato products) three cans may be seamed and soldered in one operation. It is then possible to produce up to 1,200 cans per minute on one line.

Soldering techniques, too, had to be adapted to these speeds. Even though soldering with a rotating solder roll, where the liquid solder is forced into the side seam, can still be considered as the standard method, developments which allow more rational application of solder and its auxiliaries have not been lacking. Injection of liquid solder and flux through a nozzle directly into the seam are developments which have become known as "jet-soldering" and "jet fluxing" respectively.

When using very thin tinplate, body making by soldering still requires the presence of tin in the solder. Bonding techniques that could be performed without tin have therefore been investigated. This work was done particularly in view of the "political situation" of tin. Again, it has been the production speed required which has governed the suitability of the processes to be employed.

Development of welding techniques deserves special mention. Briefly, the process is performed as follows: a strip of very thin tinplate, already cut to the required width (which depends on the circumference of the can being made), is passed through a station in which the material is weakened by a scoring operation in those areas corresponding to the height of the can being produced. At the welding station the strip is then formed into an endless tube, the welding area being heated by high-frequency current. Immediately following this, the thickness of the weld is reduced between pressure rollers to facilitate the cover and end. The endless tube is then separated into individual body cylinders by cutting along the score lines between the bodies by direct current. This technique allows the production of up to 2,000 cans per minute.

Apart from welding, the cementing of side seams has recently been investigated. This research has proved successful. Cementing of cans for products which are to be pasteurized (as for example in the brewing industry) but not sterilized, is now possible using polyamide cements. Present research is aimed at the development of cements which would be resistant to a sterilization temperature of e.g. 121° C.

There are other processes in which the joining of edges (by soldering, welding or cementing) can be avoided. These point toward seamless containers. There is for example the conventional deep-drawing process, which allows the production of containers from very soft deep-drawing material on multiple die presses by a varying number of individual operations. The operating speeds of such machines are comparatively low and hardly meet the requirements of economic food can manufacture. A modern process for the manufacture of seamless containers combines the operations of drawing and ironing. Initially, a container with a drawing ratio of up to 1:2 is made from a blank. The ironing operation then follows, producing a container with the desired height and wall thickness, after which it is finally trimmed to the right height and flanged. There are machines in which the drawing and ironing operations are combined so that outputs of up to 400 cans per minute are expected. Such drawn-and-ironed containers combine very low wall thickness with extraordinary stability. The following reflection should show that this process is economic. In the manufacture of very thin tinplate. considerable reduction in thickness is possible by the use of a second finishing rolling after the last annealing process. In this way double-reduced plate of thicknesses of 0.16-0.18 mm. is produced. In the drawing-and-ironing process this second finishing rolling operation is performed during the can making process itself. Thus, part of the cost of the rolling process, which increases when the conventional plate thickness is reduced, is saved.

(c) Manufacture of covers and ends

The manufacture of covers and ends for food cans has been less influenced by technical innovations than has bodymaking. Ends are manufactured on automatic stamping presses with double dies which permit outputs of up to 700 per minute.

On the other hand, turning to the development of new lining compounds, the lining operation, which follows the manufacture of the ends, has been considerably rationalized. The use of solvent-based lining compounds has rendered unnecessary the drying operation which was performed with water-based lining compounds in spindle or turret ovens. Hexane, the solvent used in these lining compounds, rapidly evaporates and no further drying process is required before the ends are packed. For small diameter ends, two-station injection machines have been developed which permit the lining of up to 800 ends per minute.
Efforts to develop easy opening ends must also be mentioned. "Easy opening" ends have been made from aluminium with such technical perfection that they really deserve their name.
Aluminium may be particularly suitable for such applications, but the steel and canning industries should not abandon their efforts to develop similar opening systems for steel plate ends.
An "easy opening" feature has been available on several types of fish can for many years. It involves controlled scoring of the material along the lines to be torn open, thus weakening them. The thinner the sheets are, the more difficult it becomes to use conventional can openers. Much development work has still to be done in the field of can opening if steel is to keep its predominant position in can manufacture.

(d) Lacquering and printing

At present the conventional methods of lacquering and printing are sheet lacquering and sheet printing. The prelacquered and pre-printed sheets are then cut into strips by slitters and the body blanks and cans are made from these strips. However, these processes can no longer be used when the above-mentioned methods of bodymaking (i.e. welding into a continuous tube and drawing and ironing respectively) are employed.
Machines therefore had to be developed for the lacquering and printing of the finished body cylinders. Conventional spray-lacquering equipment is able to spray the insides of the cans, the lacquer being subsequently cured by stoving. The external treatment is performed in two stages: a primer is applied initially (and then cured), followed by the application of up to four colours and a final transparent lacquer coating or varnish. After application of the final coat, the whole external decoration is stoved. All the processes are arranged in sequence in the line to ensure continuous operation.
Modern rotary offset printing installations combine optimum accuracy with economic operation.
Problems are likely to occur when sheet lacquering and printing are carried out at present speeds (up to 6000 sheets per hour) if the size of the sheets is increased and/or their thickness is reduced. Reduction in plate thickness and increase in sheet size also create such handling problems that the mechanism used for transporting the sheets from the feeder via the printing machine and the oven to the sheet stacker has to be modified.
There is much talk at present of the tinless can because of the political cloud which threatens tin supplies, but it should be remembered that in Germany cans were already being manufactured from tinless plate during the second World War. A number of cans manufactured and filled at that time are still in existence, some of which, after 25 years, show only slight external corrosion. The sheets were first lacquered and the body cylinders welded. Internal and external lacquering was then carried out for the protection of the welded seam. Finally the body cylinders and ends were spray-lacquered and dried. Although production speeds were relatively low and the technique would no longer be considered economic, it is still true to say that the tinless can was a reality 25 years ago (at least from the point of view of its manufacture and surface treatment) and proved extremely useful to the canning industry at that time.

(e) Closing the cans

Covers and ends are attached to the body cylinders by the double seaming technique, eacn double seam being formed in two operations. During the first operation, the cover hook is interlocked with the flange of the body cylinder; in the second operation, the interlocked hook and flange are tightly rolled together. The formation of such double seams (and the construction of efficient double seaming equipment) entails a large number of calculations and also requires much experience. Again, high-speed machinery is necessary for can closing. A leading American can manufacturer has recently introduced a 12-head seamer with an operating speed of 1400 cans per minute.

(f) Shipping of cans

The greater becomes the demand for food cans, the more serious become the problems that arise due to the space the cans occupy during storage and shipment. Shipment should therefore be carried out as rationally and as rapidly as possible. Cans are normally packed into cartons or baler bags, but there is an increasing switch-over to palletization. During this operation the first layer of cans is arranged by a collating mechanism according to the pallet area and then pushed onto the pallet. After a sheet of cardboard has been laid over these cans, the pallet is automatically lowered and further layers of collated cans are added in a similar manner. A loose wrapping of re-usable cardboard is finally given to the completed pallet load. These pallets which, according to can size, hold up to 1500 cans, are then loaded on to lorries by fork trucks. One important advantage of palletizing shows itself at the customer's end: on depalletizing, the cans may be fed direct to the filling and sealing equipment via chutes.

Summary

We have tried to give a general impression of modern can-manufacturing processes. It should be remembered, however, that constant efforts are being made in the directions of economic manufacture and quality improvement.
Finally a criticism must be made: all the modern can manufacturing processes presuppose the existence of a corresponding market for the respective containers produced. The above-mentioned high capacity machines require that the number of cans manufactured is in economic relation to machine costs. A task with which Europe in particular is confronted is the standardization of the great many can sizes used at present for food preservation. All the work required can be accomplished only by co-operation with the food-processing industry, and it also needs a degree of understanding and support from that industry. The can making industry would also be pleased to receive energetic co-operation from consumers. Can makers require from the steel industry the further development of steel for can making and lower prices for the material. Improved quality and even closer tolerances are possible ways of meeting competition from substitute materials. Co-operation will enable the can manufacturing industry to meet the reasonable demand for higher speed manufacture of even better quality and cheaper cans.

Jean Walter HEYMANS

Vice-Président de la S.A. Sodemi
Bruxelles

Tinplate and its Use in Can Manufacture

(Translated from French)

With the present Congress devoted to "Steel in Agriculture" and Working Party III especially to "Steel in the Storage and Marketing of Agricultural Produce," my own subject, "Tinplate and its Use in Can Manufacture," is of course highly relevant to both fields, and still more to that dealt with in the introductory paper to the Working Party's second session, "Packaging as a Means to the Marketing of Agricultural Produce."

Since their invention by Appert 150 years ago, tinplate cans have been the type of packaging most widely used for the preservation and out-of-season sale of agricultural produce. They can be used for this purpose with

(a) vegetables of all kinds, such as peas, beans, carrots, celery, spinach, asparagus, etc.;
(b) fruits, such as strawberries, cherries, apples, pears, apricots, peaches and so on, and jams, compotes, made from them;
(c) milk in condensed and powdered forms, milk-based preparations such as baby foods, etc.;
(d) meat products (from beef, pigmeat, etc.);
(e) agrumina (tomatoes, etc.).

World consumption of tinplate has latterly been running at some nine million tons a year, of which round about 50% may be estimated as going on the preservation of these items of farm produce. This gives a world total of over 30 million tons of farm produce canned each year in tinplate containers.

As the tin coating represents less than 1% of the total weight, it can be taken that over four million tons a year of the world's steel production are absorbed by the canning of farm produce.

I do not intend to go in detail into present-day methods of can manufacture. I would merely mention that the automated production lines now employed turn out from 400 to 1,000 cans a minute in the case of cans up to and including size 1/1 (1,000 or 850 cc.) and from 150 to 300 a minute for the larger sizes.

With this high-precision machinery it is essential that the raw material—the tinplate itself—should also offer very accurately-specified properties and tolerances. Accordingly, the ECSC tinplate producers and consumers have come to an agreement and secured from the High Authority the introduction of two Euronorms, Nos. 77/63 and 78/63, on tinplate qualities and sizes, indicating all the details and requirements, and industrially practicable for this type of material. ISO, the world body, is also working on a world tinplate standard on the same lines.

Both producers and consumers of tinplate are still engaged in extremely detailed research on possible ways of improving the quality used for cans, as regards both mechanical and physical strength and surface performance, in order to supply the canning industry with the most efficient type of container at the lowest possible price. As a result, both the production of the actual tinplate and the manufacture of the cans are becoming more and more specialized sectors requiring fully-equipped planning and research departments.

In conclusion, I should like to say a word about steel's potential competitors in the packaging industry, and in particular about aluminium.

Present world consumption of aluminium for the preservation of farm produce is not known, as the published figures include the tonnages used to make the beer and soft-drink cans now extensively employed in America. The proportion may perhaps be put at something like 3-4%. Although this is very small, marking only a beginning in the aluminium producers' campaign, it is clear that aluminium very definitely can be used for packaging matter for human consumption, and undoubtedly could be so employed for agricultural produce also. Since the packaging industry's main job is to supply the canners with the best and cheapest containers, it must bear in mind the technical and economic potentialities of all other suitable materials as well as tinplate and similar steel-based products. Undoubtedly, aluminium is one such material, and glass is another.

As I prefer not to end on a gloomy note at ECSC's Steel Congress, I should like to add that I have every confidence in the future of metal packaging—that is, of containers made primarily of steel—for the preservation of agricultural produce: it has given consumers every satisfaction for well over a century, and it can and should continue to do so in the future.

Marcel VIVIER
Ingénieur

Éts. J.J. Carnaud & Forges de Basse-Indre
Paris

Agriculture and Tinplate

(Translated from French)

Nothing, surely, could be more unlike at first glance than farming and steelmaking, as regards both the means and methods employed and the men engaged in them. All the same, they do have this in common, that in some connections they both produce for the same ultimate end.

My purpose in this paper is to draw attention to an aspect usually not very clearly grasped, and not always accorded the importance which in fact it has on the economic side, especially with regard to sales outlets. I refer to tinplate, a sector in which the steel and the agricultural interests are especially strikingly interlinked.

Not too far back in the last century, the farmers' commercial position was altered, indeed revolutionized, by Nicolas Appert's discovery concerning the preservation of foodstuffs by heat sterilization. For so long as foodstuffs remained inherently perishable—despite such empirical devices as salting, curing, smoking and drying—agriculture had to be confined, if it was to pay or in fact to survive at all, purely to the meeting of immediate requirements. A minor glut of the produce in season was as frightful a disaster as storm, flood or hail.

So, economically, there was no point in trying to grow fruit and vegetables intensively.

If it had not been for Appert's process, we may wonder whether some of them would since have come to be grown on the scale they have. For 90% of the peas at present grown are taken for preserving, 70% of the string beans, 50% of the tomatoes, and the same goes for various other items of agricultural produce. However, what made the change, as it were, a change from cottage industry to modern industry proper was the adoption of tinplate as the material for the preserving container. Appert, whose imagination had not gone beyond glass jars, was outvied within the year by a British competitor, Durand: the latter patented a process which was identical with Appert's in every respect except that it employed metal cans, and it is accordingly he who has gone down to history as the inventor of the device (the child of steel) that has since become everywhere supreme.

Appert and Durand between then enabled the growers to expand their production without fear of the consequences. Being thus absorbed swiftly and smoothly, on a properly industrialized basis, agricultural produce is safeguarded for an indefinite period, with a flexibility in marketing which is quite impossible in the case of fresh products. As regards the social aspect, consumers are supplied at prices not only within the means of everyone but actually often lower than those of the ordinary market product; as regards the international aspect, countries suffering from malnutrition can be aided without need for special storage conditions, and at the lowest possible expense to them.

The combined invention of Appert and Durand, then, has unquestionably served to steady prices and supplies. Its ability to do so has been increasingly enhanced over the past forty years by continual improvements in the quality of the steel and the tin coating, and by higher and higher production speeds both for the metal and for the cans. Only tinplate production has reached the pitch of industrial efficiency needed for the prompt absorption of agricultural produce. Cans are nowadays turned out at anything from 300 to 900 a minute; closing and sealing processes have been similarly speeded up.

While tinplate and the tinplate can are thus among the great servants of modern agriculture, their sales would not have expanded as rapidly as they have done in the last few decades had it not been for agriculture. After all, of a world tinplate production of some ten million tons, 75-80% goes on the canning of agricultural produce and allied products such as beverages and fish. Rough estimates based on world consumption, suggest that the tinplate used by the food preserving industries is apportioned as follows:

vegetables	35%
fruit	24%
milk	13%
beverages (beer, fruit, juices, soft drinks, etc.)	12%
fish	9%
meat	7%
	100%

The European Community countries' consumption of tinplate is about 1,400,000 tons a year in the canning of agricultural and allied products they use close on a million tons of tinplate for the packaging and preservation of around 6-7,000,000 tons of finished products, representing at least 10 million tons of agricultural produce. And the trend is still going on, for there is every likelihood that the demand for canned foods will continue to increase.

The present rate of growth shows no sign of slackening, either in the world generally or in ECSC. In France, where the rate has in the last few years been among the lowest, the increase for the years ahead is put at 7-8%, whereas the population is growing at only about 1%; French habits are moving more and more into line with those in other countries where consumption of preserved foods is much higher.

There is still some way to go, since compared with the American and British figures (41.5 and 35.4 kg. respectively per head of population in 1964) the Community countries' consumption, though steadily rising, is still pretty low:

Germany	24.7 kg.
Netherlands	21.0 kg.
Belgium	20.9 kg.
France	18.0 kg.
Italy	8.5 kg.

So the proportion of agricultural produce undergoing industrial processing of a type which requires the appropriate packaging materials to be manufactured for preserving purposes may be expected to rise further in the coming years.

Tinplate as at present produced, with the benefit of forty years' application of the latest advances as regards steelmaking, rolling and coating techniques, should hold its ground. Moreover, modern can-making processes offer the user and consumer the ultimate, the absolute in safety.

With the various new preserving methods coming into use, it has occasionally been wondered whether Appert's process might not be becoming obsolete — which would be a heavy blow to sales of tinplate and of the traditional type of can. However, as matters now stand, there seems no real reason to think so.

It is natural that new ways of preserving foodstuffs should evolve parallel with the march of science and the techniques science makes possible, but in this field—in which the Americans are taking the lead—refrigeration, deep-freezing and lyophylization are employed primarily in the preservation of special and high-grade products, and have not interfered with the expansion of ordinary canned goods. In France, in a smaller way, the position is much the same: for instance a few products, such as poultry, account for 52% of the total amount of frozen foods sold in the whole country, which does not affect the traditional canning industry at all as poultry is hardly ever canned.

By and large, to judge by developments in the United States in recent years, it looks as though the real inroads made by the new preserving processes were on the types of produce traditionally delivered fresh to the consumer. In France again the trend is similar, since the foodstuffs industries, including preserving, account for nearly 50% of the deep-frozen foods on the market.

As for lyophylization, the range of products so treated in the United States appears to be still pretty small. What is more, it seems to be the industrialists' conclusion that the traditional metal can—airtight, shockproof and cheap to produce—is the best form of packaging at present on the market.

Hence, contrary to the view taken in some quarters, there is at present no reason why Appert's food-preserving process and the tinplate can should not retain their share in the preserving of agricultural produce; moreover, the product so treated works out substantially cheaper than its newer competitors, without involving extra capital costs for the producer and extra storage costs for the distributor and consumer. As regards packaging proper, tinplate is still the most convenient material for purposes of preservation,

and—despite occasional arguments on the subjects—tinplate cans are still among the cheapest forms of packaging for the technical advantages they offer.
Thus the movement of the indices for the cost of packaging in France, as compared with the indices for the products contained in the can, shows unmistakably that the share of the can itself in the price of the end product has decreased sharply since 1938, the downward movement continuing throughout the last few years.
So it seems probable that tinplate, and the tinplate can in the form in which it reaches the foodstuffs industries, will continue their services to agriculture by enabling seasonal produce to be quickly and efficiently preserved, largely by the process discovered by Appert.
For these various reasons, then, it is nighly desirable that close and constructive co-operation should be systematically built up between the steel producers, the metal processers, the canners and the growers, by means of Working Parties in which they would meet to discuss, objectively and without bias, the respective problems they will be facing as a result of market developments in the years ahead.

André KLENIEWSKI

Chambre syndicale des forges productrices de fer-blanc et de fer-noir
Saint-Ouen

Some Practical Aspects of the Use of Tinplate Containers for Agricultural Pesticides

(Translated from French)

Apart from the use of tinplate for the preservation of agricultural produce, there is another field in which its use is increasing although it is generally little known—the packaging of chemical products and in particular pesticides.
The fantastic increase in the use of pesticides is a concomitant of the drive to increase agricultural yields and productivity by research, technology and extension programmes (Biblio. 1).
The general term pesticide denotes any of the following products (Biblio. 2):
(a) an insecticide;
(b) a fungicide;
(c) a rat poison;
(d) a weed killer;
(e) a bactericide.
Pesticides may come in the form of solids, pellets or powder for dispersion in water, in the form of concentrated solutions to be emulsified in water or oil or in the gaseous state as aerosol products (Biblio. 3).
In addition to active products, there are auxiliary chemical products to improve a given property of the pesticide itself, for example the pyrethrum extender piperonyl butoxide.
It is often difficult to select a packaging material for these products. Pesticides for agricultural use are often stored for more than a year. They may be intended for tropical countries and consequently subjected to considerable temperature fluctuations. As they are often corrosive, inflammable and poisonous both to inhale and to touch, their packaging must be absolutely impervious.

Regulations on the transport and storage of pesticides

As most of these products are classified as dangerous materials, they come under the international regulations on the transportation of dangerous goods (RID); the British and German railway tariffs and the Recommendations of the American Insterstate Commerce Commission. These regulations specify steel packaging for the majority of these products because of its high mechanical strength (resistance to impact, internal high or low pressure, compression, shear, etc.) (Biblio. 4 and 5).
The US Tariff Commission for regulations on packagings for exports also recommends tinplate as the most suitable material for dangerous chemicals (Biblio. 5).

Selection of tinplate as a barrier material

A critical examination of the packaging materials available to the industry shows that the mechanical and physico-chemical properties of tinplate make it the best material for the preservation of pesticides and their protection against the effects of the surrounding atmosphere.
Well-designed tinplate packaging provides the most favourable micro-environment for the complete protection of the product and obviates:
(a) hydrolysis with all its harmful consequences, for example:
  (i) decomposition,
  (ii) absorption of atmospheric humidity by hygroscopic products;
(b) evaporation of volatile constituents as a result of permeability;
(c) diffusion;
(e) oxidation;
(f) the migration of elements through the packaging materials;
(g) photo-chemical changes brought about by light, etc.
In addition, resistance to stress-cracking is no problem with tinplate.
If the packaging is wrong, the active constituent may deteriorate or its physical properties change, for example: the reduction or complete loss of a powder's ability to form a suspension, a well known phenomenon in the use of pesticides (Biblio. 3).
The tremendous increase in tinplate packagings for pesticides in the past ten years is primarily due to the technical progress made: steelmaking, cold rolling and electrolytic tinning.
Cold rolling provides steels with good corrosion resistance while electrolytic tinning nas the following advantages:
(a) reduction in coating weights;
(b) coating uniformity.
Where necessary tinplate lacquered on the inside may be used.
Electrolytic tinplate forms a good base for a large number of lacquers, coats of which have the following qualities:
(a) flexibility, adhesion, hardness;
(b) impermeability;
(c) chemical qualities: resistance to corrosive substances.

Advantages of tinplate containers: reliability and ease of use

Because of these properties, the use of tinplate for containers in the chemico-technical industry has increased greatly. One hundred and fifty years experience has gone into the fabrication of containers from tinplate (Biblio. 9). Tinplate containers are particularly suitable for the storage and transport of many chemical products (it is at present used for more than 30,000 products). The packagings take many different forms (barrels, round or rectangular drums, cans, etc.).
During fabrication, each sheet is inspected. The assembly processes used, such as crimping, seaming or reverse face welding have the following advantages:

(a) They prevent direct contact between weld and product;
(b) They prevent direct contact between steel and product. The bared surface of the steel is enveloped in the seam and insulated from the product.

If electric welding is used for assembly, the joint can be recoated after fabrication to prevent the product from coming into contact with bare steel.

It is difficult to list all the types of container intended for the chemical or similar industries which may be used for pesticides. However the main types are:
(a) air-tight containers, both joints crimped (or cans with ends crimped);
(b) drawn containers which have the advantage of maximum imperviousness as the body and base are of one piece, to which the lid is crimped.

Contents may vary from 50 cc. to 60 litres with wall thicknesses from 0.18 to 0.50 mm.

All these containers can be stacked for transport and storage which reduces the space they occupy. They can be sealed in many different ways with plugs, caps, joints, pouring spouts, tamper-proof necks, etc.

We shall consider two main types of closure:
(a) complete opening for solids;
(b) opening with necks of different diameters for liquid products.

Conveniently placed handles make them easy to manoeuvre.

Concave-shaped ends ensure that the containers are completely emptied. In some cases, they have two compartments to separate products which may react with each other during storage.

Another method of protection is to provide a hermetically sealed pocket inside the container.

Finally, mention should be made of pressurized or aerosol containers used for chemical products for plants (Biblio. 10).

Stability tests

At present tens of millions of non-returnable tinplate containers are used for pesticides.

The *table* on p. 343 gives some examples of their use, selected at random.

However, the life of a packaged pesticide is a complex problem. The strength of tinplate containers is affected by many variables such as:
(a) steel;
(b) tinning;
(c) surface treatment (including lacquering);
(d) design of the container itself.

In addition, the properties of the pesticide, the type of solvent, the pH, the presence of soluble salts, corrosion inhibitors or accelerators, the quantity of oxygen and the storage temperature are important factors in the pack life (Biblio. 11, 18, 19, 20).

Recent techniques enable oxygen to be eliminated from the air either by replacing it with an inert gas, by vacuum crimping or by bubbling nitrogen through the solution before filling the container (Biblio. 12). Where the active products are not contained in water shelf life is increased and the risk of hydrolysis eliminated.

Where there are constituents which accelerate corrosion or are strong depolarizing agents, the use of an inhibitor may be necessary to reduce or prevent chemical changes such as:
(a) oxidation;
(b) corrosion or polymerisation.

The inhibitor may be absorbed by the metal, react with the metal or combine with the product. (Biblio. 13, 14).

The various lacquers may be applied in different ways, for example phenolic lacquer for the body and base followed by two coats of vinyl lacquer, etc.

Co-operation with packaging experts is necessary; they know the purpose of the product, the way it is used, the abnormal storage conditions it may encounter, etc.

Specialist laboratories have methods of rapidly assessing the behaviour of the tinplate, for example:

Examples of tinplate packaging for pesticides

Category of pesticide	Name of active product physical form	Container	Capacity	Comments
Insecticide	Emulsifiable concentrates of D.D.T., compounds containing phosphorus	Drums: —rectangular —round	1-5 kg. net up to 60 kgs.	hydrolysis to be avoided
	Viscous emulsions with characteristic odour of dinitro-orthocresol	Round cans	5 kg. net	hydrolysis to be avoided
Insecticide	Concentrates of lindane emulsions	Round cans	6 litres to 60 kg. net	hydrolysis to be avoided
Insecticide	Powders with trichlorophenol base	Round drums with full size opening	6 to 60 kg. net	hydrolysis to be avoided
Insecticide	D.D.T. pentachlorophenol and lindance solutions in organic solvents	Rectangular drums	1 to 5 kg. net	hydrolysis to be avoided
Fungicide	Powders on base of colloidal sulphur, tetramethyl-thiuram-disulphide, barium sulphides, etc.	Various cans Drums	100, 250 500 g. 1 kg. and 5 kg.	Opening designed so that it can be closed again, hygroscopic product
Rat poison	Powders on base of Urginea, Maritima, Warfarine etc.	Round cans	50, 100, 500 g. 4 and 5 kg.	Opening designed so that it can be closed again, hygroscopic product
Bactericide	Unctuous solutions of monochlorhydrate of quaternary ammonium etc.	Round cans	100, 250, 500 g. 1 kg. up to 60 kg.	Opening designed so that it can be closed again, hygroscopic product
Weed killer	Powders and concentrates based on 2-4 (dichloro-phenoxyacetic acid) dinitrophenols, dalapon, T.C.A., etc.	Round cans Round drums	1 to 5 kg. up to 60 kg.	Hygroscopic and volatile products

(a) curves showing the evolution of the various constituents of the tinplate or packaging (curve E — f (I) or Corrosivity Tester diagrams (Biblio. 15);
(b) polarization curves (Biblio. 16);
(c) intentiostatic measurements to assess the effectiveness of corrosion inhibitors (Biblio. 21);
(d) electro-capillary measurements to determine the action of corrosion inhibitors;
(e) tests on test pieces totally or partially immersed at different temperatures;
(f) resistance to salt spray, etc.

However, in situ tests under actual service conditions still remain the most reliable method of checking the stability of a formula.

Some practical solutions, even in difficult cases, have been found by these methods.

Tests carried out in conjunction with pesticide manufacturers have been helpful in specifying containers suitable for use under tropical conditions (impervious drums, reverse face-welded, with a high coating weight, treated with a diphenolic lacquer).

Conclusion

Containers of various types of tinplate provide many practical methods of packaging pesticides for agricultural use.
However, a preliminary survey in close co-operation with the packaging expert facilitates the production and development of the most suitable containers for pesticides.

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Paul ROCQUET

Directeur général du Centre de recherches de fer-blanc,
Florange

Tinplate Research

(Translated from French)

Accounts have already been given by other speakers of the advantages of metal packaging—it is strong, light-excluding, and above all, any internal pressure, the first sign of developing microbic contamination or undue corrosion, causes it to bulge, thereby warning the consumer that something is amiss. I would emphasize in particular the value of a metal which has been used for over a century in the preserving of foodstuffs, namely tinplate, an admirable material for this purpose, on which extensive research has been going on for nearly forty years.

Its reactions to biological media often highly complex in their behaviour have been and are being subjected to lengthy and to the researcher tremendously interesting investigations.

The need for these became apparent over years of experience. Tin. a non-toxic metal, has proved not only to be an eminently suitable coating for steel in the manufacture of hermetically-welded containers, but also to stand up better than many other metals to the corrosion produced, in the absence of air, by the organic acids present in foodstuffs.

It does exactly what a protective coating is required to do, since in these media it is anodic to steel—the steel is what gives the container mechanical strength, but without the tin coating it would ruin the appearance and taste of the contents.

As is so often the case with new devices, the first makers of tin cans had no idea what a perfect material they had hit upon. A century of experience has not invalidated their choice, despite the many attempts made to popularize other materials instead.

I shall try to show you why, but I think the work of the many research laboratories in different parts of the world which have been tirelessly experimenting with tinplate, seeking explanations for its good or bad reactions to foods, and setting forth how best to use it, has helped to make it such a safe and reliable form of packaging.

The following are a few of the most important researches which have been carried out.

First, it was endeavoured to establish why tin was such a good coating for steel. This was not immediately apparent, as according to normal potentials tin should have been cathodic to iron, with the result that the iron would corrode wherever a pore occurred in the tin coat, as it does when exposed to the atmosphere. The work of Kohman and Sandborn, Lueck and Blair in 1928, and that of Morris and Bryan and of T.P. Hoar in 1934, finally elucidated the reasons for tin's anodic potential in organic acid media.

Quite small amounts—50-60 mg./kg.—of iron entering the fill (not necessarily from corrosion of the can) can be tasted: three times the quantity of tin will usually have practically no effect at all.

The tin-iron couple is always present owing to the pores in the tin layer, which is from 0.5 to 2 microns in thickness. These vary in number according to the quality of tinplate used and to any accidental scratches occurring in the manufacture and handling of the cans. It is therefore vital that in this couple the tin should be anodic and dissolve while the cathodic iron is protected.

Another factor which adds to tinplate's excellent corrosion resistance has also been studied by numerous authors—the inhibition of steel corrsion by the presence of tin ions in the solution.

A study of these basic features of tinplate corrosion in an acid medium shows that when an unlacquered can contains naturally acid products such as fruit or artificially acidified products such as fish, the tin will dissolve and liberate hydrogen, which will increase the pressure within the tin but not perforate it.

The presence of highly reducing stannous tin salts is useful in the case of some products (such as juices of citrus fruits) which must be protected against oxidation to preserve their flavour. The appearance of certain products (mushrooms, asparagus) can also be preserved by this reducing effect.

A logical way of saving on packaging costs was to reduce tne amount of tin used on the steel. For strategic reasons this problem became urgent in the United States during the last war. Efforts were made to find a process giving a more even coating than the hot-dip process. The result was electrolytic tinning and the development of tinning baths suitable for use on an industrial scale, which the previous process had not been. The tin coating is at first microcrystalline, dull and very soft, and therefore has to be melted and quenched to give it the required lustre and hardness. As we shall see, this operation, like hot-dip tinning, produces a substratum of a tin-iron alloy ($FeSn_2$), which is an important factor in tinplate's corrosion resistance and in weld adhesion.

Research in the United States in recent years has shown that the alloy layer between the tin and the steel is important with respect to corrosion by fruit. Tests used to assess the corrosion resistance of tinplate are particularly sensitive to this.

Numerous examinations by electron microscope showed that to obtain optimum results this layer must be as continuous as possible and consist of extremely fine crystals.

Tinplate manufacturers then undertook research into the best way of obtaining continuous microcrystalline layers and some degree of success was achieved with various processes, although these necessitated special precautions in rolling, annealing and tinning operations.

The porosity of the deposit increases as the thickness of the tin coating decreases. This factor, which affects the can's corrosion resistance, means that for each product to be canned the minimum coating weight required to give an adequate shelf life must be selected. However, it was still necessary to protect the outside of the can against atmospheric corrosion, particularly in the case of low coating weights. Rust spots may develop at any pore where the steel is not covered.

The developers of electrolytic tinning then sought a passivation process by immersion, with or without electrolysis, in dichromate baths, to increase protection against oxidation.

Various processes which I shall not detail here have now stood the test of time and this protection of the can against external oxidation is now known to protect it against sulphide discoloration as well.

Despite more than ten years' research, the nature of the passivation layer formed is still not fully known. It contains tin oxides, but also chromium oxides. It is so fine that even with the most modern investigation techniques its structure cannot be determined. The next few years will undoubtedly see much research into this subject. It is to be hoped that the protection afforded by this passivation layer can be increased as a result.

To complete this account of the corrosion of bare tinplate in contact with acid products, we should mention the extensive research, notably that of T. P. Hoat (1936) and Hartwell (1941), into the effect of the composition of the steel base on the corrosion resistance of tinplate. The important point revealed by this research was the harmful effect of silicon in the steel. The silicon additions formerly required when cut sheets were rolled can be dispensed with for continuous strip-rolling processes.

The introduction of continuous rolling and the improvements in melting-shop techniques have made it possible to reduce the contents of elements such as sulphur and phosphorus which may affect corrosion.

A frequent reaction in products heated to sterilizing temperatures is the formation of sulphuretted hydrogen or metallic sulphides as a result of the thermal degradation of thioamino-acids or thioalcohols, or the sulphur dioxide introduced into the can with certain raw materials (sugars) used in canning.

Tin and iron sulphides are highly coloured, the former brown and the latter black. Tin sulphide is adherent and merely changes the appearance of the can without affecting the product. Iron sulphide is generally not adherent and may cause black patches. As it only forms at a pH of not less than 6 it only occurs in very slightly acid media.

We have seen that the passivation layer on electrolytic tinplate makes it far less sensitive to this sulphide discoloration than hot-dip tinplate. Lacquering the inside of the can has long been used to prevent such discoloration.

As we mentioned, the tin salts formed by a slight acid attack on the tinplate are reducing agents. They act on the anthocyanic pigments of certain red fruits, and bleach the colour. To inhibit the action of these salts, cans for such fruit are made of lacquered tinplate. There are now some excellent lacquers which are completely tasteless and adhere extremely well to tinplate.

Much research has been done into these lacquers and their adherence after sterilization, and this work is being actively pursued in lacquer and can manufacturers' laboratories.

Finally, in the past twenty years great progress has been made in the manufacture of cans relacquered after fabrication. In such cans there is absolutely no metal in contact with the fill. As a result metal cans can be used for products such as beer and wine, which are very sensitive to the presence of metallic salts.

These details of research work are far from complete. It is not generally realized that far more delicate research is being conducted into the effect of certain oxidizing constituents which can accelerate corrosion by their depolarizing action. One of these is trimethylamine oxide, found in some fish at certain seasons, which accounts for the influence of the fishing season on the corrosion of the cans.

Others are the products of sugar caramelisation introduced deliberately or by chance, the effects of which are being investigated in France by the Cheftel laboratory.

Yet others are nitrates which have an appreciable effect even in contents as low as 30 mg./kg. They occur in the fruit and vegetables themselves or in the water used to make up the juice.

Finally, I should like to mention an even more detailed study made by D. Dickinson in England some years ago on the influence of fruit stones. These contain beta glucosidase. If sterilisation is not sufficiently thorough, this enzyme is not rendered inactive. Its action on amygdaline forms hydrocyanic acid which is converted to ferrocyanide and accelerates corrosion. This means that, while in an insufficiently sterilized metal can of stone fruit there is no danger of an excessive hydrocyanic acid content, the same is not necessarily true of a non-metallic container.

Conclusion

In mentioning all this research work somewhat at random, it was not my intention to alarm users of metal by the complexity of the phenomena which may occur, but rather to demonstrate that these problems are known and show how the many researchers in the United States and Europe are working on them.

This is the advantage of using a long-familiar material. Problems which are just as complex and as difficult to foresee are almost certain to arise with new materials which do not benefit from such long experience. Some materials thought to be inert are found not to be so when studied more closely and although, unlike metals, they are free from corrosion problems, they may be beset by difficulties resulting from diffusion, absorption or photochemical reactions which are no less undesirable.

Dipl.-Ing. W. GRIMM

Freising-Weihenstephan

Drying Agricultural Products on the Farm

(Translated from German)

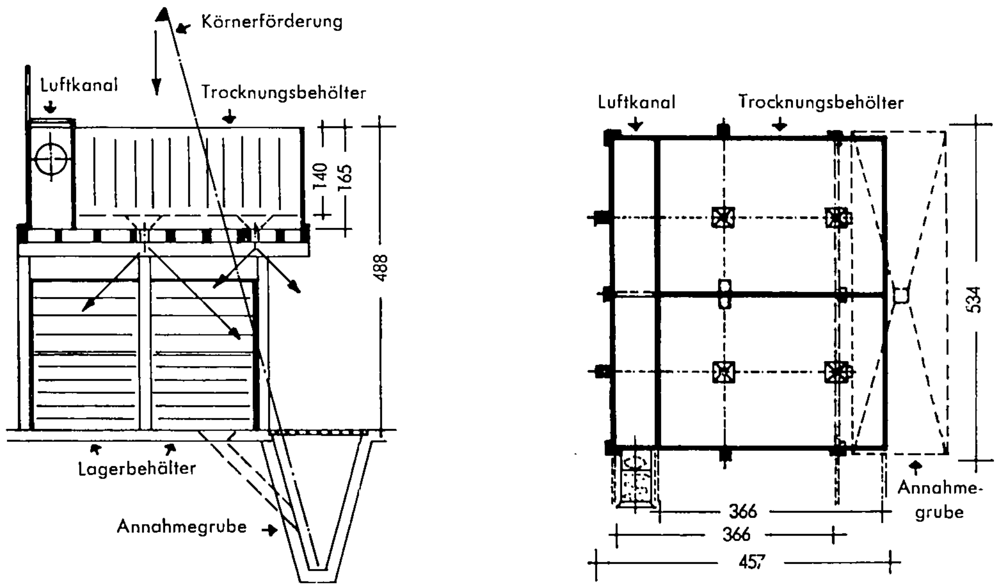
Grain drying

Today the majority of grain is harvested by reaper-threshers. Besides saving labour this method has the advantage that harvesting can begin at an earlier date. As soon as the grain is fully ripe it is not necessary to wait for the desirable, but weather-dependent drying on the stalk. A disadvantage of this method is that the grain must generally be dried within a short time. This can take place at any stage between harvesting and consumption.

Facilities for silo drying are often too far removed from the grain harvest and sometimes transport difficulties are encountered. Hence it is advantageous for the producer to dry the grain himself; due to the elimination of transport and waiting times this procedure cannot be surpassed in terms of price, if the grain is used for fodder on the producer's farm. This applies to more than 60% of the harvested grain. A drying installation on the farm is only unprofitable if the total harvest is less than 500 cwt. Equipment of the type customary in industrial drying plants (hot-air batch or continuous driers) can be installed at reasonable cost on farms with a total harvest well in excess of 1500 cwt. This equipment will not be discussed here.
Ventilation drying is most suitable from the cost and labour viewpoint for farms with grain harvest between 500 and 1500 cwt. This system operates with the air being heated up by only a few degrees (max. about 6° C.).
The slow, uniform drying ensures that the grain does not remain damp at one point, while becoming over-dried at another. Furthermore, the harvested grain cannot become too hot and thus lose its germinating or baking capacity. Finally, the profitability of ventilation drying must be emphasized. The applied heat is fully utilized, whereas greater heating of the air may cause considerable heat losses.
A ventilation drier consists of the following parts: drying bunker, air distribution system, blower with special heating elements or mixing head, heat source for warming the air.

— Drying bunker and air distribution system

For ventilation drying the grain is stored in large, boxshaped bunkers with a perforated bottom or ventilation ducts distributed over the bottom. The air is blown upwards through the grain. Generally speaking, the layer depth should not exceed 1,4 m., otherwise the necessary blower equipment becomes too expensive.
In other types (with box-shaped or cylindrical bunkers), the air is not blown from the bottom but transversely through the grain.
Drying installations are offered by various firms and assembled on the site (*Fig. 1*). However, the bunkers and air distribution system can be largely constructed by farmers themselves.



Körnerförderung — *Grain conveyance*
Luftkanal — *Air duct*
Trocknungsbehälter — *Drying bin*
Lagerbehälter — *Storage bin*
Annahmegrube — *Reception pit*

Fig. 1 — Elevation and plan of a drying unit

— Blower and heat source

The bunker's size, blower (air quantity and air pressure) and equipment for heating the air must be adapted to each other. An air flow of about 300-400 cu.m./h. is required for each cu.m. of grain. Accordingly a blower with an air delivery of 9,000-12,000 cu.m./h. is necessary for a bunker of e.g. 30 cu.m. capacity.
Technical details of the blowers can be found in the leaflets issued by the manufacturers. Blowers recognized by the DLG (German Agricultural Association) are particularly recommended. Complete blower-heating units are also available. Apart from the blower, they contain either a special heating element for connection to a hot-water central heating system or a mixing head *(Fig. 2)* if a hot-air stove is provided as heat source.

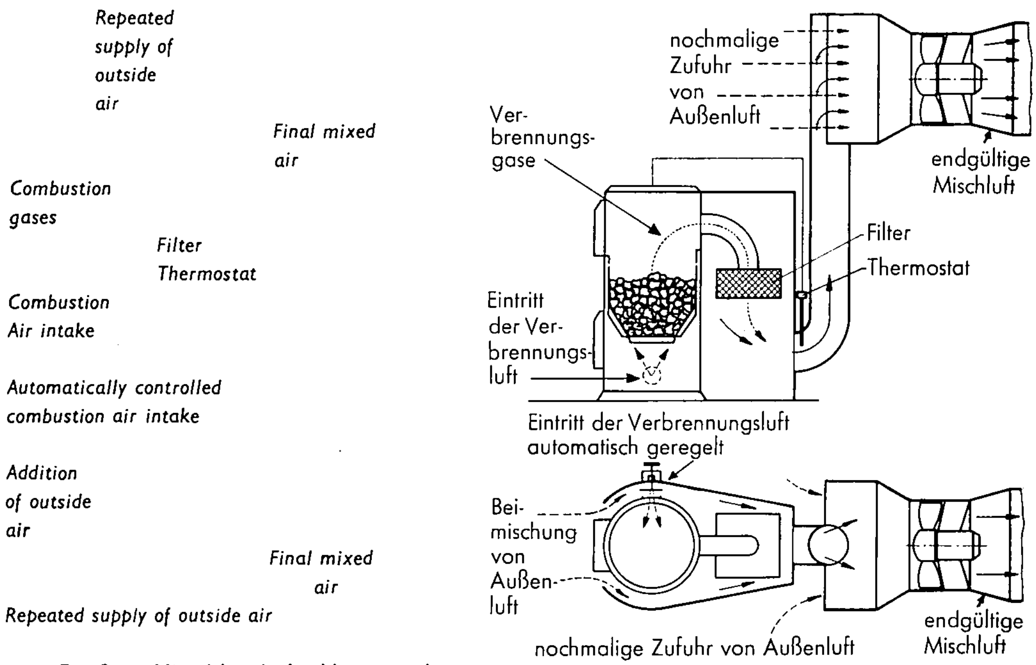
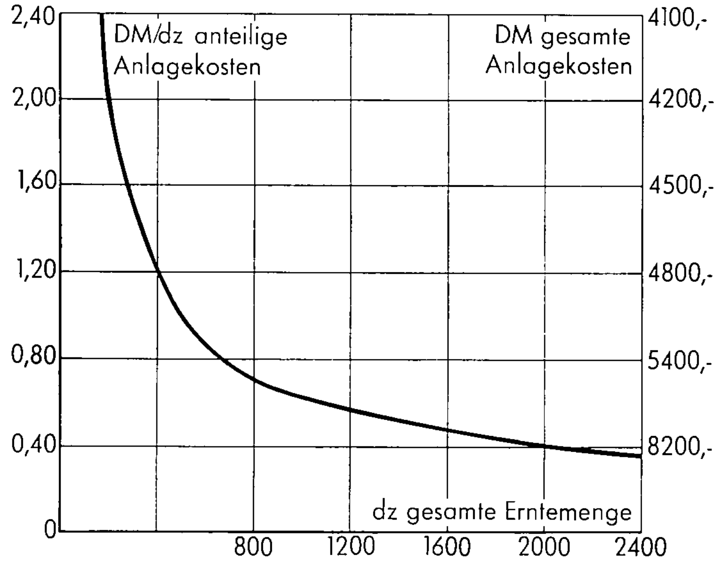


Fig. 2 — Mixed head of a blower and heat installation.

If a hot-water central heating system (coke-fired boiler in cellar or coke stove in kitchen) is available, it is advisable to connect the grain drying system to this installation if less than 30 metre piping is adequate in this respect. With larger distances the costs of the double-insulated pipes are no longer justifiable.
In this case or if hot-water heating is not available, a coke-fired hot-air stove is used as heat source. This type of stove is transportable and can be used for drying grain and green fodder (with or without chimney stack connection) as well as for stall heating (only with chimney stack). It is available in three sizes: 12,000, 25,000 and 50,000 kcal./h. with chimney stack connection or 14,000, 30,000 and 60,000 kcal./h. (without chimney stack connection). Its capacity is so large that it only needs to be charged twice daily. An automatic regulator sets the desired air temperature.
The quantity of heat to be emitted per hour by the heat source (coke-fired boiler, heating stove, hot-air stove) is obtained from the tensity of the air flow and extent of air heating. With heating by a maximum of 6°C about 2 k.cal. must be supplied for each cubic metre of air. Consequently an air flow of e.g. 6,000-8,000 cu. m./h. requires a heat output of 12,000-16,000 kcal./h.

— What is the cost of grain drying?

The drying costs are obtained from the first costs and operating costs.
The quantity of grain determines the size of the installation and hence the first costs *(Fig. 3)*. For instance, an installation for drying a harvest of 800 cwt. costs about DM4,800. With depreciation in 10 years (without taking the interest into account) 1 cwt. costs about DM0.60. Up to 50% of these costs can be saved by self-construction and careful selection of equipment.



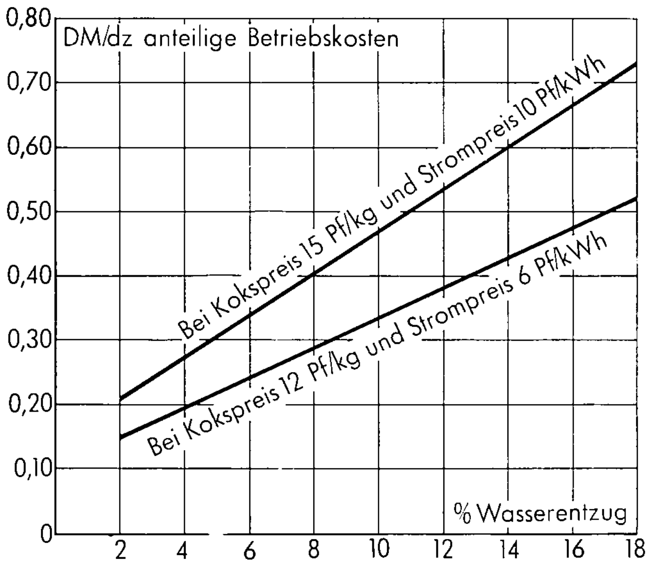
Cost of unit (DM/200 lbs.)

Total cost of unit (DM)

Total harvest (200 lbs. units)

Fig. 3 — Cost of grain drying unit

The plant must be correctly built and suitably run in order to keep operating costs as low as possible. The operating costs are dependent on how much water must be removed from the harvested crop and consist of the current costs (blower) and coke costs (heating unit) *(Fig. 4)*. Detailed surveys of about 100 installations revealed that on average about 7-8% water had to be removed. The actual dampness of the harvested grain varied between 17 and 30%. In the case of the mean value operating costs between DM0.14 and DM0.20 per cwt. of grain must be anticipated *(Fig. 3)* according to the current and coke price.
The total costs of drying one hundredweight comprise the proportional first and operating costs.



Operating cost (DM/200 lbs.)

Price of coke 15 Pf./kg.
Cost of current 10 Pf./kWh.

Price of coke 12 Pf./kg.
Cost of current 6 Pf./kWh.

% Dehydration

Fig. 4 — Cost of grain drying

Green fodder drying (hay drying)

As with grain drying the industrial installations (pusher-type turnovers driers, revolving-drum driers) will not be dealt with here. Only a few grassland farms supply green fodder on the basis of contractual relationships to drying plants in which dry green fodder is prepared.

For the optimum utilization of their own fodder, however, the modern grassland farms cannot forgo good preservation of producible winter stocks. The old method of hay-making practised from time immemorial and dependent on the weather is out-of-date. In order to obtain high-quality hay, fertilizer must be applied, cutting carried out early and frequently and the grass dried at an accelerated rate.

— Ventilation drying with heated air.

When drying under a roof considerable quantities of water must be removed (30.7 litres per 200 lbs. during drying from 35% to 15% water content), before the material to be dried is transformed into storable hay (water content about 15%). If the water content of the starting material is 55%, the quantity is as much as 89 litres of water per 200 lbs. of hay.

In principle green fodder is ventilation-dried in the same way as grain. The material to be dried is stored 1 to 2 m. high on gratings and the drying air blown through the material from below. The hay store should be closed on all sides, so that the drying air can only escape upwards.

When filling the bunker with the material, irrespective of whether it takes the form of low-pressure bales, long or chopped hay, special attention must be paid to uniformly loose storage in order to avoid closely packed areas where the material remains damp and decays. The bunkers can be of optional height, because it is unnecessary to remove the hay, the next batch of material for drying being placed on top. However, a total storage height of 6-8 m. will not be exceeded in view of the blower.

In addition to the above method of construction with bottom ventilation, there are also the so-called hay towers in which the air is blown horizontally through the material from inside. The main advantage of this method is that filling and discharging is mechanized.

Generally speaking, the material is dried continuously, i.e. day and night. The drying time depends very highly on the temperature and humidity of the air blown through as well as the initial dampness of the material to be dried. The drying process takes longer, the more humid and cooler the outside air. Drying times can be reduced by pre-heating the drying air. Experience has revealed that pre-heating should be restricted to a temperature increase not exceeding 9°C, because otherwise the hay becomes brittle and excessive heat losses occur. The following *table* of different initial states shows the optimum values for air heating.

For drying purposes an air flow of about 360 cu. m./h. is required for each sq. m. base area of the bunker. Accordingly a blower delivery of 7,200 cu. m./h. is required for 20 sq. m. base area.

The heating unit connected to the blower must be capable of supplying about 2.7 kcal. to a cubic metre of air when the air is heated by a maximum of 9°C. Hence a maximum output of 2.7 × 7,200 = about 20,000 kcal./h. is required from the heat generator for a drying bunker with a base area of 20 sq. m. The coke-fired boiler of an existing central heating system or the above coke-fired hot air stove can be used as heat generator.

What is the cost of green fodder drying?

With average outside temperature and air humidity the drying costs (blower current, fuel for air heating) are roughly as follows:

— Initial dampness of material to be dried:	35%	45%	55%
— Operating costs in DM per 200 lbs.:	0.90	1.58	2.80

There is no sense in comparing the costs of drying with and without air pre-heating. Farmers will naturally work without air pre-heating in good weather. In moderate or bad weather, however, the green fodder would deteriorate in quality or even decay if dried without pre-heating air, so that winter fodder would also have to be purchased. It is obvious that it is still considerably cheaper to obtain high-quality hay from green fodder, when the air is pre-heated than when additional fodder has to be purchased instead.

Outside air		Dehydratation (silage filled to 2 m. depth)					
		35% to 15%		45% to 15%		55% to 15%	
relative humidity %	temperature °C	recom-mended air heating °C	resultant drying time hrs.	recom-mended air heating °C	resultant drying time hrs.	recom-mended air heating °C	resultant drying time hrs.
45	5	0	90	3	130	9	130
	10	0	80	3	110	9	110
	15	0	70	0	120	6	110
	20	0	60	0	100	3	120
55	5	0	120	6	110	9	150
	10	0	100	6	90	9	120
	15	0	90	3	110	9	110
	20	0	70	3	90	6	120
65	5	3	110	9	90	9	150
	10	3	90	6	110	9	140
	15	3	80	6	100	9	120
	20	0	120	3	120	9	110
75	5	6	80	9	110	9	180
	10	3	120	9	90	9	150
	15	3	110	6	120	9	140
	20	3	90	6	110	9	130
85	5	6	100	9	130	9	210
	10	6	90	9	110	9	180
	15	6	90	9	100	9	170
	20	6	80	9	90	9	150
95	5	9	80	9	140	9	240
	10	6	120	9	130	9	220
	15	6	110	9	120	9	190
	20	6	110	9	110	9	180

Paul HERRMANN

Essen-Bredeney

Grain Drying and Storage on the Farm

(Translated from German)

More and more farms in West Germany are going over to the use of combine-harvesters, whose advantages are already well known. However, in many parts of the country, grain harvested by combine is not dry enough to be stored without further treatment. Grain with a moisture content of over 14 per cent sold in the month of harvest not only realizes the lowest price of the whole year, but the seller must also reckon with special deductions for a moisture content higher than 14 per cent. For many farms, therefore, fattening sheep or keeping flocks of layers, especially in coastal districts and areas with a high rainfall, it is very desirable to have drying facilities on the farm. Feed mixed on the farm from home-produced grain is only significantly cheaper if it does not have to be transported to a commercial drying plant and then returned to the farm.

Any farmer who decides to go over to drying grain on the farm must plan to mechanize the whole chain of work from the field right up to the milling or mixing plant, so that only one labour unit is required at each stage. In small farms it is also desirable to try to manage with one single piece of handling equipment for unloading and for transport within the farmyard.

Transport of grain to the farmyard

Tanker combines are becoming more and more the rule, because a single unit of labour can without effort both harvest and simultaneously thresh the grain with them. So as to keep the combine cutting for every minute of good weather, care should be taken that adequate transport vehicles are available to take the continuous flow of grain and that sufficient facilities for unloading are also available in the farmyard. Ordinary farm trailers can be used to carry the corn provided they have a solid covering to their floors and sides. In many cases specially made bins with outlets are placed on the farm trailers so that the grain can be allowed to flow directly from them into a grain conveyor in the farmyard. This solution is a particularly good one for farms where only two or three wagonloads have to be transported and unloaded each day.

Where many daily trips are necessary, the vehicles must be unloaded rapidly. This requires the provision of a suitable number of reception stations for the grain and also of tipping facilities. Since hydraulic tipping trailers are not commonly used in agriculture, use is often made of mechanical or hydraulic lifting devices, so that the trailer can be tipped; these are available in several types. Where the installation does not include a purpose-built intake pit, corn bins are used, varying in type according to the district and usually in conjunction with a horizontal grain auger. These bins can either be bought ready-made or constructed on the farm. The capacity of the reception unit must be adjusted to that of the transport vehicle normally used. The most economic solution to the problem of unloading and of the transport of grain within the farmyard varies from place to place and depends upon the sensible use of space already available, but standing empty, in conjunction with the most appropriate equipment and sometimes by exploiting the fall of the land. Careful and intelligent planning is indispensible.

Conveyors and handling equipment

The handling system for combined grain is decisive in the exploitation of the drying installation. A well-designed handling system can increase the capacity of a modest drying plant so as to accommodate peak periods. Where damp grain has to move by gravity the walls of the container and channels must be smooth and have a fall of at least 45 per cent. In installations designed to make use of gravity, channelling of the proper size with conveniently placed switching devices can make the employment of cross-conveyors unnecessary. Pneumatic and mechanical conveyors for the transport of grain are available in a large number of designs. Pneumatic conveyors are to be recommended for cases where the movement is lengthy and includes changes of direction from the horizontal to the vertical. All the available pneumatic conveyors can either be fixed or mobile.

Pneumatic conveyors with venturis or injectors (higher throughput) are especially to be recommended in old buildings and on farms where a maximum hourly throughput of 7 metric tons is sufficient and several containers have to be served. Suction blowers with several inlets may be recommended where the grain has to be conveyed to greater heights and where the effective throughput is over 7 tons per hour. Where considerably higher throughputs over greater distances are required suction-pressure blowers should be used serving a number of inlet and outlet points.

The most inexpensive type of mechanical conveyor is the wheeled bin for movement on the flat, but some physical strength on the part of the person using it is indispensible. These wheeled bins are particularly suitable for small farms using bins at ground level. The auger conveyor or grain auger is suitable for moving the grain either horizontally or vertically. Its capacity in vertical movement is two thirds smaller than in horizontal movement. Wet grain can only be moved horizontally or obliquely by means of an auger conveyor. Both fixed an mobile models of auger conveyors are available. Bucket type elevators are suitable for vertical movement. These stationary machines have a low power requirement and are reliable for moving wet grain.

Points to watch on these machines are a short interval between the buckets, adequate size of the inlet and a belt speed of 2.5 metres per second.
Endless belt conveyors, oscillating conveyors and chain conveyors can be used for the horizontal movement of grain. Endless belt conveyors will also move grain obliquely up to a maximum angle of 30 degrees. Oscillating conveyors are available either in mobile or fixed types. They have a very high throughput capacity. Mobile types are most useful on the farm. Chain conveyors can, other things being equal, be constructed on the farm; they are to be recommended for continuous or batcn dryers.

Pre-cleaners

It is almost always advisable to pass the grain to be dried through a pre-cleaner first in order to rid the grain of wet dirt and foreign matter. If this is done it can be dried more quickly and with less expenditure of energy. The capacity of the pre-cleaner must be suitably adjusted to that of the conveyor system, otherwise conveyance of the grain will be slowed down. The pre-cleaner is usually installed in front of the dryer, either between the auger conveyor and the blower or in the case of suction-pressure conveyors in the interval between the suction and pressure circuits. Pre-cleaners operate on the winnowing principle and also include a system of sieves to separate out the coarser foreign matter.

Air drying

Storage concerns and mills which accept a number of consignments of grain with differing moisture contents every day, must be able to dry the day's quota down to 14° in a few hours. To do his, they require large and costly installations working with heated air and expensive to run. This speed of drying is not necessary for the individual farmer. For him, it is sufficient if the single lots can be dried down to an acceptable moisture content for storage, by air drying over 8-10 days. As the harvest usually extends over a period of 3-4 weeks the consignments coming in each week can be dried one after the other in the same drying plant. As a rule, a relationship of 1:3 between drying capacity and storage capacity is adequate.
In air drying the grain is dried in the containers without movement by blowing the drying air through it. This can be done both in ground level bins and in silos. The size of the containers depends upon the volume of the harvest and the policy of the farmer. Ground level containers can be constructed and installed by the farmer himself, care being taken to provide sufficient outlets. Ready make containers are also offered by agricultural machinery firms. When drying in ground level containers the air passes through an inlet channel under the floor of the container, usually constructed from preformed sheet metal, wire mesh, or perforated ducting and is forced upwards through the wet grain.
Tower-type containers, which are mostly cylindrical, have a steel framework which carries a cladding of either perforated steel sheets or narrow meshed woven steel wire. There is a similary ventilated central pipe whose diameter is in the relationship of 1:4 to that of the cladding of the silo. The central pipe can be blocked at any desired height by an airtight bung so that drying can be carried out at any level in the silos. The air blown in passes obliquely through the wet grain to the outer cladding and escapes through it, carrying the moisture with it.
In one design the central pipe is replaced by several ventilation channels installed along the diameter of the silo and provided with an additional internal channel for the air to escape. As a result the layers of grain are thinner and the air resistance is considerably less. An equal drying effect can thus be provided over the whole area of the silo. The most efficient diameter for silos with a central pipe is about 2.50 m. and their height should not exceed 5 m. For drying in a central pipe silo 400 cubic m. of air are required to dry each cubic metre of grain on the average.
The size of the installations for storing and ventilating grain depends upon the acreage of cereals grown and the average harvest. A farm with twenty hectares of cereals and an average yield of 32 metric quintals per hectare, will usually require 30 cubic m. of drying capacity and an additional 60 cubic m. of storage capacity. The capacity required for any given size can be read off on a table.

Blowers and heaters

The amount of air required to dry grain in bins on the ground depends on the moisture content, the height of the grain in the bin, the relative moisture of the air and the period within which drying must be completed. For this reason the required amounts of air per 100 kg. of grain vary considerably according to circumstances. The volume of air blown required can also be found in tables. If the moisture content of the grain is relatively low, normal air can be used for drying purposes. In coastal districts and in areas where heavy precipitation occurs during the harvest, the air used for drying must be heated.
As a general rule it can be said that an increase in the air temperature of 1° C. will reduce the moisture content by about 5 per cent. Since a relative air moisture of 90° and over is only seldom met with, it is usually sufficient to raise the temperature of the air by 5° C. The necessary heat for this can be derived from a number of sources. Heating units may be operated by electric resistance heating, by oil, or by solid fuel. On small farms existing water heating equipment can be used for warming the blown air with the addition of a convector. The farm equipement industry has many types of blowers and complete blowing and heating units to offer, most of which are approved by the German Agricultural Association. There is a wide range of equipment of this sort capable of providing heated air for between 20 and 60 cubic metres of grain, to a height of between 1 and 1.4 metres.

Continuous dryers

On large farms continuous drying should also be considered; this operates on the moving belt principle. We shall distinguish here between tower dryers and horizontal dryers. In the first type, the grain is first warmed by very hot air and subsequently cooled. In horizontal dryers, which can be supplied as mobile units and are not very high, the grain is carried horizontally over a stream of hot air and then to a cooling area. The particular advantage of this type of machine is an uninterrupted flow, even when grain is heavily contaminated with foreign matter, and the fact that they empty themselves completely (no mixing of varieties). Any continuous dryer will require a special conveyor system which should be carefully planned.

Storage containers

The drying installation will provide storage for combined grain on the farm up to about one third of the total quantity. For the remaining two thirds additional storage space must be provided. Here there is a choice between low-level and tower containers. Where sufficient head room is available containers with self-emptying sloping bottoms are usually used. Because of the number of types of grain usually grown, a number of small containers are more useful than a few large ones. Square bins are not generally more expensive than round ones and take up less space.
When providing storage space care should be taken to see that the conveying equipment required for filling the silos can also be used for emptying them.
The farm equipment industry offers both round and square storage silos in hot-dip galvanized steel sheet which can be put up in the open. This type of silo is of interest to the larger farm where no raised storage accomodation is available. These steel silos are airtight and provide protection against vermin. They have a filling opening at the top and are usually provided with openings at the sides in which to introduce an auger conveyor.

Continuous weighing machines

Continuous weighing machines are necessary in order to calculate the amount of harvest and also the quantity used or sold, and these should be incorporated in the conveyor lines. Weighing can be done either before the grain is put into store or before it is used for consumption on the farm of for sale. Well tested models of continuous weighers are available. For farm use only the simple type of batch weighing machine with two containers and an automatic changeover device in adequate.

Milling and mixing equipment for feed grains

Grain-growing farms with a large pig or layer enterprise are increasingly turning to their own milling and mixing equipment for the grain they grow. When planning such an installation every attempt should be made to see that the grain can reach the milling equipment from raised storage by gravity without any mechanical assistance. If a hammer mill is used the chaff can be conveyed to the mixer by the blowing action of the hammer mill itself. The mixer should be installed so that it is over the storage containers for compound feedingstuff and can fill them without the need for any further conveying equipment.

The use of steel

This paragraph was written specially for the Steel Congress 1966. Its purpose is to give a short account of the use of steel in all equipment concerned with drying and storing grain. Conveyors, motive power units, blowers and warm air equipment are usually manufactured from steel. Transport containers, drying and storage silos made of steel sheet offer particular advantages over those in other materials and are therefore preferred by German manufacturers. Continuous dryers usually have a large quantity of steel in their construction. Milling and mixing equipment with the containers and apparatus is also usually made of steel.
In conclusion it may be said that grain drying on the farm, right from the moment of the reception of the grain to drying, storage and final processing, requires equipment and installations predominantly made of steel. At the present time in Germany, where more than half the total acreage of grain is now harvested by combine and simultaneously threshed, there is at present a considerable unsatisfied demand for drying installations and storage containers on farms.

Roger MARION
Ingénieur agricole

Service technique de la Fédération nationale des producteurs de lait
Paris

The Preservation and Collection of Milk in Bulk

(Translated from French)

Unless precautions are taken to maintain its state of equilibrium and original quality, milk deteriorates very quickly. Because of its high proportion of nutrients, milk is very sensitive to the development of germs carried by factors as dust, milking machines, inner surfaces of containers, etc. For these reasons milk is cooled immediately after milking, or collected as quickly as possible to avoid deterioration. The two conditions necessary for this are, either efficient cooling after milking, bringing the temperature down to about 10° C, or collection twice a day after milking.
In fact, rapid cooling to 10° C would allow one of the two daily collections to be eliminated, but this is only true of good quality milk. In most cases the milk is collected in cans which have previously been cooled in chilled water tanks (immersion tanks).
Around 1945, a different system of collecting and preserving milk first appeared in the United States, and a few years later in New Zealand. The principles involved are very simple:
(a) At 4° C most milk germs no longer multiply, thus stabilizing the milk and allowing the output of four successive milkings, or two days' milk, to be collected at one time. Transport costs are thus substantially reduced,

(b) The effect of this low temperature is not complete unless the milk is fully cooled within two hours after milking took place. Constant agitation to produce rapid and homogeneous cooling is required. Such agitation is made easier by bulk storage in large tanks which have large areas in contact with the cold source and result in savings on labour and in refrigeration plant.

(c) The adoption of road-tanker collection allows a low temperature to be maintained as a result of the thermal inertia provided by the large quantity of milk carried. Bulk transport also facilitates handling and eliminates the use of milk cans and associated equipment such as can washing machines and loading platforms. On the other hand, bulk collection has imposed stringent requirements concerning the quality of milk from different sources, without which it would have been dangerous to mix the milk from various producers.

These different methods were developed rapidly in the USA and other English-speaking countries, but appeared later and on a very modest scale in Europa (around 1960)). The expansion is associated with improvements in the structure of dairy farming, the majority of undertakings having an output too low to justify installation of a tank. Also, access to these small cow-sheds is often difficult and the smaller the amount of milk involved the waste of time becomes more serious.

At present there are some 1,300,000 dairy farms in France, nine tenths of which have less than ten cows. Equipping a farm is hardly justified when the average daily yield is less than 70 litres. This means that 60% of all producers cannot be profitably equipped. In any case the average age of dairy farmers is rather high and it is certain that the industry will rapidly lose more than half of its members, so that final cooling tank requirements will amount to about 300,000 units. A survey carried out by the Rural Engineering Department has shown that about 130,000 tanks will be required during the next five years. At present the French market absorbs about 15,000 tanks per annum with the following capacities:

200 litres	54%	600 litres	7.5%
300 & 400 litres	35%	1000 litres & more	3.5%

In constructing farm cooling tanks and collection tankers, materials are used which ensure absolute cleanliness and facilitate efficient cleaning. In nearly all cases 18-8 stainless steel is used for the internal lining in contact with the milk. The tanks used to keep the milk at 4°C generally have a simple shape such as a horizontal or vertical cylinder, a hemisphere or a rectangular prism.

The cold source consists of a double wall, and mixing by means of an agitator brings down the temperature of the milk. The inner wall is generally made of stainless steel or 18-8 chromium-nickel steel. The outer wall, which can be made of the same material because of the ease with which it can be cleaned, may also be made of various other materials such as plastics, aluminium, and enamelled or painted steel plate.

The heat exchanger of the refrigeration system is located within the double wall. Equipment available from French manufacturers incorporates two types of heat exchanger: the direct expansion system in which expansion of the refrigerant takes place in direct contact with the inner wall; and the chilled-water system in which the space between the two walls is filled with water and ice and the exchanger is located within the liquid. The second process has an appreciably higher power consumption but generally permits the temperature to be lowered more rapidly as a result of its inherent thermal inertia. It is most advantageous for small capacities since the amount of ice required for large volumes necessitates the construction of heavy and bulky equipment. A variation of the first process consists of placing the heat exchanger, a cylindrical or ring-shaped plunger, directly in the milk.

The equipment associated with the tanks, such as milk quantity gauges and agitator spindles and paddles, is also made of 18-8 stainless steel.

The unit is protected by a cover which has to be particularly tight and an efficient thermal insulator. Usually it is made of plastics or stainless steel. The refrigerating units are protected from dust and splashes (the environment in which the cooling tanks is used being particularly moist) by a light steel or plastic shousing.

The equipment must:

(a) lower the temperature of the milk to 4° C in less than two hours;

(b) maintain this temperature whatever the external temperature, using as little electric power as possible (tank consumptions range from 25 to 50 watts per litre of milk kept for two days);

(c) be easy to clean and not contaminate the milk in any way;

(d) be robust and durable.

In most cases direct expansion tanks consume less electricity than chilled water tanks.

Bulk tanks are manufactured under greatly different conditions varying according to the maker. For instance, a small number of firms manufacture them in large batches, one such firm being responsible for nearly half the total market. A large number of firms make them on a small scale in small workshops and their products provide a range which is often very varied but only represents a small part of the market.

Where milk producers receive a subsidy for installing bulk tanks, the latter first have to be approved by a commission consisting of representatives of the government and of the trades and professions concerned. The conditions under which tanks are approved include observance of certain rules intended to maintain the quality of the milk kept in them.

Among other things, it is required that the milk should only come in contact with completely neutral and easy-to-clean material. This is one of the reasons why type 18-8 stainless steel rapidly came into extensive use, nearly all tanks being made of this metal.

The collection tankers, which are a logical extension of the farm tanks, have to meet the same quality requirements of harmlessness and ease of cleaning in respect of surfaces and fittings coming into contact with the milk. The tankers, whose tanks are normally made of stainless steel, have greatly different capacities ranging from 4,000 to 10,000 litres. This range results from the great variety of local conditions such as length of rounds, negotiability of country lanes and accessibility of farmyards. Two methods of drawing the milk into the tanker are available. In one a centrifugal pump is used and in the other a vacuum is created in the tanker. The latter method requires a more robust tank design. Various accessories accompany the tanker and these include a reception vat for the milk cans, suction hoses with pipes to take milk from bulk tanks without draw-off valves, a volumetric meter to measure consignments, a sampling valve and sometimes even automatic equipment.

An evaluation of road tanker requirements for the next five years has indicated that 2,000 tankers with a total capacity of the order of 100,000 hectolitres will be required. Of these 50% will hold 5,000 litres, 29% 3,000 litres and 16% 7,000 litres, the remainder having higher capacities.

The change-over from the old system of conditioning and transporting milk in cans to the new system, appears to be well under way. However, it will only expand to an extent dependent on the rate at which installation of bulk handling equipment is made possible by production structures. Certain restrictions on expansion connected with quality considerations should also be noted. One of these results from the fact that agitation of milk having a rather high concentration of germs at the time of milking and exposed to air may facilitate the development of yeasts. Such micro-organisms speed up the rate at which butter manufactured from such milk becomes rancid. Furthermore, the low temperature automatically eliminates lactic ferments which have an acidifying effect, but does not destroy germs such as bacterium coli and spore forming bacteria that develop in neutral media and are harmful in cheese making.

Such considerations make it necessary to popularize maximum cleanliness in milk production at the same time as bulk handling techniques are expanding.

It is evident that this field provides an important outlet for stainless steel since, when a minimum of 2 sq. metres of stainless steel is required to fabricate a 200 litre tank, some 400,000 sq.metres of stainless steel plate will be used in the tanks provided for in the five-year period considered.

L. CASAYS
Ingénieur en chef du Génie rural des eaux et forêts
J. SURUN
Ingénieur E.N.S.I.A. contractuel
R. SAINT MARTIN
Ingénieur contractuel

Section technique centrale des industries de transformation
des produits animaux, Ministère de l'agriculture
Paris

Stainless Steel and the Agricultural and Food Industries

(Translated from French)

In the agricultural industries whose origins are lost in antiquity, the use of both containers and machines has always been essential.

The different materials used to make these items have evolved with the progress of science. Wood and earthenware were followed by glass, copper, iron, steel, aluminium and now stainless steel and plastics. This development has not always been easy because although a new material has new qualities (robustness or corrosion resistance, for example) these very qualities often do not allow products identical with the earlier ones to be produced. An example of this is the action of wood on wine and alcohols or of coppe ron spirits. Nevertheless, increasing production capacity in workshops through the ages and the need to make products of uniformly high quality in order to meet customers' demands and face up to competition intensified by improvements in transport facilities have impelled manufacturers to chose the least corrosive and strongest materials.

Consequently, as we shall see, stainless steel has played an increasingly important role in the agricultural and food industries in the past twenty years or so.

Stainless steels

Before studying the position of stainless steel in detail, we had perhaps better give some simple facts on this material, ignorance of which has often led to serious mistakes.

Stainless steel is a general term which covers a considerable number of different grades of steel. It must contain at least 12% chromium, the element which gives it its remarkable corrosion resistance. Chromium, which is highly oxidizable, provides on the surface of the alloy an oxidized compound which slows down and even arrests the progress of corrosion.

A surface which has just been worked is called active and has an electrode potential lower than that of hydrogen, while after exposure to moist atmosphere or treatment in an oxidizing medium or by electrolytic polishing the surface becomes passive and has a potential close to that of platinum (Fe = — 0.441 ; Cr = — 0.71 ; Ni = — 0.22; Pt = + 1.2). [1]

Metals such as nickel, molybdenum, copper, etc., are generally added to the chromium-iron alloy to increase the chemical resistance and extend it to non-oxidising media.

The main stainless steels under the AFNOR designation of the type Z 20 C N 1810 [2] are:

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(1) It should be noted that the electrode potential of hydrogen taken as a basis of reference is taken as zero. The potential indicates the electro-chemical corrosion caused by electrical currents set up in a moist atmosphere between two metals of different potentials. The one with the lower potential diffuses to the advantage of the other. Thus zinc (—0.76) or chromium (—0.74) coatings provide excellent electro-chemical protection for iron (—0.44).
As for stainless steel, it moves fairly rapidly from the value —0.10 to —0.40 (depending on the grades and the type of machining or treatment to which it has been subjected) in the active phase to +0.60 to +0.90 in the passive phase. Consequently, in the presence of stainless steel, iron (—0.44) and ordinary steel dissolve by electro-chemical corrosion, particulary in the second case.

(2) In the AFNOR designation:
a the letter Z indicates a high alloy;
b the first number of one or two figures expresses the approximate carbon (C) content expressed as 1/10,000 (for example 8 for C 0.08%)
c the group of letters represents the metals in the alloy in decreasing order of content
C = chromium (Cr)
N = nickel (Ni)
D = molybdenum (Mo)
T = titanium (Ti)
S = silicon (Si);
d and the final group of one or two numbers expresses the approximate content of the most important constituents expressed as percentages in the same order as the letters of the preceding group.

1. Chromium steels, ferritic and magnetic in the mild state, which include
   (a) martensitic steels, the desired mechanical properties of which depend on their carbon content (greater than 0.08%) and the heat treatment they undergo (annealing, quenching and tempering). They contain up to 13% chromium.
   Example: Z 30 C 13: analysis C = 0.30, Cr = 13
   They are used in mechanical engineering, some in the cutlery industry and others in the oil industry.
   (b) ferritic steels with a fairly low carbon content (less than 0.10%); and a high chromium content (from 12 to 30%).
   Example: Z 8 C 17: analysis: C = 0.07, Cr = 17
   Depending on their grade they are used in the oil, cutlery and jewellery industries (they can be cold formed). A high chromium content gives them excellent resistance to oxidation in a high-temperature sulphurous atmosphere.
   (c) austeno-ferritic or semi-austenitic steels, few in number, an intermediate category. The chromium is accompanied by a small percentage of nickel and other elements such as magnesium and titanium.
   Example: analysis: C = 0.05, Cr = 18, Ni = 2.7, Mn = 10, Ti.
   They are more easily welded and machined than ferritic steels, and slightly more corrosion resistant.
2. Austenitic steels or chromium-nickel steels, containing not more than 20% chromium but more than 6% nickel. These are the most common as their properties are extremely valuable:
   (a) corrosion resistance in the atmosphere and in chemical media,
   (b) resistance to oxidation, even at high temperatures,
   (c) ductility often as great as that of copper,
   (d) high mechanical strength after cold working.
   Most of them are centred round the famous 18-10 category (18% chrome, 10% nickel).
   Example: Z 3 CN 18.10: analysis: C = 0.03%, Cr 18, Ni 10.
   To increase their corrosion resistance in certain chemical media, elements such as molybdenum, titanium, copper and niobium are often added.
   Example: Z 8 CNDT 18.12: analysis: C = 0.08, Cr = 17, Ni = 12, Mo = 2.3, Ti.
   Their range of applications is extremely wide. Their disadvantage lies in their cost, which is higher than that of chromium steels.
3. Heat-resisting steels, a category of steels, chiefly austenitic, designed for use at high temperatures. The chrome and above all nickel (up to 38%) contents are often very high.
   Example: Z 15 CNS 25.13: analysis: C = 0.15, Cr = 23, Ni = 13, Si.
   Z 10 NCS 36.18: analysis: C = 0.12, Ni = 38, Cr = 18, Si = 2
   Depending on the atmosphere, these may be used at up to more than 1,100° C.

An examination of corrosion tables shows that only austenitic steels have a high resistance to all the constituents of agricultural products. One exception is milk, for which ferritic steel would be adequate, but its use is not advisable because of the hot detergent solutions used for cleaning and because of the possible use of such containers for products containing various amounts of lactic acid.

One of the most widely used of the austenitic steels is Z 3 CN 18.10 since its low carbon percentage enables it to resist the intergranular corrosion occurring in slightly acid media.

However, the Z 8 CNDT 18.12 molybdenum steels must be used for particularly corrosive products or products likely to contain large amounts of sulphur dioxide. Their use is consequently recommended in the sauerkraut, cognac, preserved fruit, fruit juice, mustard, vinegar and white wine industries.

Martensitic steels are used for cutlery and ferritic steels for forks and spoons, but this is hardly an industrial use.

Statistical data I have collected show that per capita consumption of stainless steel sheet and strip (hot and cold rolled) in France has increased from 1.1 kg. in 1962 to 1.45 kg. in 1965, while figures in other countries for the same period were:

Germany	1.4 kg. to 2.5 kg.
Italy	0.7 kg. to 1.0 kg.
Netherlands	0.7 kg. to 1.2 kg.
Belgium	0.55 kg. to 1.15 kg.

The share of the agricultural and food industries in these estimates is difficult to assess; although it is easy enough to ask the large fabricators to break down their consumption it is often difficult to obtain precise data and it is almost impossible to determine the end-use of the stainless steel sold to small firms through merchants and stockholders.

It is estimated that present consumption of sheet and strip in France by the agricultural and food industries is from 5,000 to 6,000 metric tons, to which must be added tubes and castings, the end-uses of which are not included in the statistics. A rough approximation therefore gives 10,000 tons of stainless steel per annum used by the agricultural industries, representing a capital expenditure of about 250 million francs.

It is interesting to note that productive capital investment in buildings and plant by the agricultural and food industries using stainless steel (dairies, breweries, slaughterhouses, canning factories, curing factories, manufacturers of biscuits, spirits, aerated drinks, fruit drinks, soups and vinegar)—I have not included wine making as the use of stainless steel in this industry is still in its infancy and it is not used at all for vintage wines—amounts to about 1,100 million francs and consequently the share of stainless steel in productive investment would be 25%. Stainless steel would thus account for about 45% of capital expenditure on plant and equipment (490 million).

Examination of the data collected in respect of the Anglo-Saxon countries shows that

(a) in the USA, the total per capita stainless steel consumption in 1957 was 3 kg. per annum while in 1964 it was 4 kg., with the food industries accounting for about 5%;

(b) in Great Britain, the consumption was 3.2 kg. in 1965, of which 6.3% went to the agricultural and food industries.

In comparison France, which produced 11,500 ingot tons in 1938—it should be remembered that scrap (for remelting) during rolling amounts to about 20%—74,400 in 1955, 234,000 in 1964 and 246,400 in 1965, only uses some 130,000 tons or 2.7 kg. per person, 7.7% of which goes to the food and agricultural industries.

Per capita consumption in the agricultural industries of the countries for which data and approximations were available can be summarized as follows:

USA	220 gr.
Great Britain	200 gr.
France	200 gr.

These results should only be taken as approximate in view of the vagueness of the information obtained. It is very difficult to draw conclusions as these annual consumptions may be greatly affected either by fashion or by the emergence of a new technique; for example the introduction of milk refrigeration on the farm in France may lead to a consumption of 1,200 tons per annum for a few years, or 12% more than present consumption. Likewise in Great Britain when the breweries went over to stainless steel in 1964 there was a demand for an extra 4,000 tons, or 40% of consumption. In addition the large-scale concentrations now under way in the various food and agricultural industries, in France in particular, may give rise to a high demand for stainless steel in addition to what is needed for replacement purposes.

The per capita consumption of 6 kg. forecast in America for 1970 is an encouraging sign for the future of stainless steel.

Main applications and rival materials

Having made these points, I now propose to go into more detail on the various applications of stainless steel in the agricultural and food industries and the various materials competing with them.

1. Use as containers

The need is mostly for large-capacity containers, but even quite small ones of the drum type are also made. They may be simple storage or transport containers or production vessels with heating, refrigerating or mixing facilities.

Rival materials for the same uses are:

Wood, which is difficult to clean and not neutral to the product, but has some insulating power and is of high strength; for some applications wood can be used with a coating (wax in beer barrels), after impregnation (paraffin-impregnated barrels for butter transport, bakelite-coated barrels for beer), but its use is declining.

Copper, which because of its excellent resistance to acids and high conductivity has long been the preferred material for kettles and boilers in the brewing, cheese, canning and confectionery industries and in the kitchen. Unfortunately, it has certain disadvantages: its ions may be inconvenient catalysts and under certain conditions toxic products or production accidents may occur, or it may require costly tinning, which is difficult to maintain.

Aluminium, generally used as an alloy (with Si, Mg) since more than 99.5% purity cannot be obtained. Its resistance to acids and bases is not good because of the amphoteric nature of the protective alumina. Minute cavities form and make proper cleaning difficult. To overcome these disadvantages certain coatings have been developed but they are difficult to apply and their life is problematical as regards the perfect continuity of the film. What is more, because of its very low potential (—1.67) aluminium acts as an anode to other metals (Fe = —0.441, Cu = +0.344, Pt = +1.2) and consequently there is a danger of electrolytic corrosion. However, because of its lightness and low price it is commonly used in the construction of milk churns and tanks, and containers for the storage of apple juice.

Steel can rarely be allowed to come into direct contact with foodstuffs and is generally only used as a base. There are various coatings such as paint, lacquer, enamel, vitreous enamel, plastics and even stainless steel cladding.

The latter (bimetal) is now perfected but its cost is such that it is only economic where high strengths are necessary for large capacities or for high service pressures (example 6 mm. of steel —1 mm. of stainless steel). The cost of the other coatings varies greatly but is generally considerably less than that of stainless steel, so they are extensively used; however, their lack of strength and the difficulty in detecting defects and preparing for their application introduces a degree of unreliability which is not compatible with modern products.

Concrete has a much more restricted use; it is rarely used without a coating except in wine making, where it is unaffected by tartaric acid. Its main advantage is its low construction cost, but insufficient research has been done on maintenance costs and the life of the structures to determine whether it is really economical. It is also used coated with

(i) purified bitumen emulsions, which have not been proved to be completely non-toxic (in aqueous or organic solution);

(ii) plastic-based coatings: vinyl paints, hot spraying (ebonite, rilsan, polyethylene), hot-welded and bonded plastic sheets, coatings with a chlorinated rubber base, etc.;

(iii) brittle and costly glass tiles or ceramic tiles;

(iv) stainless steel strip welded on to a netting embedded in the concrete vat or directly attached.

Plastics of which there is a very wide range, may have excellent chemical inertia but need to be used with care. Polymerisation may be incomplete and the free monomers may affect the flavour or even be toxic, or there may be traces of solvents or lubricants containing fatty acids.

Plastic tanks are made by moulding or by winding; in both cases the various parts must be bonded, which forms a weak link in the continuity of the film in contact with the foodstuff.

The most widely-used materials for this purpose are polyesters laminated with glass fibre; however it is possible that in use the polyester film may wear and expose the glass fibre, so that particles of glass become detached and leave minute cavities which make cleaning difficult.

At present research is in progress on the production of a stainless steel-plastics combination which would give containers the qualities of the stainless steel and the lightness and insulating power of the plastics. In any case these products are at present too expensive to offer any real competition to stainless steel used on its own.

From the above it is clear that apart from the question of price stainless steel is the best material for the production of containers if the quality is correctly selected to suit the contents.

2. Use as a base

This is a variant of the above case applicable to solid products in the food industry (meat, fruits, vegetables, etc.). Stainless steel is used in the form of sorting tables, conveyor belts, inspection tables, trays, dishes, etc.

For tables and trays its main competitors are:
(a) wood which has bacteriological disadvantages;
(b) aluminium alloys, which are easily scratched and become difficult to clean;
(c) enamelled steel, which has little impact strength;
(d) plastics, which are not always sufficiently hard;
(e) concrete, covered with ceramic tiles for example, which is extremely strong but heavy, and hence only suitable for fixed installations, and is also difficult to work.

Consequently here too, with the exception of cutting tables, stainless steel can be extremely useful.
Steel for handling equipment or steel frameworks can be protected by metal coating or galvanizing or by the use of low alloy steels, a comparatively recent corrosion-resistant category. These are less costly than the traditional stainless steels and their main feature is the presence of an adhesive oxide layer which forms on their surface and inhibits the progress of corrosion. Better paint adhesion makes it possible to use this category when other steels are not recommended, for example for grain silos at ports.

3. Piping

There is little competition in this field. It is extremely difficult to coat the inside of small-diameter tubes, and even more difficult to inspect the lining when the pipes are in use. For foodstuffs, then, only monolithic pipes are of any use.
Copper, tin and even cast iron are found in some industries (brewing, wine), and more recently plastics too, but the only real competitor, a fairly new one, is pyrex, the well-known heat-resistant glass. This is also easy to clean and transparent, a considerable advantage; it appears more fragile than it actually is, and its price is about the same as that of stainless steel.

4. Equipment and machine parts

This application is the same as in any other industry; for these purposes stainless steel is used in the food industry for its surface qualities, its mechanical properties and even its resistance to cleaning agents.
Because of the instability of certain liquids and the need to work in an environment free from any source of contamination a material with these qualities will frequently be preferred.
However it should be noted that
(a) stainless steel does not have a very high heat conductivity; for heat exchangers titanium, which is light and a good conductor and has non-stick properties, could become a serious rival if its cost was lower;
(b) in taps of stainless steel, spigots tend to bind if they are of the same grade as the shell, so that it is necessary to select different grades or to use different materials for the spigots (teflon for example).

5. Wall claddings

These are now widely used in the building industry, generally for decorative purposes. Viewed from a new angle, i.e. with the need for a good cladding for the food industry in mind (water and gas tight, no angular or hollow shapes, impact strength, etc.) stainless steel would seem well able to compete with the ceramic tiles generally used. Research into this is required.

Examples of applications:

Let us take a look at some of the actual and potential uses of stainless steel in special industrial food establishments.

In slaughterhouses it is used as containers for blood. The content of chlorides, although low, makes a high grade necessary, preferably containing molybdenum. It is used for collection troughs, the agitators in these troughs, and storage containers, particularly if the blood or its complexes are later to be treated to make them suitable for food or pharmaceutical use.
For miscellaneous products (organs, fat, waste) stainless steel is used for storage and handling of high-grade products, but plastics—less noisy and with a higher impact strength—are often preferred to it.
For washing troughs, concrete covered with ceramic tiles (or often mosaics) has practically died out. Galvanized steel grows dull very rapidly. Stainless steel gives complete satisfaction.
For tripe pots (scalding, blanching, boiling, pressure cookers, autoclaves) cast iron has practically disappeared. Galvanized steel cannot be used for cooking. Austenitic steel (18-8) would be very suitable for this purpose, but although it does not scratch as easily as aluminium, the latter which has the advantage of excellent heat conductivity, is usually preferred.
For rendering departments only stainless steel is fully satisfactory for the production of edible fats from the slaughterhouse by-products.
Stainless steel is not suitable for cutting tabletops in slaughterhouses because it blunts the knife edge. Wood or certain types of plastics must be used, although both have disadvantages.
For viscera inspection tables stainless steel because of its hardness is often preferred to aluminium.
Stainless-steel conveyor belts are often found in meat-cutting rooms to serve the work tables and packing stations.
Mention should be made of a type of tubing peculiar to multi-storey slaughter houses—the chutes to convey products from the slaughtering department to the preparation departments or storage premises. An unequalled standard of cleanliness can be maintained with stainless steel by means of steam cleaning.
Circular conduits of plastics are also used. They are less strong. Concrete is rarely used because of the construction difficulties (shuttering), the difficulty in making alterations if the workshops are rearranged and the need to find a smooth wearproof coating.
In the category of equipment and machine parts meat hooks should be mentioned. These have developed in recent years and plain steel, which nevertheless was quite serviceable, generally because it was well greased by the meat, has gradually been replaced by galvanized steel or aluminium. Galvanized steel is not to be recommended because zinc salts are toxic, and aluminium is less strong, so that stainless steel is the obvious choice. Unfortunately it is still expensive and it would be a good thing to have two or three standard shapes developed so that mass production could overcome the cost disadvantage.
Also machines used in tripe and viscera-dressing departments should be mentioned. Because of the fats, the abundance of water and the salt, austenitic steel is the ideal material for parts in contact with the products (drums, vats, conveyor fingers, slides) and certain mechanical parts. Designers should take special care to see that there are no iron parts in contact with stainless steel units.
The only suitable wall cladding used so far in the carcas dressing room and in preparation departments for meat and edible organs is the enamelled ceramic tile, frost-proof, sufficiently large (at least 10 × 10) to be easy to clean, and properly laid (full joints) to resist impact and frost.
Stainless steel has as yet really only been used as a covering for circular columns, the concrete being poured directly into the sleeve which also serves as the formwork.
As it is frost-proof it would be invaluable on the insulation of cold rooms.
There is therefore virtually no contra-indication to the use of stainless steel in the special environment of the slaughter house.
Generally speaking, grades can be selected by remembering that

(i) ferritic steel can be used in some cases but in the long term it is less corrosion-resistant than austenitic steel, which can be identified with a small magnet, since it is magnetic;
(ii) in some cases a steel alloyed with molybdenum is preferable.

There is no need to go into lengthy details concerning the use of stainless steel in the dairy industry.
A visit to a modern plant suffices to show that stainless steel is supreme: it covers most of the industry's needs for the storage and transport of milk by pipe and the making of the equipment used for the treatment of milk and the manufacture of the various products. Its closest competitors are aluminium, glass for bottling or packaging—a field in which stainless steel is hardly used—and plastics and pyrex for pipes.
Any exhibition of dairy equipment illustrates the great use made of stainless steel by the designers of all

types of equipment from milk pumps, taps and cheese trays to the largest apparatus used in the dairy industry such as pasteurizers, separators, churns, ultra-modern continuous butter-making or pasteurized-milk units, and milk drying and concentrating installations.

Conclusions

To sum up, I consider that in the future stainless steel will play an even more vital role in the capital equipment of the agricultural and food industries, since it can meet almost all their demands.

In most cases it is in contact with a food product, stainless steel is the material, and in practice only its high cost limits its use.

However, the public will need to be better informed about the best steel qualities to use. In fact, in many cases the user asks the fabricator to make equipment for him without specifying the desired quality or the products which will be in contact with the material and their temperatures. Frequently the order is placed with the supplier quoting the lowest price, who has generally used a cheaper quality which may well be unsuitable for the job it has to do.

Then again, the literature available gives corrosion tables for a pure atmosphere; in point of fact the products concerned are complex affairs, and to my mind these tables should be revised, particularly for the agricultural and food industries, in line with the conditions commonly encountered there i.e. the products themselves (hot or cold) at different stages in their production, the cleaning solutions etc.

Moreover, although there are many large companies specializing in cleaning problems, it should be explained to the user what quality of stainless steel he has bought and what products should not be used with it. In fact, I think the AFNOR designations should be indelibly stamped on all items leaving the factory.

Finally, a word in praise of stainless steel which with its many different qualities can be adapted to suit any industrial requirements, and the price of which, as a result of mechanization in its production and increased sales, has kept steady despite the rise in the cost of living—in effect, a price reduction.

Dott. ing. Valerio PEROTTO

Servizio sviluppo del mercato—Terninoss
Cologno Monzese,

Uses of Stainless Steel in the Stocking of Agricultural Products

(Translated from Italian)

In modern farming in which everything is planned to improve and increase production at ever lower costs, the role of storage-tanks and containers in stainless steel is increasingly important. Milk which requires to be kept refrigerated, oil, wine and fruit juices require to be stored in hygienic and adequate containers, suitable for the purpose.

The key to holding the costs of this storage within certain limits is the correct choice of materials for the construction of these tanks.

Stainless steel is being increasingly used for the construction of agricultural tanks, because of the many advantages it offers as compared with other materials. Amongst these are:

The corrosion resistance of stainless steels is mainly due to the content of Chromium in their composition *(Fig. 1)*. A minimum content of 12% Chromium provides good corrosion resistance because this element,

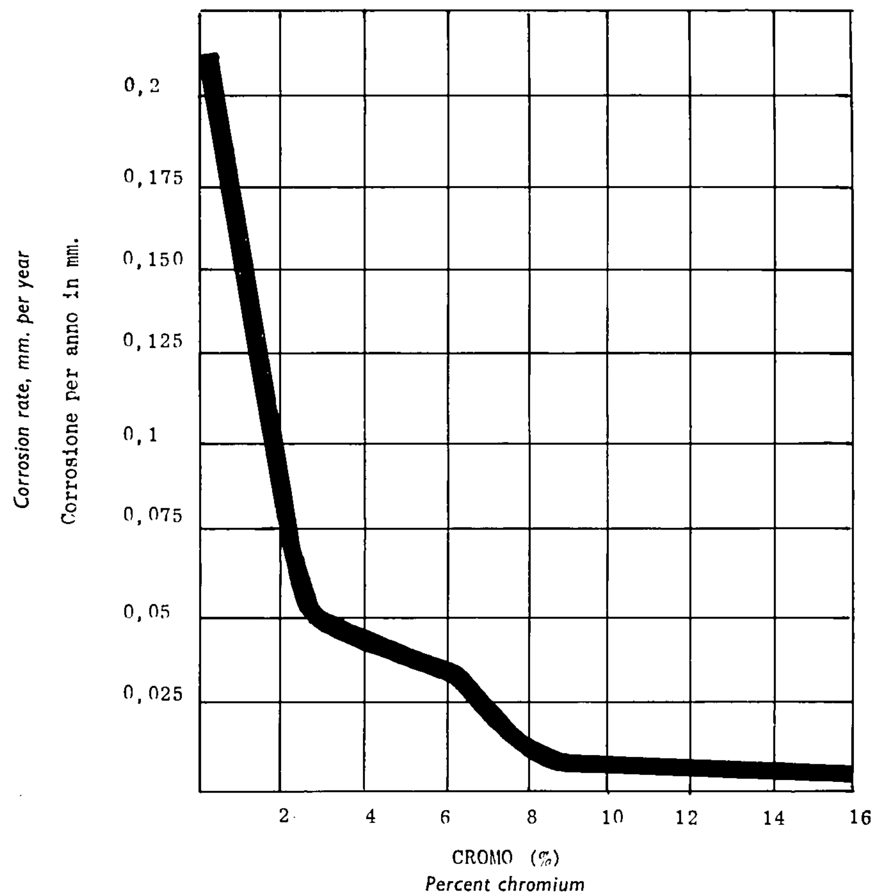


Fig. 1 — The influence of Chromium on the corrosion resistance of stainless steels

reacting with oxygen, forms an invisible surface skin which is resistant to the majority of attacks from chemical substances and which, when maintained open to oxygen, is automatically continuously renewed. This oxydizing process is called "passivation." Nickel, Nitrogen, Molybdenum, Manganese, Titanium, Niobium are other elements included in various types of stainless steels in order to obtain certain particular qualities (high resistance to corrosion, high temperature resistance, better fabrication properties, etc.). In the *table* on p. 367 the chemical compositions of the most commonly used stainless steels, according to the American Iron and Steel Institute are listed.

Stainless steel offers the best guaranties of hygiene because of its inertness in contact with foodstuffs and because of ease of sterilization with chemical solutions, without its surface being attacked and thus remaining smooth and compact, always easy to clean.

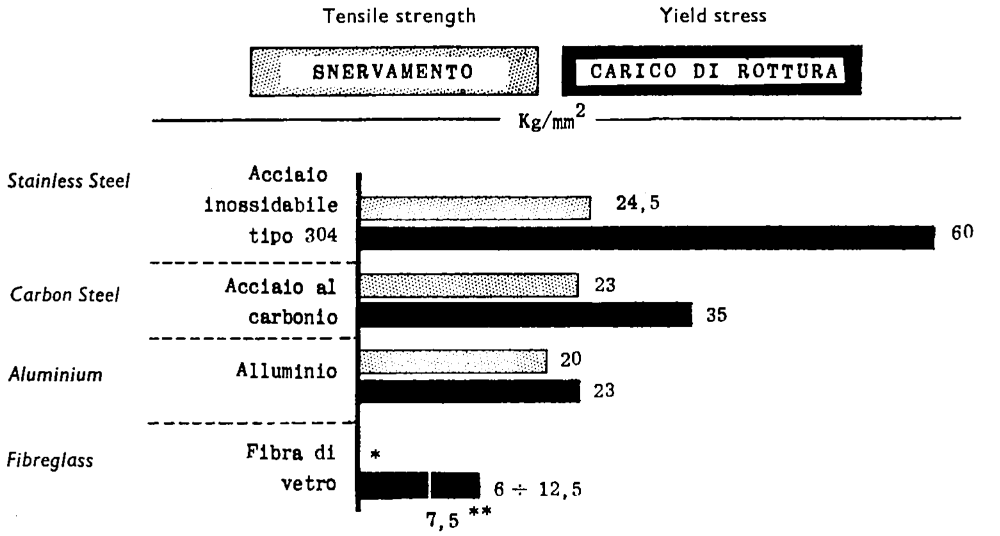
The same container, when properly washed, can safely be used for either wine, or oil, or fruit juices, or other products, without affecting the organic characteristics.

The tensile strength of 18-8 stainless steel in the annealed condition is approximately 50% more than that of Carbon steel, 100% more than that of aluminium and approximately 300% more than that of fibreglass reinforced plastic *(Fig. 2)*.

With the use of stainless steel containers expensive shut-downs for maintenance operations such as repairs, repainting with anti-rust, cleaning of filters, tubes, nozzles, etc. blocked up with rust, are unnecessary. Generally thorough washing followed by copious rinsing is sufficient.

The period of write-off of a stainless steel container can be considered as at least 20 years, in view of the practically unlimited life of stainless steel provided that the minimum precautions for suitable design and periodic washing are carried out.

It is commonly supposed that the high cost of stainless steel renders its use prohibitive. It should, however, be stressed that, with the use of stainless steel, the high initial cost of material is largely offset by the practically unlimited service life of the product and by the minimal maintenance requirement. It is a fact that the use of stainless steel at the time of construction effects considerable economies provided that the



* *Glass-fiber-reinforced plastics usually break before yielding.*

** *Results of tensile tests on specimens cut from a fibreglass reinforced plastic tank. Average of five specimen valves.*

T. F. Shaffer Jr., and R. L. Johnson: "What you need to know about stainless-steel agricultural chemical tanks," Fertilizer Solutions, May-June, 1965.

Fig. 2 — Strength of various types of construction material

Stainless steels (includes only selected types to be considered in dairy applications

(Chemical composition)

Nr.	C	Mn	P	S	Si	Cr	Ni	Mo	Cb-Ta
301	0.15 Max.	2.00 Max.	0.045 Max.	0.030 Max.	1.00 Max.	16.00/18.00	6.00/8.00		
302	0.15 Max.	2.00 Max.	0.045 Max.	0.030 Max.	1.00 Max.	17.00/19.00	8.00/10.00		
303	0.15 Max.	2.00 Max.	0.20 Max.	0.15 Max.	1.00 Max.	17.00/19.00	8.00/10.00	0.60 (1) Max.	
304	0.08 Max.	2.00 Max.	0.045 Max.	0.030 Max.	1.00 Max.	18.00/20.00	8.00/12.00		
304L	0.030 Max.	2.00 Max.	0.045 Max.	0.030 Max.	1.00 Max.	18.00/20.00	8.00/12.00		
305	0.12 Max.	2.00 Max.	0.045 Max.	0.030 Max.	1.00 Max.	17.00/19.00	10.00/13.00		
316	0.08 Max.	2.00 Max.	0.045 Max.	0.030 Max.	1.00 Max.	16.00/18.00	10.00/14.00	2.00/3.00	
316L	0.030 Max.	2.00 Max.	0.045 Max.	0.030 Max.	1.00 Max.	16.00/18.00	10.00/14.00	2.00/3.00	
317	0.08 Max.	2.00 Max.	0.045 Max.	0.030 Max.	1.00 Max.	17.00/19.00	9.00/13.00		10×C Min.

(1) Optional.
Source: "Stainless Steel in the Dairy Industry" AISI, January 1965.

design is suitable, combined with the use of lighter gauges and consequently lighter weights, in view of the greater mechanical strength of stainless steel.

Milk containers

The dairy industry is in rapid evolution in many countries. Systems for the preservation, transformation and transport of milk, which is one of main and most complete human foods, are being more and more developed. At the recent 17th International Dairy Industry Fair in Munich the utilization of 18-8 stainless steel in all dairy equipment was seen to be general and widespread. The reasons for this general success of stainless steel lie in the fact that it is non-toxic, non-absorbent, does not affect the organic characteristics of milk, is easy to clean and stands up to disinfectants generally including Chlorides, Soda or Nitric acid. Not the least reason for this success is that 18-8 stainless steel has good mechanical qualities and it is easy to work (good ductility, easy to weld, etc.). The mechanical properties are also superior to those of other materials used, particularly fibreglass-reinforced plastic. Finally stainless steel is not susceptible to thermal shock and maintains its characteristics at both high and low temperatures.

In the food industry sanitary designs and good fabrication are necessary. In the USA the "3-A Sanitary Standards Committee" has laid down precise standards for the choice of material and for the design and construction of dairy equipment, in which stainless steel is one of the first materials selected.

In order to facilitate cleaning of the equipment, bottle-necks sharp angles and cracks are to be scrupulously avoided in the design and construction.

Standards and recommendations for the correct use of disinfectants in cleaning operations have been published (Pasteurized Milk Ordinance—"1964 Recommendations of the Public Health Service" and "Protecting stainless steel Equipment from corrosion").

In particular it is recommended that chemical bactericides should be used, shortly before the equipment is brought into use, that the sterilizing operation should never be prolonged for more than 20 minutes and that it should always be followed by abundant rinsing with water.

This is to avoid damage to the stainless steel from prolonged contact with disinfectants, liquids which are nearly always based on chlorides and are therefore strongly reducing and would destroy the invisible protective surface skin and attack the stainless steel itself.

For milk storage-tanks stainless steel AISI type 304 (18% Cr and 8% Ni) is generally used. For use with refrigerating brine, AISI type 316 (2 + 3% Mo. added) which is suitable for the severest service conditions, is used.

For use in the dairy industry only finish 4 is specified. This is a "satin" finish obtained by polishing with 150-180 grit. abrasive. This finish is uniform, easy to clean and allows of marching of welded areas with the remainder. The final surfaces should be free of flaws, breaks and metallic contamination. It has been demonstrated bacteriologically (Michigan Agricultural Experiment Station no. 2482) that there is no significant difference between the case of cleaning of finish 4 and that of finer finishes.

The storing of milk in refrigerated containers at the cow-sheds on farms is becoming common. These storage-tanks generally vary in capacity from 400 to 3000 litres depending on the numbers of cattle kept. These are fabricated from 18-8 stainless sheet type 304 finish 4 in gauges 1.2—1.5—2.0—2.5 mm. In these refrigerated-containers milk can be kept for up to 2 days on site, at a temperature of 4° C. Filling is generally carried out under vacuum and refrigeration by direct expansion of refrigerating gases. A variable-speed impeller prevents the accumulation of fat on the surface. The washing of the inner container takes place in closed circuit. Insulation is carried out by means of polyurethane.

The use of stainless steel and the degree of final polish guarantee a high degree of hygiene thereby, together with the low temperature, contributing to the preservation of the milk whilst awaiting transport to dairy plants.

Vertical containers for cheese making

These containers are made in capacities from 3,000 to 100,000 litres. The largest containers are to be found in Northern Europe and they are normally anchored in concrete emplacements with insulating materials between the containers and the emplacements. The insulation is sufficient to guarantee lengthy storage of the milk, whilst the use of stainless steel is a guarantee against possible contamination.

Large vertical containers of 30,000 litres capacity have been installad, for instance, at the Caseificio Milani in Marzano (Milan) and at the Trockenmilchwerk in Hartberg (Austria). They have been made entirely in stainless steel AISI 304, finish 4. Thicknesses 2—3—4 mm. Net weight of each container is 4,920 kg. The insulation is of cork-conglomerate mats; for the absorption of moisture a silicate-gel is used. The specification includes an elliptical man-hole; a vertical impeller; a contact dial thermometer; a level gauge; a system for pressure-washing in closed-circuit.

Road tankers for transportation

The capacity varies from 4,000 to 15,000 litres and over, in one or more sections; steel of type 304, finish 4, thickness 2 mm. and 3 mm. is normally used. Insulation is provided by means of polyurethane injections. Filling is carried out under vacuum; anti-sloshing baffles are provided in every section. Equipment for obtaining the vacuum and the forced closed-cycle chemical washing functions by direct coupling to the truck-drive. Safety valves, manholes, piping and valve system all are in stainless steel. The perfect insulation allows long range transport in the most severe climatic conditions; the full use of stainless steel and its high quality finish offer the best guarantee of hygiene and sanitation.

Wine storage tanks

Cr-Ni stainless steel, already used for many years in the treatment of wine for tubing, pumps, filters, and separators, is now increasingly used also for vessels for storing, fermentation and ageing. Cases in which stainless steel is not used those in which a particular "breathing" of the wine is necessary during the ageing and it is still kept in traditional oak barrels. The main factors which have influenced the adoption of stainless steel containers instead of the traditional wooden barrels and in reinforced concrete vats are:

(1) the organic characteristics of the wine are not affected, as there is no modification of the metallic elements, of the odour, or of the taste. Compatibility tests with wine and stainless steel have been carried out at the agricultural school in Montpellier, and at the Experimental Station in Burgundy.
On many occasions both in Italy and in other countries it has been determined that with the use of stainless steel the iron enrichment is entirely acceptable, even with wines of a high degree of acidity and containing free sulphur dioxide of around 200 mg./l. In vats of non-vitrified concrete, in case of damage to the plaster, calcium and other metals become dissolved in the wine, with detriment to its keeping qualities In plastica-lined vats, after long periods, there may be changes in the organic characteristics of the wine.

(2) Ease of washing and sterilization even with fairly concentrated detergents. Stainless steel allows the employments of stronger descaling media. The surface is not attacked by either Tartaric, Citric, and Malic acids present in the wine or by the detergents used for washing and always remains smooth and dense.

(3) Ease of heat exchange with the exterior, particularly important in refrigerator cells. The high resistance to corrosion of stainless steel impedes the formation of deposits of rust, which are always an obstacle to the transference of heat.

(4) Possibility of removal and enlargement of containers whenever necessary.

(5) Possibility of using the same container for storing either red or white wine, because the surface of the stainless steel does not retain any colouring substance as is the case with concrete vats.

Until now wood has been shown to be an ideal material for the construction of large tuns for wine, however it is difficult to clean and to sterilize. Repairs too are difficult and expensive, Enamelled cast iron is often subject to failures as a result of thermal shock or of faulty execution. Aluminium has not produced good results, being liable to pitting. Copper is particularly soluble in wine. Containers in reinforced plastic are ideal as far as not being subject to attack, but give off smells, and flavour the wine and are not strong enough.

Stainless steel has none of these draw-backs and consequently is a valuable material for the equipment. Generally, as for milk storage-tanks, AISI type 304 is used, 316 type steel is also used in cases where storage times are particularly long. A new department for sparkling wines at Tenimenti of Fontanafredda-Alba (Piemonte) Italy with tanks in stainless steel has just come into use with a total capacity of 13,000 hectolitres

for storage in refrigerated compartments of sweet Muscat wine, intended for the production of "Asti Spumante." The increase in iron content of the wine after 6 months storage in 3 containers, each of 64,000 litres, was completety acceptable, not exceeding 0.2 to 0.5 mg./l.
The high cost of containers in stainless steel which can be even 70% more than of vats in vetrified concrete and 30% more than construction in reinforced plastic is largely offset by the advantages outlined above. Despite the high initial cost, stainless steel containers used in agriculture turn out to be definitely more economical because of the lack of need for maintenance and because of their long amortization periods.

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Joseph-Victor BAIRIOT

Président honoraire de International Nickel Benelux S.A.
Bruxelles

Stainless Steel for Storage and Handling Equipment in the Food Industry

(Translated from French)

Essential requirements of an equipment used for the handling of food and drink are that it should be clean and sterile in service, thus preventing contamination of the product by corrosion or by the building-up of harmful bacteria. The surface of the equipment used for storage of food and drinks must be capable of being cleaned easily and the material of which the equipment is made must resist attack by the aggressive cleaning and sterilizing agents often used for this purpose. Strength, ductility and the ability to withstand arduous service conditions are also important. Any material used in the food industry must combine all these qualities to allow the designer the maximum latitude in the choice of his design. Economic considerations are always important and the material chosen must be capable of fabrication into the required type of equipment at a competitive price.
Chromium-nickel stainless steel is an ideal choice from all the above points of view. Its resistance to corrosion by a wide range of media encountered in the food and drink processing industries forms the basis of its fundamental suitability. The ease with which the stainless steel surface can be cleaned free from waste food products ensures long life and versatility of the equipment. It is frequently possible to handle a wide variety of foodstuffs, or even chemicals and foodstuffs alternately, in the same piece of chromium-nickel stainless equipment with only the simplest of intermediate cleaning operations, and the advantages of this steel have been widely recognized in the food processing industry as a whole. It is perfectly feasible to consider handling a strong chemical such as caustic soda in a chromium-nickel stainless steel container which after a simple cleaning operation will be ready for use, for example, with beverages such as beer, wine or milk.

The excellent corrosion resistance of stainless steel is largely due to the presence of a thin but very adherent oxide film. This oxide film is insoluble in and impermeable to many liquids and gases, and as it remains intact and tightly adherent to the steel surface the latter is protected from corrosive attack. Even if the oxide film is disrupted, thus exposing the underlying metal, the film is self-repairing, provided that oxygen or an oxidising agent is present, and it is only when the film is prevented from repairing itself that corrosion in the form of pitting or general attack will occur.

The type of chromium-nickel stainless steel most commonly used for handling food and drink products is based on the 18-8 chromium-nickel composition, with additions of titanium, niobium and molybdenum to provide additional resistance to attack in especially severe conditions. Steels of this basic classification are strong and ductile, and can easily be fabricated by forming, machining, welding and all other normal manufacturing techniques used for vessels, heat exchangers, pumps, pipework, valves, etc.

It is now proposed to describe the use of chromium-nickel steels for certain types of equipment for storage of liquid foods in the dairy, brewing and wine industries.

Dairy industry

Chromium-nickel stainless steel has been widely accepted for many years and is almost universally used for dairy equipment such as pasteurizers, plate coolers, centrifugal separators, evaporators and pipe-work handling all milk products. The inherent corrosion resistance of the steel enables strong detergents and sterilizing agents to be used for cleaning purposes, and the easy cleansibility of the surface ensures that undesirable deposits do not adhere to it so that bacteria are eliminated, and the milk is produced under the most hygienic conditions possible. A relatively new application for stainless steel is developing rapidly in this industry in the form of refrigerated tanks for bulk storage of milk on farms, and associated with this is the use of stainless steel for the bulk tanker which collects the milk from the farm tanks and transports it to the collection centres or the dairies. Bulk milk collection is replacing the old method of collection in churns at many of the larger farms in the United Kingdom and the system is spreading quite rapidly in most of the dairy-farming countries throughout the free world. Chromium-nickel stainless steel is the ideal material for the bulk farm tanks which maintain the temperature of the milk at a constant 40°F (4°C). The quality of the bulk milk so produced is undoubtedly improved, for which buyers often pay a premium.

The dairy industry authorities in various countries have their own specifications for stainless steel farm tanks, but basically there are two types in use at the present time, namely chilled-water tanks and direct-expansion tanks. The chilled-water tank system makes use of ice as the coolant, an icebank being built up over a relatively long period of hours and dissipated quickly to give the required rate of milk cooling. This system includes a small refrigeration unit but demands the presence of a chilled-water tank and an icebank controller to regulate the size of the ice reserve. Although independent chilled-water units can be used with farm tanks, the chilled-water system is usually built into the main tank structure.

The direct-expansion tank contains no storage of cooling capacity, so that the refrigeration unit must be capable of extracting the heat from the milk within about 2 1/2 hours. Thus a refrigeration plant larger than that used in the chilled-water system is required and the design of the tank must be such that the refrigerant can circulate directly in contact with the milk vessel.

Bulk farm tanks are provided with an agitator, a level measuring device and a thermometer, all in nickel stainless steel. The tank lid is also usually in stainless steel. In many designs the exterior casing of the bulk tank is also in stainless steel to enable cleaning to be done more easily and to ensure a perfectly hygienic product. All parts of the stainless steel coming in contact with the milk are provided with a polished finish. The tanks are made in a wide variety of sizes in the range of 50-500 gallons (225-2250 litres) and a typical tank is shown in *figure 1*. Many thousands of such stainless steel tanks are now in service throughout the dairy farming world, and as the demand for higher quality milk increases, so will the demand for bulk farm tanks increase.

Brewing industry

As in the case of the dairy industry, there is an increasing demand in the brewing industry for a cleaner, more hygienic and sterile product, and the modern trend in the U.K. brewery trade is for a filtered and carbonated type of beer known as keg beer. This type of beer has greater clarity than the traditional draught beer and is almost universally dispensed from pressurised containers of between 10 and 20 gallons (45 and 90 litres) capacity, or from larger cellar tanks of approximately 200 gallons (900 litres) capacity.

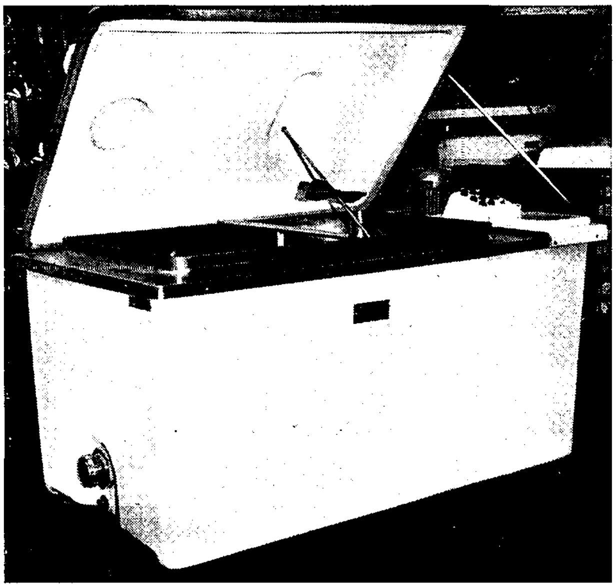


Fig. 1

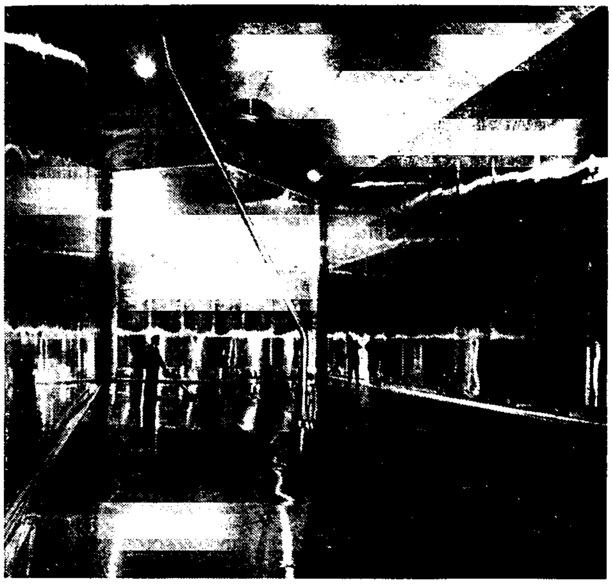


Fig. 2

The advent of this pressure-dispensed beer has created a demand for containers to withstand pressures of several atmospheres and which can also withstand the rough handling which they receive during transportation and unloading. Chromium-nickel stainless steel provides the ideal combination of strength, corrosion resistance and ease of cleaning for this application. The complete absence of maintenance required to the surfaces in contact with the beer give it an added advantage over other materials used for barrels. The grade of stainless steel normally used for barrels is a low carbon 18-8 chromium-nickel austenitic type, basically similar to that used for domestic holloware, catering and food manufacturing equipment. It is particularly suitable for automatic argon-arc welding and is capable of being pressed and spun into all the shapes required for making beer containers. Generally speaking the barrels are of homogeneous stainless steel, the walls being approximately 0.048" (1.2 mm.) thick. Unlike some other metals used for making beer barrels, chromium-nickel stainless steel requires no form of treatment to or coating of the surface in contact with the beer, so that maintenance costs are reduced to an absolute minimum. Furthermore, the high strength and rigidity of the steel makes it very resistant to denting during handling, a feature which is important when the volumetric capacity of the barrel is considered.

An an indication of the growing popularity of stainless steel beer barrels, it should be mentioned that the two major U.K. manufacturers have each installed plant capacity to produce 100,000 barrels per annum. Several European manufacturers are also producing stainless steel barrels and the annual consumption of steel for this purpose is several thousand tons.

In the brewery itself large tonnages of chromium-nickel stainless steel are used for mash tuns, vats, fermenting vessels, filters and pipework, and almost every modern brewery now uses this material for the majority of its processing equipment. Intermediate storage of beer during processing is often carried out in very large tanks, and the world's largest stainless steel brewery tank of this type is shown in *figure* 2 (capacity 288,000 gallons—1.3 million litres).

Wine industry

None the less important from the point of view of hygienic production is the wine industry, where, in France, there is a definite move to put the production of "vin ordinaire" on the same hygienic basis as milk and beer. Once again chromium-nickel stainless steel is the natural choice for wine processing equipment, storage and transport tanks. For the more expensive and higher quality wines, champagne and liqueurs stainless steel equipment is almost essential for maintaining quality whilst at the same time maintaining economic production. Tests over long periods of years with stainless steel at various wine research institutes in Germany and elsewhere have clearly shown that chromium-nickel stainless steel in no way affects the flavour of the wine, even after storage for several years in contact with it, nor is there any sign of pick-up by the wine of metal particles from the steel. Depending upon the sulphur dioxide content of the wine, and its acidity generally, it may be necessary to use a molybdenum-containing grade of chromium-nickel stainless steel for long-term storage tanks and transport tanks. In Germany, where the SO_2 content is limited by law to less than 40 mg./litre, it is quite permissible to use the plain 18-10 chromium-nickel stainless steel, and this steel has given excellent service over many years. However, in France, where the SO_2 content can be considerably higher than this figure, and also in South Africa and Australia, it has been the practice to use the 18-12-3 chromium-nickel-molybdenum steel to maintain resistance to pitting attack.

Stainless steel is gradually replacing concrete and resin-lined carbon steel for storage and fermentation tanks in many of the wine cellarages in Europe and elsewhere. In Germany, several large tanks of more than 1 milion litres capacity have been erected in the last 12-18 months, and very large wine storage facilities have recently been built in South Africa and Australia, all in chromium-nickel stainless steel. One of the advantages of this material is that tanks can be used for storing white and red wines alternately, without affecting the flavour of either, with only a simple washing out procedure employed. Already many thousands of tons of stainless steel have been used for wine storage tanks and the rate of utilization is increasing rapidly. In Australia, the introduction of a competitive storage tank design based on corrigated stainless steel sheet has greatly increased the potential for this material in this field. *Figure 3* shows part of a very large stainless steel wine storage installation in Germany, the storage capacity being 490,000 litres.

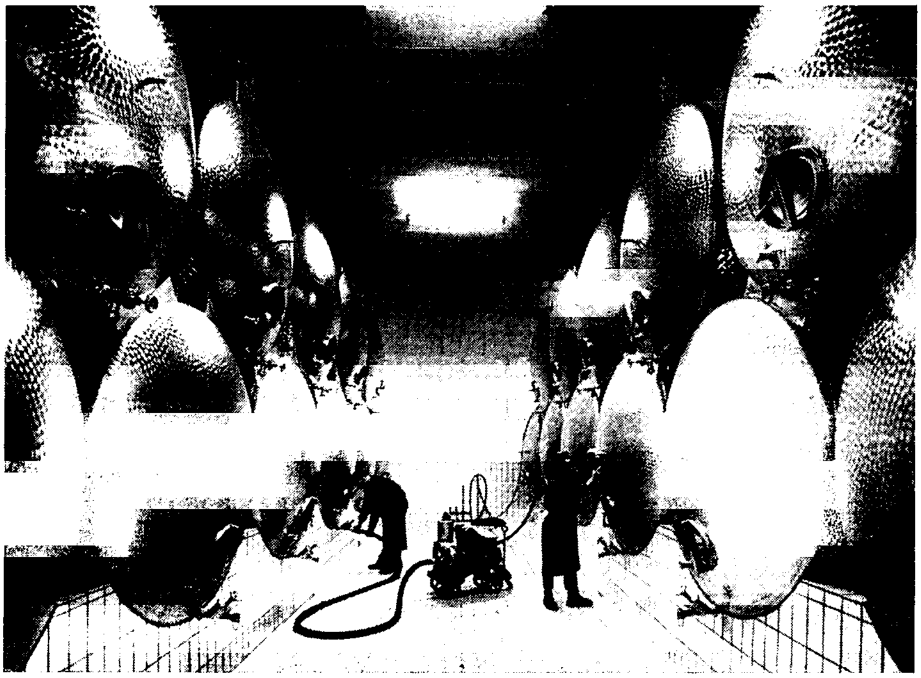


Fig. 3

Transportation of wine in bulk is becoming more popular, and again chromium-nickel stainless steel is widely used for road tankers and for ship-board containers. Several manufacturers are now making transport containers up to 600 gallons (2,700 litres) capacity for shipping wines from Australia to the U.K., and also for transporting whisky from the U.K. to America. The designs of tanks employed are based on a thin stainless steel inner lining reinforced with fibreglass and epoxy resin, with an insulating medium between the inner and outer shells. This type of construction is light in weight, is immensely strong and has stood up extremely well to rough handling in service.

There are a great many more applications for which chromium-nickel stainless steel is used in the food and drink industry, but the purpose of this paper is to draw attention to some of the more outstanding ones and to emphasize the contribution which this material is making in this field.

Jacques M. DEFRANOUX
Ingénieur civil des Mines

Laboratoire "Corrosion" des Aciéries électriques d'Ugine
Ugine

Stainless Steel in the Dairy and Wine Sectors

(Translated from French)

Strictly, stainless steel is not corroded at all by contact with milk and wine: the corrosion rates are absolutely negligible. Corrosion can, however, occur from the use of various compounds to clean the installations (milk) or to serve as additives to the product itself (wine).

Moreover, much research and years of practical experience have shown that stainless steel has no deleterious effects either on the products or on any biochemical changes taking place in them. I propose to sketch very briefly the behaviour of stainless steels in dairy and wine-producing installations, with special reference to the storage aspect.

Milk

(a) Cleaning preparations

The cleaning of dairy installations is exceedingly important, particularly from the health point of view. The methods used need to be studied very carefully with regard both to their biological effectiveness and to the behaviour of the material of which the installations are made. Methods which can be recommended for cleaning 18-10 steel, very widely employed in dealing with milk, include

(i) on the farm (1) rinsing with cold water; (2) 30 minutes in an alkaline detergent at 45-50°C; (3) rinsing with water at 45-50°C; (4) cold, a solution of bleach (200 mg. active chlorine per litre) plus 5 grammes per litre silicate of soda; (5) rinsing with water at 45-50°C. Vigorous brushing during stages (2) and (4);

(ii) in co-operatives and farming companies (1) 1.5% caustic soda; (2) rinsing with water; (3) 1.5% nitric acid; (4) rinsing with water. All stages effected at approximately 65°C.

A great many other methods can also be used.

(b) Deposition of solids

The presence of solids on stainless-steel surfaces is liable to produce localized corrosion, due to the usual processes of differential aeration or to concentration cells. Thorough polishing of the working surfaces will help to prevent deposition. For the same reason the first stage in cleaning must not be carried out at too high a temperature, as the casein would coagulate and cling to the sides of the container. Calcareous furring from the washing water used also has to be got rid of. Descaling agents based on passivated hydrochloric acid should be avoided, and preference given to the sulphamic-acid type, which do not attack 18-10; some manufacturers recommend a 5% solution of nitric acid.

The problem is particularly serious in the case of installations operating with circulating refrigerating brine (plate heat exchangers). Here it is best to use 18-10 molybdenum steel, which is very much stronger; it is sometimes considered desirable to add trisodic phosphate to the brine, as this inhibits localized corrosion. There are a number of preparations on the market for getting rid of the "bronzing" which sometimes occurs. It seems clear that all the corrosion effects observed hitherto in stainless-steel dairy installations can be avoided by adhering to a few simple rules.

(c) Bacteriological aspects

An American Public Health Association study with radio-active tracers has shown that 18-10 stainless steel is superior to other metals and to plastics as regards elimination of bacteria, especially in the case of micrococcus aureus. Careful polishing is of course also a help in this connection.

(d) Bulk refrigeration of milk at the farm

It is safe to say that the employment of stainless steel at all stages of the milk cycle is a major advance. One of the greatest improvements is the on-farm storage of the milk in refrigerated tanks until it can be collected by the co-operative's or company's road tankers. This is of course a much more convenient and hygienic arrangement than the use of churns. It is now being adopted more and more extensively in Europe. The milk needs to be kept only just above freezing-point, so that a refrigerating appliance has to be fitted to the tank. Milk tanks are mada of 18-10 stainless steel and hold several hundred litres; the inside corners are bevelled and the inside surfaces are highly polished to facilitate cleaning. The outside casing is of 18-10 surface-worked or glazed sheet. Between the two is the heat-insulating material (polystyrene, glass wool, etc.). Most tanks have a stainless-steel screw agitator to ensure even temperature distribution.

There are various refrigerating metnods in use, each adapted to the capacity of the tank. We have for instance the ice-bank coolants, mostly employed for capacities of 300-400 litres, and the direct-expansion coolants (immersed or external evaporator). More expensive, but extremely quick-acting, are the non-freeze liquid coolants now coming on to tne market. Some tanks are mounted on tyres so that they can be brought to the roadside. The milk is then pumped into the tankers, which are also of stainless steel. The suction-pipe method seems better than bottom broaching. Some tankers are fitted with an automatic sampling apparatus.

All in all, these methods can be regarded as pretty fully developed, and how far they can be expected to come into universal use depends much more on economic and financial than on technical considerations.

Wine

(a) Steel quality to be selected

It has been found, on the basis of much laboratory experimentation and a good deal of practical experience, that 18-10 stainless steel reacts ideally to wine: only in the case of wines containing sulphur dioxide (more especially white wines) is it desirable to use 18-10 molybdenum steel. Wines can, of course, contain anything up to 400 mg. of sulphur dioxide per litre, so that some equipment manufacturers prefer to make everything in 18-10 Mo to be on the safe side. The manufacturers are throughly familiar with the wines in their particular area, so their judgment can be trusted.

(b) Advantages of stainless steels

(i) Unlike some other metals, stainless steel imparts no metallic flavour to the wine.

(ii) It does not interfere at all with the biochemical processes of fermentation and ageing.

(iii) It does not induce the process known as "casse", or discoloration, in which, where the wine has an unduly high content of ferric salts or sulphides, colloidal precipitates, including phosphates, are produced by the action of cupric salts.

(iv) The acidity of the wine (pH 3-4) is unchanged; any reduction in the acidity, of course, causes wines to go "flat" and lose their bouquet.

Accordingly, stainless steel has been used for equipment of all kinds, from pressing to bottling plant, and including pasteurizers, evaporators, sulphitizers and desulphitizers, and so on, as well as the pipes, pumps, valves, etc., required in handling the fluid.

(c) Storage of wines

Formerly wine used to be stored in casks, which were supposed—wrongly, it now appears—to accelerate ageing, and were exposed to mildew.

For economic and space-saving reasons there has been a growing inclination since the turn of the century to favour concrete vats: these have their drawbacks, however, as the alkaline concrete tends to reduce the acidity of the wine and makes it go "flat". Also, should the concrete crack down to the reinforcement, dissolved ferrous matter may enter the wine and make it go "off" ("turn", change colour). A number of solutions have been suggested, but none of them seems to have entirely overcome the problem.

Stainless-steel tanks, however, as we have seen, do not have these disadvantages. In addition, they are very light in weight, and since they are corrosion-resistent outside as well as inside, they can be used for storage out of doors, even where sulphur dioxide is present (18-10 Mo).

As stainless steel is higly formable and weldable, it is now possible to make these tanks very large indeed. Some tanks have been made simply of ordinary steel with a stainless-steel lining, but in such cases of course the outside has to be specially corrosion-proofed.

Conclusions

In both the milk and the wine cycle stainless steel has proved outstandingly valuable, as more can be done with it and it even lends itself to the introduction of new methods altogether. It may be expected to come into wider use, as a natural consequence of the industrialization of agriculture in line with the growing movement towards co-operatives and farming companies.

E. KLENK
R. MAURER

Staatliche Lehr- und Versuchsanstalt für Wein- und Obstbau
Weinsberg

The Use of Steel Containers and Stainless Steel in the Wine Industry

(Translated from German)

Considerable changes have taken place in the wine industry over the past few years. A mere 15 years ago wine was fermented and matured almost exclusively in wooden vats, but the expansion of the market brought about by a marked increase in wine consumption made it necessary to concentrate and enlarge storage capacities in a manner which would have been impossible using traditional wooden vats. At the same time, health regulations with regard to wine vats were made stricter and there was a rapid increase in the demand for large containers that were easy to clean. As a result, steel vats now hold pride of place in all large wine-cellars and many firms have only kept a few wooden casks as showpieces. Moreover, a number of modern techniques used in winemaking were only made possible with the advent of steel vats.

Advantages of steel vats for wine producers

Steel tanks possess a number of very definite advantages for the wine producer. The chief of these are as follows:

1. they may be obtained in any size required;
2. they have a long life;
3. they are easy to clean and sterilize thanks to their pore-free inner surface;
4. stock does not dwindle;
5. they are gas-tight and thus suitable for long-term storage;
6. they may be used for special purposes such as the application of pressure, heat, cold, etc.

Disadvantages of steel vats for wine producers

Some of the advantages listed above might in certain circumstances be regarded as disadvantages. Thus the good qualities of heat conduction possessed by steel, which are a great advantage when it comes to maintaining the contents of a vat at a moderate temperature, may be positively harmful where cellar accommodation is bad and the temperature varies widely.

Then again, the suitability of steel tanks for slow-maturing wines kept for a long period cannot be regarded as a desirable characteristic when a wine is to be sold young.

A particular problem encountered when using non-alloy steels is the choice of lining. The best results to date have been obtained with vitreous enamel, but this is very expensive and is not easy to repair when damaged. Linings of plastic or lacquer have not so far proved entirely satisfactory and often need replacement. This problem does not, of course, occur when the vats are of stainless steel.

Special consideration must also be given to the type of external protection provided. Whereas previously the coatings usually applied did not afford protection for any length of time, it is now possible to obtain a high degree of protection against corrosion by the use of multi-component lacquers. There are, however, still a number of weak points, namely those parts of the tank which are subjected to considerable mechanical stress, such as the inlet pipes and the area adjacent to the manhole.

Types of container used

(a) Storage tanks

Storage tanks are those tanks which are used exclusively for storing and ageing wine. They are usually of very simple design and are only provided with a minimum of necessary fittings. In the German wine-growing area they usually have capacities of up to 60,000 litres, and larger vats tend to be constructed as free-standing silos. Stainless steel has been much used for this type of container because of the low wall-thickness values required and is generally recommended by the technical institutes concerned.

(b) Pressure tanks

Pressure tanks are used for a number of purposes in the wine industry. They are mainly used as fermenting vats. The vessels used for this purpose are generally able to withstand a maximum working pressure of up to 6 atm. There are roughly speaking two types, viz. pressure vessels for the fermentation of white wine and those for the fermentation of red-wine pulp.

These two types of tank differ in design. The tank used for the fermentation of white wine is very similar in design to the storage tank except that it is made of thicker plate and is provided with the necessary pressure-resistant fittings. Because of the special requirements involved, the tank used for the fermentation of red wine is provided with a large outward-opening outlet for the pulp. These vats are often designed to withstand working pressures of up to 8 atm.

Pressure tanks are preferably provided with an enamel lining *(Fig. 1)*. The combination of thick walls and enamel coating gives these tanks an unusually long life, but some vats still have linings of stove enamel or lacquer. Little use has so far been made of pressure tanks of chromium-nickel steel because of the large amount of material required and the correspondingly higher price. Experiments with plated steels have been restricted to individual cases but there is no doubt that pressure tanks made from special steels would in fact arouse a great deal of interest.

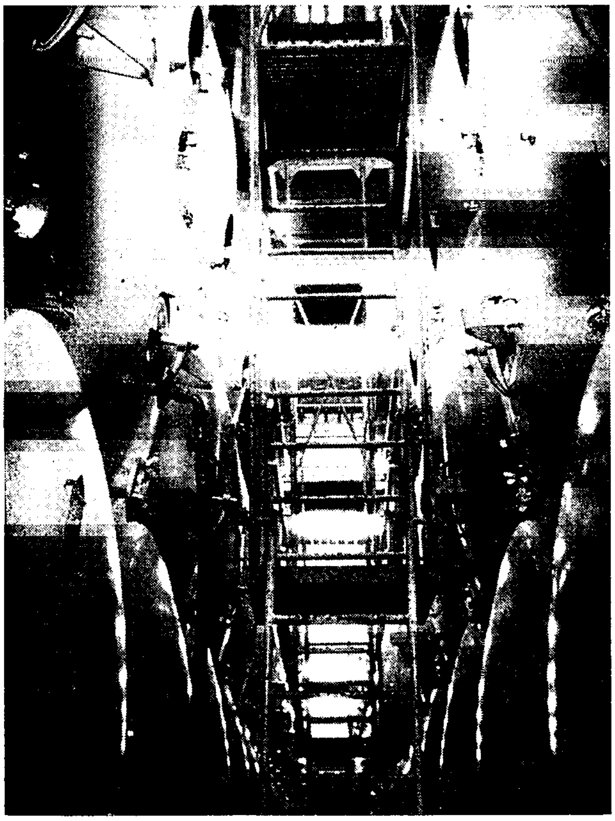


Fig. 1

Fig. 2

Pressure tanks are of special importance in the production of sparkling wine. Here too the shortage of labour has, in many cases, forced the industry to abandon the bottle-fermenting process which required a large number of workers and to produce sparkling wines by a mass fermenting process in steel tanks. If care is taken there is no reason why the quality of the products thus obtained should not to all intents and purposes be as good as bottle-fermented wines. Another field in which pressure tanks are used is in the production of so called *Perlwein* which also has a high CO_2 content at a pressure of less than 2.5 atm.

(c) Tanks for special purposes

The first tanks required in the wine-making cycle are the drainage tanks. Traditional tanks were horizontal and provided with drainage plates or grids and a large outlet but were otherwise very similar in design to ordinary storage tanks. It was soon found that this design was not efficient in rapidly draining off the grape

juices and modern drainage tanks are usually vertical with upright plates. Square containers with tilted floors containing built-in drainage plates are also on the market and in some cases these are provided with screw conveyors for removing the pulp.
Certain techniques require double-walled tanks, which are used mainly for stabilizing the potassium bitartrate content in young wines. In this process the contents of the tanks are cooled to about —4° C so as to eliminate the potassium bitartrate from the solution which at this temperature is saturated. Cooling is effected using cooling plates.
Double-walled tanks are also used in the manufacture of red wines. Particularly good results have been achieved in the fermentation of the red-wine pulp by heating the cold pulp in the fermenting tanks with hot water through the double wall. This causes fermentation of the pulp to commence sooner, speeds up the process as a whole and results in a better-quality product.
A double-walled tank is also required when heat is used to stabilize wines. Here the wine is heated to about 40-45° C and cooled to cellar temperature. This treatment eliminates a number of unstable products, mainly protein material, and is best carried out under a CO_2 cushion so as to prevent the flavour of the wine being impaired. Double-walled pressure tanks are, however, required.
The third special type of tank used in the wine industry is known as a mixer or blending tank. These tanks are of more or less the same design as normal storage tanks but have a capacity several times that of the usual vats. They are generally provided with stirring elements which ensure that the contents of the tank are well mixed. Nowadays they are built in the form of large vertical silo-type tanks of stainless steel and have a capacity of up to 1,000,000 litres.

(d) Other steel containers

Besides the vats specially designed for storing wine, most cellars will, of course, also use a large number of other steel containers. Particular mention might be made of the *tubs* which hold between 500 and 2,000 litres and are used for storing the grapes during the harvest. Where growers can afford it, they prefer to use square tubs made of stainless steel.
Many other types of steel vessels are used in the wine industry, *e.g.* buckets, syrup vats, filling cans, drip pans, etc. Stainless steel is nowadays the material generally used for all these vessels.

(e) Designs

The most common form of wine vat is the horizontal, cylindrical vessel. Non-pressurized casks are provided with slightly concave bases while high-pressure tanks have floors shaped like a flat-topped arch. From the wine producer's point of view, it is best if the front portion of the floor is about 3% larger than the rear. This facilitates optimum filling and drainage of the tank which is positioned with its longitudinal axis exactly on the horizontal without it being possible for an air-lock to form during filling or for the tank to be left partly filled. Conical tanks of this type are, however, more expensive and therefore not much used. Cylindrical tanks are preferably positioned horizontally but vertical tanks are used for special purposes.
Another type of tank which is steadily increasing in importance is the large free-standing "wine silo". Vats of this type can, of course, only be used for very large quantities of wine but have the advantage of being extremely cheap. These vessels may have capacities of up to 1,000,000 litres. The first experiments made were with tanks of non-alloy steel, but nowadays they are made exclusively of stainless steel. A number of well-known wine-processing firms in Germany already own tanks of this kind, and they are also found abroad.
The industry also uses a number of differently-shaped tanks, such as oval tanks with straight vertical sides, but these are only made in smaller sizes. Recently, concave tanks holding up to 10,000 litres were brought on to the market. Both these types of tank are mainly made from stainless steel, the object is to help prevent the considerable waste of space where round tanks are used.
It was with the same purpose of saving space that square wine storage tanks were introduce *(Fig. 2)* Initially it was difficult to prevent the side walls of the tanks from bulging out and attempts were made to solve

the problem by fitting tie members and external reinforcements. The resultant casks were ugly and awkward to work with and efforts were then directed towards the elimination of additional reinforcements in straight-walled tanks. One solution was to stamp corrugations in the straight tank walls and this did in fact enable the required degree of rigidity to be obtained. When steel tanks of this type are used, the number which can be accommodated exceeds even the number of concrete tanks which would be possible. They may be located in a cellar and be accurately adapted to the space available, taking into account vaults and niches. Such tanks are also best made of stainless steel.

Some mention should also be made here of the method of lining concrete tanks with chromium-nickel-steel foil, which has been tested in a number of cellars and has given good results. The chromium-nickel-steel foil is inserted in the concrete tank in rolls and is there welded to a steel framework embedded in the concrete. This method is relatively costly and it is often more advisable to buy a new vat rather than re-line the old concrete tank.

Chromium-nickel steel in the wine industry

From what has been said above it should be clear that chromium-nickel steel is widely used for wine vats. It has such ideal characteristics from the point of view of oenology that its importance in the wine industry is bound to increase. Besides being used for containers it is already being used for a large number of appliances in the wine industry such as pumps, valves, pipelines, heaters, centrifuges, fillers, sterilisers and other equipment which comes into contact with the wine.

The material most used for general purposes in the wine-processing industry is austenitic chromium-nickel steel No. 4301. This steel is sufficiently resistant to corrosion by the usual ingredients of wine and is much used for containers. Equipment which is exposed to considerable thermal stress during production is best made of stabilized steel No. 4541. Only when stresses are extreme, and particularly when a considerable amount of sulphuric acid is present, has it proved necessary to use molybdenum steels. Steels 4401 and 4571 have given good results when used as conduits for sulphuric acid and they have also been successfully used in SO_2 gas sterilisers.

Where sheet is to be used for equipment for the wine industry, we nowadays prefer cold-rolled sheet (process IIIc). This is then merely pickled and the welding seams ground. Only a few firms take on the additional cost of a fine-grinding, polishing or charing process. Such processes are not necessary from the winemakers' point of view but the vats are checked visually. It is unfortunately impossible to obtain cold-rolled sheet which is more than 3 mm. thick and hot-rolled plate with surface finish IIa is then generally used.

Steel in its various forms is therefore an important material in the modern wine industry and in fact made possible the development of modern techniques. There will doubtless be a large number of new uses for steel in the future, and particularly for corrosion-resistant steels, which represent one of the most valuable technical contributions to the development of the modern wine industry.

Dr.-Ing. Heinz QUEST

Institut für Maschinenwesen der Bundesversuchs- und Forschungsanstalt für Milchwirtschaft
Kiel

Stainless Steel in Apparatus and Machinery for Milk Production and Processing

(Translated from German)

In machinery for milk production and utilization, there are special requirements for the materials in those parts which come into contact with the milk or the products made from it, since, in view of its intrinsic function as the only food for mammals in their first few weeks of life, it contains all the substances required for nourishment and is easily digestible. It is therefore also a good nutrient medium for micro-organisms, especially bacteria. These convert the lactose contained in the milk into lactic acid through their metabolism, etc. causing the albumen in the milk to curdle and thus making the milk unusable for many purposes. On the other hand, this bacterial metabolism is utilized in a controlled form to produce sour milk products. Other bacteria, agents of putrefaction, release metabolic products which are harmful to health in the milk. Milk is also a good nutrient medium for agents of disease, e.g. of tuberculosis and dysentery, so that unless appropriate measures are taken they can be spread by milk. Propagation of bacteria is prevented by cooling to +2 to +4° C, while germ reduction (pasteurization) is achieved by heating to 60-85° C and complete elimination of germs (sterilization) by heating above 100° C. These characteristics of milk make it necessary for the apparatus and machinery used in production and processing to be thoroughly cleaned of milk residue and disinfected after use. For cleaning, use is made of lye solutions at a temperature of about 65° C with a pH up to 11.5 and often containing chlorine for disinfecting.

It is also important for the milk not to be in contact for a long time with copper or copper alloys, because copper accelerates the oxidation of the milk fat catalytically, causing loss of flavour.

The materials should not affect either the smell or the taste of the milk. It is self-evident that they must be physiologically harmless. Thus the German Foodstuffs Law (of 21.8.1958, BGBl I, No. 46, p. 950) forbids *inter alia* the use of lead and tin for these purposes.

These conditions are decisive in the choice of materials for parts which have to come into contact with the milk. Some of these regulations are even laid down in a special Milk Law (of 31.7.1930; RGBl I, p. 412) which must be observed in addition to the Foodstuffs Law.

Materials for parts coming into contact with milk

Copper, bronze and brass were used at first, hot-dipped for the reasons given above. Tinplated mild steel is still used today, e.g. for milk churns. Because the tinning has only a low mechanical strength, it has to be regularly replaced.

Glass-enamelled mild steel was also used until recently for containers; its corrosion resistance satisfies all requirements as long as the brittle enamel coat is not damaged.

As a result of the shortage of tin during World War II tin-plating of milk churns had to be replaced by stove enamel, an emergency measure which did not prove satisfactory.

With the coming of aluminium, this material also came into use in the diary industry. Pure aluminium, Al 99.5, is widely used for containers of the most diverse kinds, in particular transport containers which today are mostly made from this material, and it has given good service when suitable cleaning materials are used. Some of its alloys are also used on account of their greater stability under certain conditions, although their corrosion resistance is not as good. See also: *Die Werkstoffe des Molkereimaschinenbaus,* Deutsche Molkerei-Zeitung, 75, p. 572, 1954. Protective coatings produced by anodic oxidation, in conjunction with a layer of varnish, are applied as an additional corrosion protection, e.g. on milk churns made of an AlMgSi alloy.

The low mechanical strength and poor corrosion resistance of pure aluminium were the reasons for the rapid progress of stainless steel in this field, beginning in the thirties and only interrupted by the shortage of nickel during the war and post-war years. Its advantage over pure aluminium is to be found in particular in the much higher corrosion resistance, permitting a freer choice of cleaning agents and cleaning temperatures. The possibility of using even nitric agents, which not only serve to passivate the steel but also facilitate the removal of hardened milk residue (milk stone), is of great value in plant hygiene. The disadvantage of its higher specific weight and price is partly offset by its greater strength. Thus in milk-processing plants today, almost all the parts which come into contact with the milk are made of stainless steel. The milk piping with its unions and shut-off devices, milk pumps, heat exchanger plates, bowls and plates of cream separating centrifuges, cheese vats and moulds, cream maturing vats for souring the cream for churning, butter makers for batch and continuous operation, vacuum evaporating equipment for condensing milk and spray towers for producing milk powder, vessels and storage tanks, instruments and many other types of equipment *(Figs. 1 and 2)*, are now of stainless steel.

Milk churns of stainless steel, however, are being used decreasingly because they are too expensive and the farmers to whom most of them belong are not prepared to invest the necessary capital in them. Another reason is probably also the increased danger of loss by theft.

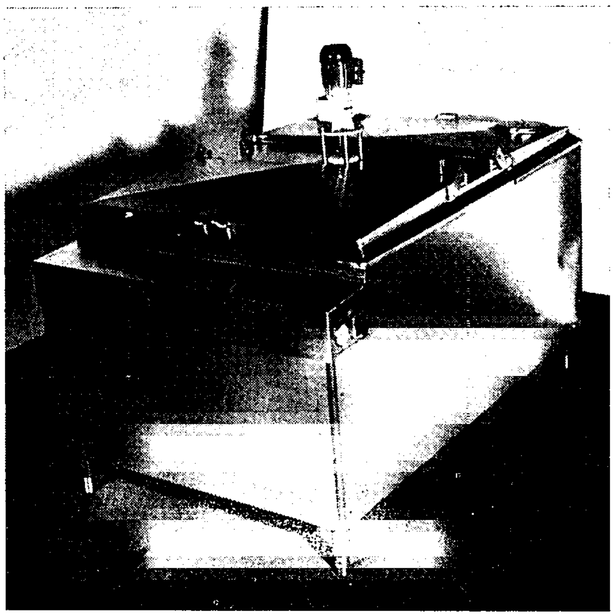


Fig. 1 — Milk cooling tank for farms

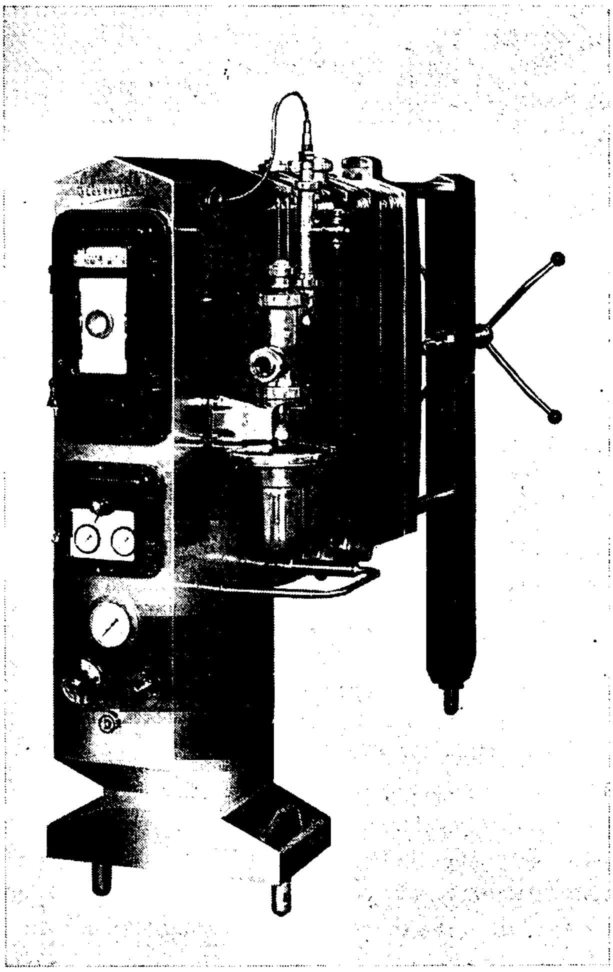


Fig. 2 — Pasteurizing apparatus for milk

In the case of apparatus for milk production on farms, stainless steel is making much slower progress. The reason is first the high price, which is more serious for farmers than in industry, and secondly the lower hygiene requirements usually prevailing here. Only with the use of tanker vehicles for collecting the milk, less frequent than previously, thus requiring the milk to be kept longer on the farm, did the hygiene requirements rise, and with them the use of stainless steel for cooling vats, farm containers, immersion coolers and milk piping from the milking machine in the cowshed to the milk store became more frequent.

Practically, only austenitic chrome-nickel steels of the 18-8 type are chosen, often with 2% added molybdenum to give better resistance to chlorine ions in the cleaning agents and the cooling liquor. For welded parts the low-carbon or stabilized grades are chosen, so that there is no need for heat treatment after the welding. The appropriate grades are used foı castings. Casting steel with 30% chrome which was sometimes used in the past has largely disappeared, mainly for manufacturing reasons. In any case, cast parts are avoided as far as possible and replaced by forgings, which are sometimes welded together from two drop forgings, e.g. valve casings.

Previously used 18% chrome steel for parts subject to little corrosion is practically no longer used. The reasons are first the great care which must be used in welding in order to avoid intercrystalline corrosion at the seams, and secondly the limitation of the number of grades of steel handled by the manufacturers, in order to avoid confusion, both reasons which are particularly important when skilled personnel are lacking.

Surface treatment

Apart from the fact that stainless steels only exhibit their greatest corrosion resistance when they have a smooth surface, such a surface is also needed for hygienic reasons, since infected milk residues stick in the smallest surface defects and it is particularly difficult to remove them. Therefore, the surface quality must correspond at least to a fine polish with an 18% grain. This requires considerable manual labour, especially in the case of complicated shapes. But even for simple shapes, e.g. the tubes, in which the nominal diameters are most frequently 40 and 50 and large tanks, the amount of work required is considerable. Therefore, other work-saving processes have been introduced. 6 m. long tubes, for example, which were previously longitudinally ground internally on belt grinders, and other parts, are now often electrolytically polished or a sufficiently smooth surface is produced by very carefully executed cold drawing. In the case of tanks, the trend is towards the use of cold-rolled sheet whose surface quality satisfies the requirements, so that only the welds need to be finished-ground. The outer surfaces are fine ground or polished so that the germs which have dried on there do not pass into the air and cause air-borne infection of the milk or milk products. The machinery should also give a hygienic impression just from their outside appearance.

In the case of moving parts, the running properties of stainless steel are also important, e.g. in the cocks which are the most frequent shut-off devices for milk. Since stainless steel tends to seize, the cone-shaped surface of the cock plug is hard chromium plated and polished, giving good sliding properties.

Stainless steel for other purposes

Dairy buildings are very damp during working hours, making it necessary to protect non-alloy steel components such as machine frames, sheet metal housing, etc. against corrosion. This is done in the usual manner with a coat of paint, but this only withstands the chemical, thermal and mechanical stresses for a relatively short time and then has to be renewed. This work, which interrupts the process, is particularly inconvenient because only the evening and night time is available for doing it, since most dairies also work on Sundays and holidays. One is often also limited in the choice of paint solvents, because on the one hand only quick-drying paints can be used, and on the otner it is necessary to avoid any effect on the taste of the milk caused by the solvents evaporating as the paint dries. The trend is therefore towards the lining of such parts as centrifuge and heater frames, electric motors, etc. with stainless steel sheet, or making the outer cladding of cooling tanks, storage tanks and other vessels, churns and bottle washing machines completely from stainless steel sheet. This, of course, requires a much higher capital expenditure, but this pays for itself relatively quickly, especially with today's high wages. The machines are also more hygienic in appearance, an advantage which must not be underestimated. Therefore many other parts, such as supports for piping and fittings, railings and hand-rails, corner protection strips in tiled walls, etc. are also being made from stainless steel.

Development prospects

The field of application of stainless steel can be extended much further in the dairy industry, but a competitor has appeared in the shape of certain plastics which are already showing their first successes. In particular the high corrosion resistance, the low specific weight, good sound absorption, low thermal conductivity and the low price make plastics appear predestined for many purposes. Even the mechanical strength is high, particularly in the case of the fibreglass reinforced plastics. Disadvantages are the low resistance to heat and low surface hardness of some plastics. Much development work still remains to be done in this field, but further successes can be expected.

Louis GENDARME

International Nickel Benelux S.A.
Bruxelles

Road Transport by Tankers

(Translated from French)

Road haulage, particularly of liquids and foodstuffs, is currently undergoing tremendous expansion. Tankers are the vehicles most used for this purpose, in the form either of trailers, semi-trailers or simply containers carried on a lorry. In the case of semi-trailers the prime mover supports part of the load. In that of outright trailers it bears no vertical load, only a horizontal traction stress. Where containers are placed on a lorry the latter of course bears the whole of the vertical load. If the products carried are non-corrosive, or if possible deterioration in colour, taste or composition is a minor consideration, tankers are usually made of high-carbon or low-alloy steels.

Stainless steel in road tankers

On the other hand, for the carriage of products which are corrosive or must not be allowed to deteriorate in any way, it is essential to use higher-grade materials which will not react to or pollute these products. Foodstuffs, for reasons of hygiene, have to be carried in non-reactive containers; even aviation spirit (kerosene or JP-4) is nowadays transported in stainless steel tankers to keep it pure, as this is vital to the safety of the aircraft.

Two types of material are used for such purposes, namely "stainless" or high-alloy steels, and light aluminium-base alloys. As the subject of the present Congress is "Steel in Agriculture," I propose to deal today with stainless-steel road tankers, and more specifically with a particular design which looks as if it had a big future, owing to its various advantages as regards quality, flexibility, convenience in use, and lightness.

The advantages of stainless steel for the construction of road tankers are well known. Here are a few:

1. Stainless steel is very easy to clean, either with the usual type of detergent or with more abrasive agents such as caustic soda, which would damage any other material. Time is thus saved in cleaning, with a consequent shortening in turnround times; in addition there is less risk of contamination by the previous load—an important consideration in dealing with large tonnages and expensive freight.
2. Stainless-steel tankers can be used to carry a wider range of products than tankers made of other materials. This means, among other things, no need for empty return trips: it is perfectly possible—in fact it has been done—to send a tanker carrying kerosene on the outward run, and bring it back carrying wine or fruit juice.
3. The mechanical properties of stainless steel are firstclass, and are not impaired by the treatment and working of the metal during construction.
4. Welded joints show no tendency to fatigue fracture, a very common hazard in transport vehicles.

5. As the corrosion-resistance of stainless steel is accurately calculated in given conditions, there is no need to add an extra "anti-corrosion" thickness, or apply coating or painting of any kind.
6. This corrosion-resistance has the further attraction that the outside surface will continue to look pleasing irrespective of the operation conditions: of whatever type—glossy, matt, semi-matt or otherwise finished—it is dust- and dirt-repelling. Consequently it is easy to clean, a point much appreciated by some users.
7. Stainless steels will withstand far wider extremes of temperature than many other materials, in fact than any others that are used in the construction of tankers. Moreover their low heat conductivity is an advantage in the carriage of perishable goods: as the loss of heat is less, these keep much better.
8. In the course of the handling they undergo, road tankers are inevitably liable to sustain scratches, dents and other minor damage: these, however, in no way interfere with the corrosion-resistance of stainless steel, which is a solid homogeneous product requiring no surface protection.
9. The tanker shells are extremely strong and practically unpierceable. There is no repair problem. If de-denting or welding is necessary, the equipment required is of a type widely available and does not need to be operated by specially skilled workmen.
10. As a result of all these factors, a road tanker usually has a much longer life than its prime mover: some hauliers talk in terms of one tanker to three prime movers.

In a word, stainless-steel road tankers are long-lasting, usable for a great many different purposes, easy on the eye and convenient to use.

On the other hand they are admittedly very heavy. And in transport weight is the big problem.

In practice, road tankers used traditionally to be constructed as follows: a container, designed on the accepted lines of conventional static metalworking, was placed on a beam frame, the beams resting at the rear on a set of wheels with one or more axles, and at the front on a bearing which transmitted the load to the prime mover. This arrangement takes no particular advantage of the special mechanical properties of stainless steel.

Lightweight stainless-steel road tankers

One school of thought has endeavoured to introduce greater lightness by making the container do the job previously performed by the frame. This brings the total weight of the tanker down to round about that of the lightest ones made from other materials. The design here consists basically in a thin-gauge shell reinforced by "top-hat" stiffening rings placed circumferentially along the entire length of the tank. As in aircraft construction, the tank shell is made to take its share of the bending, shear and torsional stresses, the sag being checked by the spacing of the stiffening rings.

It presents no problem provided the comparative thinness of the shell is born in mind. This means that attachments must not be welded direct to the shell, nor of course the sections transmitting the load and stresses to the running gear, fifth wheel and kingpin: these are best welded to the sides of the "top-hat" rings, and not, for the same reason, to the web.

The thin gauges used in this connection have incidentally one special feature which is an advantage: the tank is rendered more flexible and better able to stand up to jolting from uneven road surfaces (it is a recognized fact that an over-rigid structure is more trouble than it is worth). The design has the further advantage, in the case of cooled or heated containers, that the reinforcing rings can be connected to two collectors, and so used for either cooling or heating: the heating or cooling medium circulates through the rings, where contact with the product requiring temperature control is closest, and thus ensures optimum exchange efficiency. In addition, thermal insulation is as easy as A B C: all that is necessary is to fill the space between the tank shell and the stiffening rings with any recognized insulating material.

Where the internal pressure is high it is obviously best, from the point of view of resistance, to choose a circular section. Should the service pressure increase, there is no need to increase the shell thickness: it is enough to move the stiffening rings closer together and calculate them appropriately.

This type of self-bearing tanker can also be of oval section. This is more expensive than the circular form, as is the cylindrical/conical section. Choice of section will depend on the basic parameters for the carrier, such as maximum volume or maximum capacity for given sizes, or restrictions as to the neight of the vehicle. The number of compartments or partitions is fixed in the same way as for conventional tankers.

The self-bearing stainless-steel tanker is a comparatively recent development, though some of them have already travelled several hundreds of thousands of kilometres. Thanks to the various features I have described, it is progressively, and increasingly, ousting the traditional type: it is now to be found in all countries, and most manufacturers are able to supply it.

I have so far dealt only with self-bearing road tankers. To give a fuller picture of the position, I should also have described the steadily growing part which stainless steel is playing in transport generally, including for example the road, rail and sea containers for international shipments.

It is considered in some quarters that in a few years' time three-quarters of the world's freights will be carried by means of these containers: a piece of apparatus will no longer have to be packed or transhipped, but will simply be put into a container by the manufacturer and delivered, still in the container, to the user.

Just a few words on what needs to be done where ordinary carbon steel would fail in particular circumstances. It does so under various types of external stress.

Thermal stresses

For exceptionally high temperatures, the addition of such elements as chromium, molybdenum and/or nickel gives a better creep point and oxidation resistance. There is quite a range of such steels, from the low-alloy types to the refractory chromium-nickel qualities. For low temperatures the metal is kept ductile by adding nickel: there are 2%, 3.5%, 5% and 9% Ni steels, which are usable down to —200° C, while 18-8 steels can be used at not far from absolute zero.

Mechanical stresses

Addition of manganese, silicium, nickel and so on tremendously increases the strength of the steel. The qualities range from the high-tensile steels to the maraging steels with a resistance of around 200 kg. per sp. mm.

Chemical stresses

Addition of chromium, plus nickel and molybdenum, renders steels "stainless" against just about any form of chemical attack.

I could go on almost indefinitely. But I need only refer you to the steelmakers' catalogues, which will show you that steel can come up with the answer to *any* problem.

In the case we were hearing about, it was complained that traditional stainless-steel road tankers were too heavy. So they were. So the thing to do was tackle the weight aspect. And you have heard how the designers tackled it. The new models now weigh about the same as the lightest of their competitors in other materials, while retaining the special advantages of stainless steel.

I quote this instance to show that even where it looks as though steel could do no more, it always can. You have only to ask.

Dott.ing. Valerio PEROTTO

Servizio Sviluppo del mercato—Terninoss
Cologno Monzese

(Translated from Italian)

I am not proposing to go over again what I said in my paper, but I would just like to make the following points.

It is quite true, as has been repeatedly pointed out, that there is a particular quality of stainless steel for every conceivable purpose. Nevertheless, I would stress that in the dairy industry, the wine industry and the foodstuffs sector generally the quality most commonly used is 18-8, and that there is no need to employ qualities with higher properties except in special cases where they really are essential, as for instance for refrigerating plant operating with cooling brine, tanks for wine with a high sulphur-dioxide content, and so on.

On the other hand, the mere fact that an object is made of stainless steel will not in itself ensure that it gives perfect satisfaction: it is necessary also to give careful directions concerning both its manufacture and its use. In my paper I quoted American standards and directions as to selection of material, sterilization and so on. Three cases occurred recently in Italy of corrosion in 18-8 milk tanks supplied by a well-known firm; it was established at the subsequent inquiries that these were caused respectively by the fact that

(1) the brine has been too concentrated;

(2) washing with hypochlorite had been continued for over twelve hours;

(3) an iodine-based sterilizing fluid had been used.

It is to be hoped that in future fuller directions for use will be given in Europe (as they already are in America), especially in the case of stainless-steel equipment to be sold to farmers.

Installations made of reinforced plastic in combination with stainless steel should be avoided. For example, there exist plastic milk tanks with stainless-steel agitators, manholes and cleanout doors. These are cheaper, but have the serious disadvantage that the couplings between the plastic and the steel portions are not secure. In addition, the outside of the tank has to be of stainless steel, as it must be completely airtight and this can only be ensured by welding. Where it is of plastic, the sudden changes of temperature when the tank is washed, as is usual practice, with powerful jets of hot or cold water tend to split it, so that after a time the water finds its way into the insulating layer.

A stainless-steel installation must have all its accessories—connections, cocks, filters, etc—also of stainless steel. If these are of electro-plated bronze or chromium-plated brass a primary cell forms between the steel and the other material and corrosion develops, or at the very least there is metal contamination of the food product inside. There was an occasion at the Oecological Institute at Asti when an unusual increase was detected in the amount of ferrous matter in the wine in a particular tank. All the chromium plating on the cocks and connections was in order. Finally it was discovered that the wire-gauze reinforcement of the rubber linings had worn through to the lining surfaces.

Lastly, I would emphasize that stainless steel is in no way out to take the place of ordinary iron and steel, not merely for obvious and unavoidable reasons of cost, but primarily because for the applications in question there is no need for specially high corrosion resistance. On the other hand, stainless steel can be, and is increasingly being, used in preference to other corrosion-resistant materials both old and new, such as copper, aluminium, glass, earthenware, plastics and wood. We may hope, therefore, that both stainless and ordinary steels will come increasingly into use on farms with the progress of efforts to rationalize agricultural equipment, and in the long run enable farmers to achieve higher production at lower cost.

François AILLET

Fédération nationale des coopératives de céréales
Paris

Problems Related to the Use of Steel in Grain Storage

(Translated from French)

The formation of auxiliary collection centres that can easily be moved from place to place may, for the following reasons, be of interest to storage organizations which cover a wide area;

(a) an auxiliary collection centre helps to prevent congestion in deliveries at the organization's silos during the July-August peak period.
(b) an auxiliary collection centre avoids long hauls for producers remote from storage facilities;
(c) an auxiliary collection centre improves the profitability of the collection lorries sent by storage organization to distant producers; when an auxiliary centre exists, lorries no longer have to go to the producers' farms, but only run to and fro between the auxiliary centre and the storage organisation. Turn-round times are improved, for lorries run fully laden and are loaded rapidly with suitable equipment.

An auxiliary ollection centre could consist of the following:

(a) storage amounting to 3,000 quintals (bushels), consisting of three 1,000 quintal bins, which can be added to in 3,000 quintal stages;
(b) a reception hopper easily accessible to all sorts of vehicles (lorries, trailers, etc.);
(c) a separator to remove coarse impurities such as stones, straw, etc.;
(d) a continuous weigher to weigh deliveries;
(e) an elevator with a sufficiently high capacity to handle arrivals easily (a minimum of 400 to 500 quintals/hr.).

It is desirable for the whole auxiliary centre to be *mobile* and easily transportable from place to place, as it might be necessary to move the entire plant if grain production in the original zone should fall for various reasons such as crop changes or large-scale construction work. There could be mobile collection centres at points where the heaviest grain deliveries take place; such points could even move during a single harvest.

Use of travelling cranes *(portiques mobiles)*

Many ports have quayside conditions which prohibit the construction of permanent cranes for loading and unloading grain. Such quays are criss-crossed by railways, haulage ways, etc., or are shared by several firms dealing in commodities such as coal, timber and so on.

Grain silos on such sites would require mobile gantries that could be easily moved away from the quayside at right angles to the waterway.

A mobile gantry for loading and unloading grain should have the following features;

(a) a minimum capacity of 2,000 quintals/hr.;
(b) a grain weighing system;
(c) a chassis with multiple tyred wheels to reduce the force on the ground;
(d) means of withdrawing the gantry at right angles to the quayside.

Partitions for flat-bottomed storage bins

At the present time there is no available partition for flat-bottomed storage bins to enable the entire contents of the bin to be removed by means of a raking device. The partitions used in the past incorporate tie-rods which prevent all the grain from being raked, and leave large quantities of grain at the bottom of the partitions.

A new type of partition should be designed without projections such as tie rods on the side in contact with the grain.
It might, for example, be possible to construct L-shaped partitions with the angle reinforced with a sloping plate; this would allow a bin to be emptied completely by means of the raking device alone.

Information regarding farm storage equipment—a problem in communications

Many grain producers install storage facilities on their farms to permit rapid handling of the large quantities of grain threshed by combine harvesters. At present farmers can obtain most items such as steel bins, elevators, driers, etc., separately to enable them to construct grain-storage installations. However, there is no storage unit on the market which can be bought as such by the farmer. Furthermore, site preparation work is often carried out by the farmer without precise information being available which would enable him to adopt the best layout.
It would be desirable for manufacturers of farm grain-storage equipment to market 3 or 4 ranges of complete installations comprising all the equipment required for handling and storing grain, and for them to assist in the installation of such equipment by providing farmers with typical layout drawings showing them the best layout for obtaining high efficiency from their machines and enabling their work to be well organized. The provision of such information for farmers could constitute an effective means of promoting the better use of steel in grain storage on the farm.

Joachim LOUIS

Mannesmann-Landtechnik GmbH
Düsseldorf

A modern Method Preservation as a Suitable Means for Increasing Productivity in Large-scale Cattle Rearing.

(Translated from German)

The problems encountered by progressive farmers and architects in the reconstruction of old farms can seldom be solved today by traditional methods and forms of construction. As in industry, new production methods requiring quite special forms of construction were developed in post-war agriculture. On farms concentrating mainly on the rearing of beef-cattle, the different types of silo have been supplanted by a new, central fodder store, hence the modern farm is being constructed and developed along new lines. This trend has been considerably influenced by the introduction of the Harvestore in agriculture. From a purely technical viewpoint this installation is nothing more than a fully gastight silowith a mechanical, "bottom" discharge arrangement. In this way a completely new production method was supplied and consequently a new type of farm, which is now regarded as a permanent feature of the agricultural industry. The Harvestore can be supplied in types with a useful volume between 88 and 405 cu.m. (see table) and consists of bent steel plates provided on both sides with a special ceramic enamel, i.e. melted with glass and therefore corrosion-resistant. The wall thickness of the plates is between 2 and 5 mm. The bunker consisting of different plates is assembled from the top downwards by means of a lifting frame. When the foundations have been completed, first the roof and then the top plate ring are assembled. The top of the bunker is then raised by spindles and the next ring can be bolted in position. Assembly takes about 250 hours after completion of the foundations and casting of the

foundation ring. The joints between the different bunker plates are sealed by a bitumen cement, which remains flexible and ensures that the bunker remains gastight.
Pressure equalisation is ensured by two plastic bags arranged below the domed roof of the Harvestore and connected to the outside air by a vent in the dome.
These plastic bags equalise the pressure at the different temperatures. When heated up the carbon dioxide above the fodder expands and thus forces air out of the plastic bags. When the temperature falls the pressure in the Harvestore is reduced, so that outside air flows into the plastic bags. A safety valve is actuated if the air bags become overloaded.

Technical data

Bunker type	Height (m.)	Nom. dia. (m.)	Useful volume (cu. m.)	Weight (tons)
1422	6.96	4.26	88	3.6
2022	7.27	5.97	165	5.3
1740	12.27	5.20	240	9.7
1750	15.07	5.20	300	11.4
2040	12.43	6.00	325	11.8
2050	15.22	6.00	405	13.8

Thickness of steel plates:	2-5 mm.
Joints:	cadmium-plated bolts
Seal between different plates:	bitumen cement

All fodder crops suitable for hay-making, i.e. can be air-dried, are suitable for preservation in the Harvestore. The fodder is cut in the same way as with hay-making, chopped to 2 cm. length with the field chopper after brief drying to about 40% dry matter content and subsequently filled into the bunker by a blower from above.

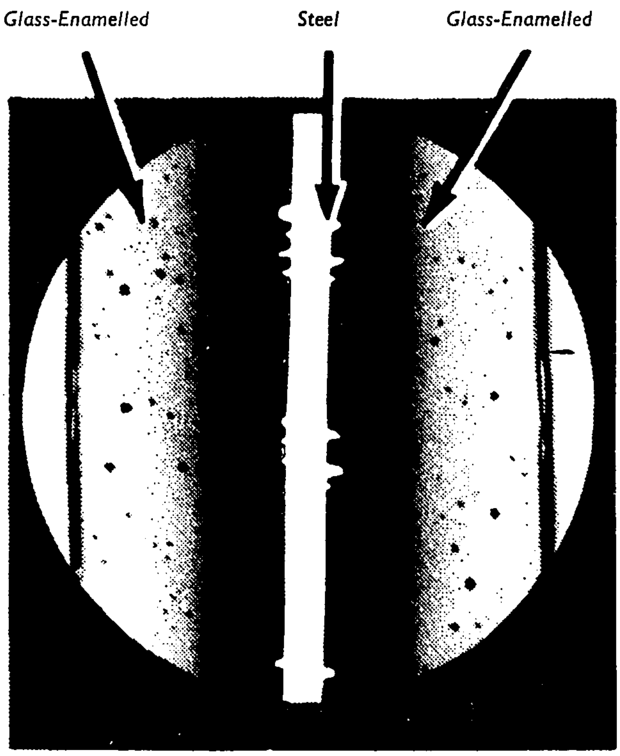


Fig. 1 — Diagrammatic view through glass-enamelled steel plates

The residual oxygen is respired in a very short time. The desired lactic fermentation is achieved as a result of the gastightness of the bunker. A fodder with a dry matter content between hay and wet silage is obtained, the so called fermented hay. Maize can also be preserved advantageously in the Harvestore. In this case fermented hay is not formed, but a high-quality lactic acid silage as a result of the airtightness. The losses with this method are considerably lower than those with the traditional hay or silage preparation, viz. about 10% as compared with about 20% in wet silage preparation or about 25-40% in hay-making.
The extremely high nutrient content of the Harvestore fodder was the most important prerequisite for completely new methods of beef-cattle husbandry. In contrast to all the usual types of fodder, Harvestore fodder can be used by itself. Hence the cultivation of diverse fodder crops, especially fodder beets, has become superfluous. Consequently the space reserved for hay or fodder beets is no longer to be seen on modern Harvestore farms.
The fermented fodder is withdrawn mechanically from the bottom of the Harvestore by a cutter. Since the material is short-chopped and easy to

transport, it can be transferred by screw-type fodder conveyors or other devices to the feeding areas. This means that the entire feeding by the Harvestore system is push-button controlled. Before the bunker is filled, fodder recovery is already mechanised by tractor, field chopper and blower, hence all traditional manual labour is eliminated in this method of beef-cattle rearing. The system includes pen-barns and application of the herringbone-type milking pen, in which the cows are milked and the fodder distributed. With the aid of this milking pen one employee can milk 40 cows per hour.

The smooth co-ordination of all stations in the system leads to an extraordinary increase in labour productivity in beef-cattle rearing. In traditional cowsheds the annual labour requirement per cow is about 100 hours and often even double this figure, but the modern farmer can manage with 30-40 hours per cow per year when using the Harvestore system. In other words, a milker previously able to look after about 20 cows can now tend 80 animals without hard physical work.

The method can be materialized to particular advantage in multicompartment pen-barns, it being immaterial whether the open or closed form of pen is used. On the other hand, it is important that the pen be clearly divided into boxes, free-movement area, feeding place, assembly and milking area. The box system combines the advantages of the tethering pen and pen-barn. It saves straw-spreading, work and capital.

However, the above advantages of the Harvestore system are not restricted to internal labour economy measures. A comparison with traditional pens already reveals a clear advantage in favour of the Harvestore system as regards the building costs, all the more so now that new farms can be built by prefabrication methods at fixed costs. The corresponding firms then take over erection of the pen at a final price.

Costs of a prefabricated pen installation with 96 boxes

A farm in the region covered by the Hanover Chamber of Agriculture was constructed during the last few years at the following costs:

Finished pen consisting of two parallel lines of 48 boxes. The feeding area between the stalls and the yard are fully roofed over (supply and assembly):	DM 43,000
Excavation work and base brickwork:	DM 16,200
Concrete and reinforced concrete work (foundations and free-movement areas):	DM 14,200
Box partition fence (tubular frame):	DM 2,500
Liquid-manure pit, volume 240 cu.m.:	DM 24,000
Prefabricated building for milking pen with calving and calf stall, length 22.96 m. width 5.00 m.:	DM 24,900
Excavation and concrete work:	DM 7,000
Milking pen, double 5 including assembly:	DM 8,225
Milking installation including assembly:	DM 9,205
2 milk vacuum tanks, 600 litre capacity:	DM 4,460
2 immersion coolers:	DM 4,900
2 Harvestore bunkers, 405 cu.m. each:	DM 75,860
2 silo foundations (for 1.5 kg./cm.^{2} soil pressure):	DM 11,460
2 charging tubes:	DM 2,920
1 withdrawal cutter:	DM 9,450
Assembly costs:	DM 10,960
Freight costs:	DM 1,040
Costs of unloading the bunker parts on the building site with special equipment:	DM 400
Bunker foundations, including excavation work:	DM 600
Current connection for the Harvestore installation:	DM 1,000
Costs of screw-type fodder conveyor including driving motor and assembly:	DM 7,200
Water supply and drainage, electric installations in stalls and milking pen building:	DM 6,000
Total	DM285,480

Hence the costs of each box are DM 2,970
(not including subsidiary construction costs).

In contrast the costs of a heat-insulated tethering stall or box stall with swilling system for removal of manure, liquid-manure pit and mobile silo amount to about DM 4,000 to 4,500 per box (again without subsidiary construction costs).

Fig. 2 — Harvestore farm in Italy. Six bunkers with rotary milking pen, screw-type fodder conveyors and open pen-barns arranged in a circle for about 1,000 animals.

As already mentioned, the considerable superiority of the Harvestore system as compared with the traditional forms of construction becomes evident at these prices. It goes without saying that the farmer will also obtain additional advantages from the economic and management viewpoints.

J. J. PETIT
ingénieur agricole

Service régional de Caen
Caen.

Developments in Harvesting, Storing and Distributing Fodder

(Translated from French)

Recent work at our Research Centre shows that if grass is cut when its nutritive value is at its maximum its food value to ruminants is 85% of that of barley in relation to their respective dry matter contents. If each blade could be cut at its optimum stage of development and if subsequent processes and storage had only a slight effect on its nutritional value, the quantity of feed produced per acre would be considerable. In many areas with good rainfall, such as Normandy, cultivated and intensively fertilized grass land can produce 12 to 15 metric tons of dry matter—with balanced protein content—a year without irrigation.

However, present methods of harvesting, storing and distributing fodder mean that only a small percentage of this potential can be passed on to animals. Increased fodder production on the basis of traditional grazing and hay-making methods, often accentuates these problems.

Ensilage

Ensilage is still one of the most efficient means of taking full advantage of heavy spring growth, provided that strict control is maintained when making the silage. Losses are still very high, but taking all factors into consideration, there seems to be no other way to equal the value of good silage at a reasonable cost.
Ensilage is the only safe way of harvesting the heavy crops likely to be produced on good grassland in April or May, the time when the best natural conditions for growth ensure maximum value is derived from intensified manuring with chemical, and especially nitrogen, fertilisers. If silage is made quickly and at the right time, it accelerates subsequent regrowth and helps to improve the total annual tonnage produced per acre.
For some years now, mechanical harvesting of silage has been spreading rapidly, especially since storage in pit-silos made on a solid base is very convenient for self-feeding. This technique was used for the first time in Calvados around 1958-59 and by now there are several hundred similar installations in Normandy.
Silage systems, frequently organized on a cooperative basis, are now fairly common, and the use of flail harvesters means that the grass can be mown, cut up and loaded on to the trailers in a single operation.
A good silage system comprising 1.50 m. double-chop forage harvester (for shorter lengths), run off a 50 h.p. tractor, can deal with 15 tons of green matter per hour, if all the necessary equipment is available on the silage site. The most common method of using buck rakes, with long steel teeth, rear-mounted on the 3-point linkage of the tractor, is particularly helpful in placing the forage in the heap, which can then be covered at the end of each day with plastic sheeting. In England, where this is a familiar method, it is considered that the least loss occurs if the gases produced by respiration prevent aerobic fermentation: in this way an effective seal can be obtained at low cost. The horizontal silo is still the most economical means of storage. Many have been successfully built by farmers. Prefabricated passage silos are now available in concrete, wood and more recently, lined with sheet steel. The concrete floor should include adequate drainage for the juices.
In order to make the structure as air-tight as possible, European farmers have taken to using tower silos in vitreous enamelled steel and unloaded from the bottom. For these silos the grass has to be wilted to 50% dry matter content, which presupposes that the climate is fairly dry, especially in spring. The high cost per cubic metre stored can only be justified by a very high food value of the silage. Clearly then, this system is not suitable for countries with heavy rainfall or high humidity content of the atmosphere.
Tower silos which are emptied from the top also produce good silage. Here the silo is prefabricated in steel, timber or concrete; it can be filled with unwilted grass and drains down the walls and out through the base. Its principal merit is that it can be filled at a rapid rate (60-80 tons/hour with an elevator belt and a central centrifugal spreader) with a low power requirement and no physical labour. The installation can easily handle the output from a large self-propelled silorator.
Although self-feeding means that complete mechanisation of distribution can be obtained without cost or labour, tower silos have to be fitted with a considerable amount of auxiliary apparatus; an electric unloader and a handling system for distribution, either by trailer (or perhaps through a mixer) or else by augers or conveyorbelts.
Tower storage with automatic distribution is particularly suitable for large stock units. In this way a herd of similar store animals can be fed with concentrates without any of the additional appliances normally required to supplement self-feeding.

Hay-making

In many farms with poorly designed buildings, baling in the field has simplified harvesting, storing and distribution to the animals. The low-density baler used in grassland areas, which gives a good output for little power, should be replaced by the medium density press which a larger tractor can drive with ease. Medium density bales give a valuable saving in volume for transport, storage and eventual sale, both for hay and straw. And they do not come undone quite so easily.

Improvements in handling techniques have been achieved mainly in response to demand from English and American farmers—who always use medium density bales—and the average bale weighs between 12 and 15 kg. As in the case of low density bales, chain-elevators make lofting less laborious, without mechanizing it completely.

Numerous procedures have been developed to deal with loading and moving the bales from field to barn: the bales are piled on to a trailer and then taken up by a bale loader mounted on the tractor, or else on to pallets which are then lifted by fork-lift. A side elevator mounted on the tractor or a bale-thrower is used to fill the trailer; a self-loading trailer has also been developed for handling bales.

Currently there is a new trend in loose hay making launched by the countries where this method has always been popular, such as Germany or Holland, and Central Europe.

The Dutch hay tower provides an ingenious answer to the problem: the hay is blown up into it and distributed in the tower by a spinner fixed to the centre of a mobile roof. If it is sited next to one or several sheds, it can be surrounded by large feed-hoppers, filled manually by gravity.

In the field the grass can be picked up and loaded by an elevator-belt or blower.

The self-loading pick-up trailer has recently made a striking debut on the European machinery market, with the introduction of ten models in the last three years. This machine is worth a special mention because it is so easy to operate; one man can take care of harvesting, transporting and discharging the grass on to a conveyor belt or blower fitted with a feed-table which automatically supplies the storage point.

Self-loading trailers are also fitted with chopping blades which are ideal for silage and make it possible to use blowers for handling hay.

Barn-drying in conjunction with ensiling

The prime purpose of this technique, now being developed, is to improve the food value of the hay by reducing the time it is left to dry on the ground, where it is subject to weather hazards.

This method has so far been more generally employed at normal air temperature with only a slight boost in the amount of blown air/cubic metre of hay, but it is now being developed with bigger outputs (around 2.5 cu.m./hour/cu.m. of hay); the moisture content of the atmosphere is controlled by reheating (often $+ 4°$ to $+ 8°$) which reduces the wilting period. If necessary this method can be used to cut down the drying period by increasing the volume of ventilating air, which also reduces losses due to heating.

In this way, even under poor conditions (cold, moist climate, with low dry matter content) post-drying is a fairly safe method to use. However, it cannot cope with the whole of the strong first crop without a lot of extra equipment, or without upsetting the overall balance of annual production per hectare (too much growth at the end of the first cycle and reduced production during later cycles). So this process must be used in conjunction with ensilage, principally to keep up the food content of the basic ration and to keep down its overall cost. The merit of this approach has been established beyond doubt by the farmers who combine self-feeding of direct cut silage with dried hay.

Provided that there is a good supply of blown air at the correct temperature, and that silage can also be handled, the use of barn-drying for young grass can give high quality fodder (around 0.6—0.65 protein equivalent per kg. of hay).

The main problems, many of which have not yet been solved, are in handling, because drying of baled hay after wilting means handling bales which are twice as heavy as dry bales. This heavy job has to be done both during loading in the field and again when off-loading into the drying area. Also escapes of air cause heavy losses in the heat produced and there is a frequent loss of nutritive value in the compressed sections of the batch under this system.

Although barn drying can be used for low-density bales with considerable physical effort, for medium-density bales it has been necessary to develop new procedures already mentioned (continuous loaders—bale loaders—bale throwers) or others (tractor-mounted hydraulic fork-lifts or net loaders) to mechanise field loading. No proper solution yet seems to have been found to the problem of handling at the drying stage.

Direct field drying using a mobile blower-heater offers an interesting approach to the problem of medium-density bales.

The return to loose hay-making seems more logical if forced ventilation is to be used. In fact complete and simple mechanisation, which gets rid of arduous physical work, can be applied both to loose pre-wilted hay and loose dried hay by introducing the methods already mentioned (self-loading trailers).

This idea is in line with the original general trend in several countries where forage ventilation has been practised for some years.

Various methods, both pneumatic and mechanical, some of which are also familiar abroad, are being used in France, to off-load wilted loose forage onto the drying floor (grabs or blowers).

The drying process itself can take several forms:

(a) drying-floors on which superimposed layers are dried successively;

(b) drying-floors equipped with suitable handling machinery (mechanical loaders) where each batch is dried separately;

(c) towers, as previously described, but with air blown through a central pipe.

Which of these systems is used depends on the method of distribution and the type of cattle-shed chosen. For instance, the method of batch-drying successive lots of hay, which are stored flat in the barn is ideally suited for self-feeding from the stack. With the high mechanical tower, the transport trailer can be loaded automatically.

The grab, belt or blower systems can also be used to distribute dry hay among racks fed from large hoppers. For example the same blower that is used to blow dry hay loose into a horizontal silage heap can also be used to fill the hopper-rack.

The new dehydration process for forage

Although dehydration is often considered too costly, and is still largely confined to lucerne meal, rich in carotin and protein, for industrial animal feeding stuffs, the process is worth serious consideration in France for keeping grass crops.

Cattle feedstuffs, based on energy-producing foods, of which 50% by weight is cereals, have given excellent results, but this can be the case with dehydrated forage, while cutting out the majority of animal casualties. Dehydration reduces overall losses between field and animal to the lowest level known.

The cost per kilo of food has no meaning except in relation to the level of growth or milk production which it produces. However, the food value of grass dehydrated at the correct stage of growth seems to be considerable (0.8 unit of protein equivalent/kg. of dry matter).

By not chopping before compounding and by careful teddling on the day of cutting it seems possible to cut down the cost per kg. of the ground fodder without greatly affecting the food value of the product for cattle. At the current stage of development these techniques can reduce harvesting and dehydrating costs to the level of 8-10 centimes/kg. (30% dry matter) or 12-16 centimes/kg. (20% dry matter), instead of the 20 centimes frequently quoted for the normal dehydration—chopping—compounding lucerne process.

If this is so, the price per unit of balanced protein equivalent in the least favourable 20% dry matter sample would work out at only 17 centimes/unit of protein equivalent for the whole crop including 10 centimes/unit of protein equivalent of fixed costs. No other system capable of guaranteeing a similar balanced nutritive concentration has at present reached such a low unit price.

So there is an urgent need to apply this new process and to draw important lessons from it, especially for areas with a damp climate.

The choice of a harvesting and processing system for forage can only be decided in relation to its cost in terms of the quantity and value of the products obtained after conversion by the animals.

Cattle feed made up exclusively from high quality forage, and especially dehydrated grass cubes, is only suitable for highly productive animals: 5,000 l. dairy dows or 500 kg. baby-beef yearlings. This type of feeding presupposes that the animal's digestive system has been genetically adapted to cope with it.

Even when these various factors become better known, we will only be able to choose the correct processing cycle in relation to climate, soil and configuration of the ground.

The highly varied range of farm-sizes and availability of finance have led to many different ways of harvesting forage: current trends can be summarized as follows:

(1) in humid areas the extremely chancy practical success of prolonged wilting and high output potential lead to silage stored in passage silos, in conjunction with artificially dried loose hay: this is distributed by

self-feeding in small and medium-sized farms. For larger units, estates and cooperatives, tower silos for moist fodder can be combined with dehydration. Dehydration will undoubtedly become available to small farms through cooperative dehydration units, as in Britain and Switzerland. Constant output dehydration can be easily used in conjunction with silage, to handle the greater part of the spring flush, in a well-managed cooperative system.

(2) in drier areas self-feed silage and hay can be used for small and medium farms, because the loss in grass yield per hectare is partly offset by the improved quality of the conserved products. The natural conditions associated with the new accelerated teddling process (drying) make it easier to ensure wilting to 50% dry matter, which in turn reduces the cost of barn-drying in humid areas.

(3) the present tendency to form large-scale specialized installations for large animal units, usually of a uniform design and for one category of animal only, opens new horizons for the future. Technical improvements will be possible through careful choice of efficient harvesting systems and specialisation in stock-rearing methods. At the same time the size and planning of production should solve sales and supply problems more easily under a contract system.

René DELEU

Agent général E.T.C.M.
Paris

Hermetically-sealed Steel Silos for Storage Under Inert Gas

(Translated from French)

The type of silo in question is recommended for storing high initial cost produce, in particular that which has high vitamin or fat content, or which is susceptible to infestation or fermentation.

The temporary storage silo.

In France there are a great many sealed steel silos, air-filled, and used for so-called "controlled atmosphere storage": a few years ago, experiments were started with methods of storing material under gas; and those officially appointed grain storage concerns (*organismes stockeurs*) with sealed silos followed these experiments and have adapted their installations for storage under carbon dioxide.

Combine harvesters brought mechanization to the harvesting of cereals and oil-seeds at a time when manual labour was becoming scarce. This development brought new technical problems, as how to store produce harvested in this way: most of these difficulties stemmed from the fact that only rarely can seeds and grain be harvested at such a degree of humidity that their long-term storage involves very little risk.

There is a growing tendency for producers to deliver their crops to storage-concerns over a shorter and shorter period: as often as not, the drying plant is unable to cope with all this flood at once. Since moist grain deteriorates very quickly, it is essential that methods should be found for retarding this process, in order to extend the period during which drying is done. This means that preservation under gas or in "controlled atmosphere" must be developed (the writer would recommend atmospheric gas).

In my opinion the only economic material that can be used for building silos of this type is steel.

The operating procedure for this sort of silo is as follows:

(1) the container itself must be air-tight, and be fitted with a two-way safety valve at the top,

(2) fill the silo (it need not necessarily be filled to the top, so long as the grain is completely submerged under a layer of gas). Filling must be completed, a few days later perhaps, by topping up the CO_2.
(3) introduce CO_2 into the bottom of the silo. This must be done in such a way that the gas, which is heavier than air, rises slowly in the container. A satisfactory delivery rate is 2,500 litres (or 5 kilos) of CO_2 an hour. The delivery valve can be prevented from icing up either by using a heater, or by keeping the pressure down to 0.8 kilos/square centimetre. While filling is in progress, the manhole at the top of the silo should be left open to allow the air to escape.

The optimum CO_2 content, though this has yet to be calculated exactly, is around 0.15 to 0.18 kg. per 100 kg. of grain. The cost of this type of gas comes to about 0.04 FF per 100 kg. per month of storage.

Storage of dehydrated lucerne under neutral gas

Lucerne seed, the market value of which is closely linked with its vitamin content, has in France only recently been produced to any extent and it has been closely studied by storage specialists. Vitamins are known to "turn" and lose their properties if they are left exposed to light and the oxygen in the air for longer periods. This is not the least of the reasons why in most modern installations, lucerne seed is stored under atmospheric gas.

The sealed steel silo was chosen for the job. It should not be too high as there is some danger of crushing the seeds. The trouble with this product when milled is that being very powdery it easily clogs the equipment. For the same reason it constitutes a fire hazard. Polygon-shaped silos are more suitable than cylindrical ones, as the polygon-shaped installations tend to minimize dew-forming points, the source of mould. The upper and exterior surfaces of the container should be insulated as far as possible.

There are three gases that may be used:

1. carbon dioxide, supplied from a production plant, or from cylinders, depending on the size of the silo: eventually, this gas mixes with and supplements respiration from the stored vegetable matter itself.
2. nitrogen, supplied from containers or from liquid nitrogen tanks.
3. atmospheric gas, which is a mixture of nitrogen or CO_2 produced by the combustion of air.

None of these three gases has any harmful effect provided the contents of the silo are adequately stirred between the time they are taken out and when they are delivered to the customer. Present methods of handling grain after it has left the silo are perfectly satisfactory for this application also. The only criterion governing the choice of which of these gases to use is the relative costs, which often as not depend on local factors.

Storage of grain under gas should prove to be of equal interest to those for whom infestation is a problem. Pests constitute an increasing menace; losses are appreciable (being estimated at 0.3% for insect pests, and 0.5% for rodents). These percentages may not seem very great, but with an annual loss through infestation of 2.5 million quintals (of 100 kg.), with a value of about 60 million FF, this represents a major problem in France.

As far as rodents are concerned, it will be argued that there is already a wide range of reputable products on the market, and further that the necessary insecticides are also available. The main thing to remember is that, for this work, nothing must be used which can be harmful to either man or beasts other than those we are trying to destroy.

Increasing surpluses are making it necessary to export some of our cereal production, and in some countries regulations about insects are so strict that the existence of even one living specimen in an entire cargo can suffice for its prohibition. As far as we are concerned, it is of paramount importance that as many markets as possible should be kept open for our products.

This seems to be good enough reason for us to take another long, hard look at the problem, especially where it effects grain for flour and dehydrated lucerne—not to mention malting barley. Carbon dioxide storage is the perfect answer, because it kills off all parasites by asphyxiation. The high capacity, sealed steel silo is bound, in the near future, to be playing a prominent role in storage installations.

Michel DUBOIS

Ingénieur E.T.P.-Ingénieur conseil
Paris

Storage of Lucerne Meal in Airtight Silos

(Translated from French)

The development of airtight silos for the storage of vitaminized products and particularly lucerne meal will be very much influenced in years to come by two factors:
(a) the price of the gas injected,
(b) the progress made in airtightness offered by reinforced concrete.
In the USA, forerunners in the production of lucerne meal, silos are for the most part simple cylindrical bins of corrugated sheeting, erected on a concrete base, with bolted joints sealed by rubber or plastic. The rapid deterioration of the joints limits the airtightness, and users overcome this disadvantage by a generous injection of an atmospheric gas, burning up the air by means of propane, the net cost of which is negligible. In France the price of a cubic metre of nitrogen or atmospheric gas varied from 0.06 FF per cubic m. to 0,50 FF per cubic m. according to the combustible or gas used, and it would be necessary to produce annually one million cubic metres of gas to preserve efficiently 20,000 tons of produce, allowing for two applications. Progress in the development of silos for the storage of lucerne meal is not impossible provided the prices for combustibles fall.
Walls of metal silos have the disadvantage of a heat loss coefficient causing localized condensation, thereby impairing the granules. Slow self-combustion of the lucerne meal is thus produced with the formation of embers, the temperature of which can reach several hundred degrees centigrade. With the opening of the valve the fire flares up or, at best, because of the gas injected, the storage bins smoulder slowly. The solution at present adopted to avoid the destruction of the silos and to preserve the meal consists in injecting gas
(a) previously dried to lower the humidity percentage in the produce,
(b) at a low constant temperature to avoid the "dew point". However, freezing being very costly, condensation is inevitable below 6° C especially in the uppermost areas of the silos, with the resultant formation of crusts.
Solutions considered such as
(a) thermal insulation of silos, or
(b) constant high flow insufflation of gas,
have the drawback of being too expensive in proportion to the value of the produce stored or else have additional disadvantages (yellowing, acid formation, etc.)
Technical experts would gladly opt for a solution for reinforced concrete silos offering a better heat loss coefficient subject to garanteed airtightness. Numerous and repeated laboratory tests have evinced several reagents offering this quality. To my knowledge only one silo has been erected in France in reinforced concrete and the results are reported as disastrous. Nevertheless, one must not exclude the possibility of success being achieved by the unknown qualities of reinforced concrete combined with a net price competitive to steel silos.

Claude RUNNER

Ingénieur Société de Wendel et Cie.
Paris

Extension of the Port of Dunkirk Grain Silo

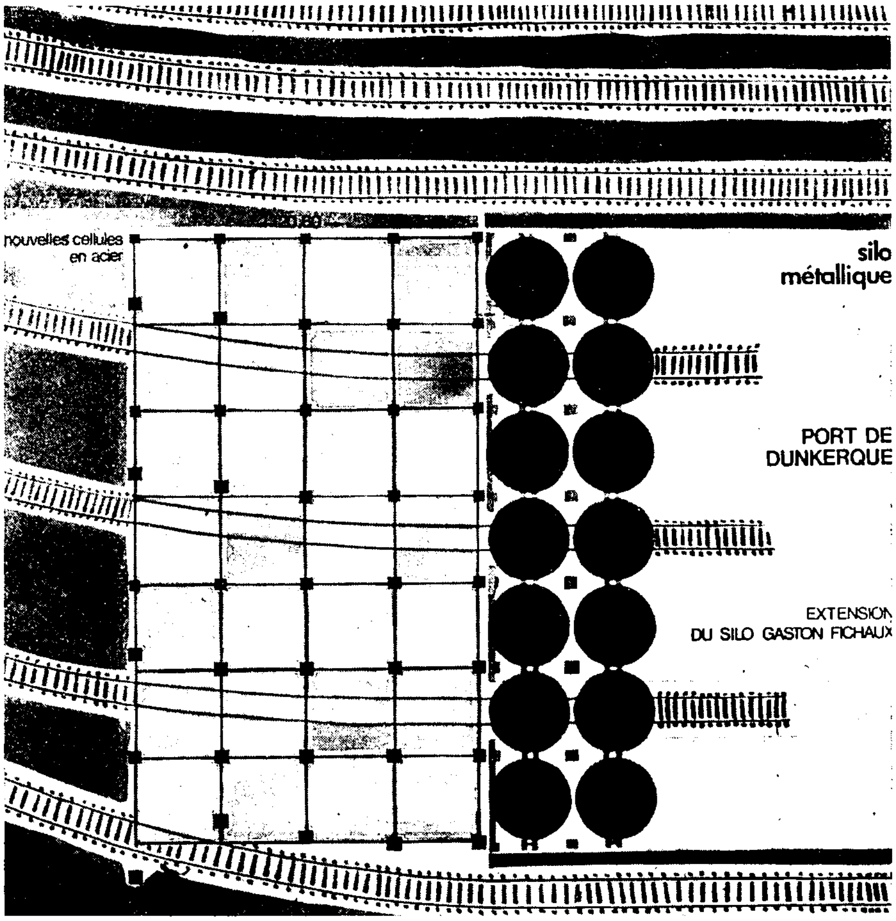
(Translated from French)

At Dunkirk, the Chamber of Commerce owns the "Gaston Fichaux" grain silo, which has a capacity of 150,000 quintals. This silo, built in 1924 in reinforced concrete, had become too small and it was considered necessary to add to it, to begin with, a series of new silo unitswith a total capacity of 100,000 quintals. Eventually, a further enlargement of 50,000 quintals will bring the total grain storage capacity of the installation to 300,000 quintals. The extension to 250,000 quintals has now been completed, and in view of its originality, the procedure adopted seems to us to be worth describing in detail. The design and execution of the project was entrusted to the Bridges and Highways Administration, responsible for public utilities at the port of Dunkirk.
The new units had to be contiguous with those of the original silo so as to make the best use of the existing loading and cleaning equipment. Furthermore, they had to be provided with conical bases, and erected at a height allowing three railway tracks to pass underneath.

Planning the structure

After consulting various competent professional bodies, notably the Technical Office for the Use of Steel, the Dunkirk Chamber of Commerce invited tenders from structural steelwork contractors. The decision to use steel had been made at the outset for reasons of economy and, above all, speed of construction. For this type of building, steel has always stood up well in competition with traditional materials:
(a) its lightness reduces the overall cost of the structure itself and particularly that of the foundation,
(b) the speed of erection makes for considerable savings,
(c) the flexibility of the method of assembly allows for later modifications,
(d) the airtightness of steel units ensures perfect grain preservation.
The above advantages applying to a steel structure were particularly important at Dunkirk because of the nature of the sub-soil, and also because of the need to underpin the existing railway lines.
In actual fact, the load-bearing capacity of the sub-soil at the port area is rather low and the foundations of sizeable buildings need to be pile-driven. Under these conditions it is obvious that the lightness of a steel superstructure (570 metric tons of steel instead of 5,200 tons of concrete, or little over one-tenth) entails a considerable economy in the necessarily lighter sub-structures.
Furthermore, a special difficulty arose, in that the curvature of the railway lines did not allow the placing of ordinary concrete pillars immediately in the line of the stanchions of the superstructure *(Fig.)*. This made it particularly desirable for steel to be used. The solution found, i.e. thin reinforced concrete arches 9 m. high, was possible only because of the lightness of the steel framework of the superstructure. Thus the construction of these arches modified the whole contract as originally conceived (two groups of silo units on two sides), and enabled a better siting of the new units (in single alignment with the original ones). They could then be filled by the same handling equipment that served the original units, particularly the same gantry, thus reducing considerably the installation costs of the new handling system. The lightness of these new metal units, therefore, helped to reduce the final cost of the new building.
Finally, the time limit allowed for constructing and commissioning into service this 100,000 quintal extension was set at eight months, a limit that was achieved only by using a prefabricated steel structure.

New steel reinforced arches



Steel silo

Port of Dunkirk

Extension of the Gaston Fichaux silo

Port of Dunkirk grain silo

Steel used

The construction of large steel silos in port areas is, however, rather uncommon, at least in France. It was feared that the highly corrosive sea air would, in the long run, make it difficult to maintain a metal building of ordinary carbon steels.

The builder therefore recommended use of a slightly alloyed steel resistant to the corrosive atmosphere. This suggestion was accepted by the Bridges and Highways Administration responsible for the technical direction of the project. The type of steel chosen had the following advantages:

(i) high resistance to corrosion in a sea air, as in fact it has in an urban or rural industrial atmosphere,
(ii) better paint-adhering properties,
(iii) superior mechanical properties,
(iv) excellent weldability,
(v) a moderate price owing to the low alloy content.

Actual construction

The extension of the "Gaston Fichaux" silo to an overall height of 28.5 m. was carried out by constructing 28 square steel units with sides of 5.15 m. and each 16 m. high, all fitted with conical bases and surmounted by a structure protecting the loading equipment.

Pile-driving began in May 1965, and this was followed in July by laying the sub-structures in concrete. The assembly of the first units began while the last sub-structures were still being laid. The work was completed on 31st December, 1965, thus complying with the time limit of five months from completing the sub-structures set by the Administration.

The walls of the units consist of prefabricated ribbed sheets 5 mm. thick, welded to supporting framework stanchions which are in the form of square sections 200 × 200 mm. The stanchions are also of sheet steel decreasing in thickness from 20 to 6 mm. The prefabricated panels measure 4985 × 2540 mm. The conical bases are in 5 mm. sheet. The welding was done with type E 48 C basic electrodes continuously regulated by a welding regulating system.

The units are roofed with a non-slip decking of rough-surface sheets carried on metal joists. The top-work structure consists of a tubular framework clothed with galvanized steel sheeting. Roof lighting is provided by polyester panes, and the interior of the top-structure is illuminated by double-glazed windows. Metal gantries located beneath the conical bases support the discharge conveyors which move the grain to railcars or barges. The following factors assure the protection of the whole building: the type of metal used, i.e. previously de-scaled, phosphated and given two coats of bituminous paint. A final coat of white bituminous paint lends a finished appearance to the job.

The example of the extension of the "Gaston Fichaux" grain silo shows that when high-tensile, corrosion-resistant steel is used, metal structures are particularly suitable for port silos, i.e. buildings exposed to sea air.

Dr. Kurt BREMER
Diplomlandwirt

Hamburg-Wandsbek

Storage and Marketing of Potatoes in West Germany

(Translated from German)

The acreage devoted to potato-growing in West Germany amounts to approximately 800,000 hectares; the yields are about 500-560 metric hundredweights per hectare, so that the annual crop averages 20-23 million tons. West Germany has the third largest potato acreage in the world; its share of European potato production is about 16% and of world production about 10%. Europe accounts for something like one-third of the world acreage and over half of world production, and Germany, as the figures I have quoted show, is one of the big European and world producers. Moreover, German growers have a reputation going back over 120 years, and have established themselves in a leading position with some 100 varieties.

One important aspect of my subject is the utilization of the crop, with the various specific activities this involves. The total crop, amounting as I have said to 20-23 million tons, is utilized roughly as follows:

seed potatoes	10%
ware potatoes	34%
potatoes for processing into food products	3%
industrial potatoes	3%
fodder potatoes	50%

For each of these five categories an entirely separate set of storage and marketing arrangements is necessary. Seed potatoes, two-thirds of which are now, following a change in practice in the last few years, marketed in the spring, have to be stored on a large scale through the winter and sold off quickly in the space of a few weeks in the autumn and spring.

Ware potatoes used as a rule to be stored in the cellar of the consumer, who drew on his stock as and when necessary. However, as less potatoes are now being eaten and fewer consumers have the necessary storage space, the usual practice is now just the contrary: it is only in country districts and small towns that the consumer still lays in a big stock, while elsewhere the tendency is to buy small amounts (2, 5 or 6 kg.) to cover current requirements. Consequently, potatoes are more and more having to be stored in the area of origin or destination, and handled at big sorting centres fully equipped to receive, store, grade and market the produce so as to ensure an even flow of good-quality potatoes throughout the year.

The processing of potatoes into food products has been going on on a steadily-increasing scale in Germany (and in Europe generally) for the last twenty years, such products now accounting for at least 10 kg. (in terms of untreated produce) of the 80 or so consumed annually per head of population. At present only about 3% of the total crop is used for this purpose, but the proportion is rising steadily and may be expected to follow the trend in the United States, where nowadays 3-4,000,000 tons a year, or something like a third of the crop, are thus processed. If the processing plants are to ensure a regular flow of production over the year, from harvest to harvest, it will be necessary not only to conclude contracts with firms and growers possessing adequate storage capacity of their own, but also to see that all the special requirements as to the air-conditioned storage and the grading and preparation of the tubers are properly fulfilled prior to the processing stage.

The proportion of potatoes set aside for industrial use is about the same, 3% of the crop. The sectors concerned are traditionally distilling, starch making and drying for animal feedstuffs; the season normally lasts from perhaps 100 to at most 150 days in the year, from the autumn to Christmas, with sometimes a short spring season in addition. The special feature of storage for this purpose is that large quantities of potatoes have to be held for short periods; the usual arrangement is to keep them in immersion tanks, or sometimes in the open air.

The highest proportion of the crop goes for conversion into animal feedstuffs. Here too storage is very important, since 8-10% of the tubers must normally be expected to go to waste in the course of the winter. Fodder potatoes include both produce set aside for this purpose in the first place, and also the many market rejects originally intended for planting or for human consumption. The extra storage precautions in their case consist principally in conserving them by ensilage, either in the raw state or after steaming, or else—a method which has been gradually gaining ground of late—by drying them to provide economic "bagged potato feeds". Storage of fodder potatoes is thus quite a specialized business.

This sketch of the position as regards potato growing and grading in West Germany is offered as background to an account of what now needs to be done in the matter of storage and marketing. This includes primarily the provision of storage premises of all types and sizes for keeping the potatoes under cover during the winter, and also the construction of large-capacity sorting plants to discharge the various tasks involved in keeping the supply of potatoes in line with the requirements of the market.

Indoor storage

It is only in the last twenty years that indoor storage of seed and food potatoes (and now, to an increasing extent, of those for industrial use and for food processing) has been adopted in West Germany on any real scale. The facilities available were, depending on local circumstances, approximately as follows:

1. small and medium-sized storehouses at the farms themselves, either built into existing structures, or made by enlarging older potato sheds, or specially constructed for the purpose;
2. joint depots specially built by several adjacent farms in combination;
3. large warehouses run by firms of potato dealers in the areas of origin and destination, and also, lately, to an increasing extent by industrial consumers and food processing plants.

For the purposes in view, the aim must be to see that these premises are so designed and constructed as to keep the potatoes in good condition over the winter, so far as is economically feasible and local circumstances permit. The stage now reached may be regarded as a provisional standard, but there is undoubtedly still room for considerable improvement as regards design and mechanical equipment.

(a) Large-capacity sorting plants

To maintain the necessary flow of saleable potatoes (particularly the seed and ware varieties) to the market, it is becoming more and more necessary to install fixed, high-efficiency central sorting plants; this is now the only way in which the commodities the consumer requires can be supplied economically in sufficient tonnages of uniformly good quality. The following systems have been evolved in the last twenty years:

1. sorting plants operated in association with storage installations;
2. sorting plants at which fairly substantial quantities of raw material are held in store on the premises.

This type of plant is usually built in the producer area, and financed principally by the agricultural associations and dealers in farm produce engaged in the marketing of potatoes. Much excellent work has been done in this connection in recent years in constructing the necessary buildings and fitting them up with mechanical equipment.

(b) Steel utilization

Steel is about equally necessary for storage capacity and for sorting plants.

Potatoes are a bulk product which can only be stacked loose especially if they are to be kept for any length of time. Consequently steps must be taken, depending on the size of the stack, to contain or steady the pressure from it.

Where the potatoes are not kept in self-supporting compartments, the enclosing walls need to be reinforced with steel to withstand the lateral pressure from the stack. But in any case, quite apart from this aspect, all such structures should comprise steel or reinforced-concrete columns and/or circular beams to give them complete static stability.

In view of the need for bulk handling in the face of the steadily growing manpower shortage, and the increasingly complex work required to ensure economic operation, it has become necessary in the last twenty years to go over more and more to mechanical stocking, destocking, sorting, selection and packing of seed and food potatoes. The process begins with the tipping of the potatoes on arrival into the reception bin, adhering soil being knocked off them at the same time. They are then taken off by conveyor belts for further treatment or storage, as the case may be.

For long-term or short-term storage, they have to be piled into compartments or large crates by means of chutes or special filling appliances. Withdrawals from storage are also effected mechanically, the potatoes being removed from the bins by conveyor belt or tipped from the crates, to be passed to the sorting machines. These separate the tubers into the appropriate size categories; selection is done by hand on separate picking belts, and finally the potatoes are weighed and packed in larger or smaller lots, also as far as possible mechanically in order to save manpower.

In all these processes steel tubes, sections and sheet play an important part.

Dott. Achille SACCHI

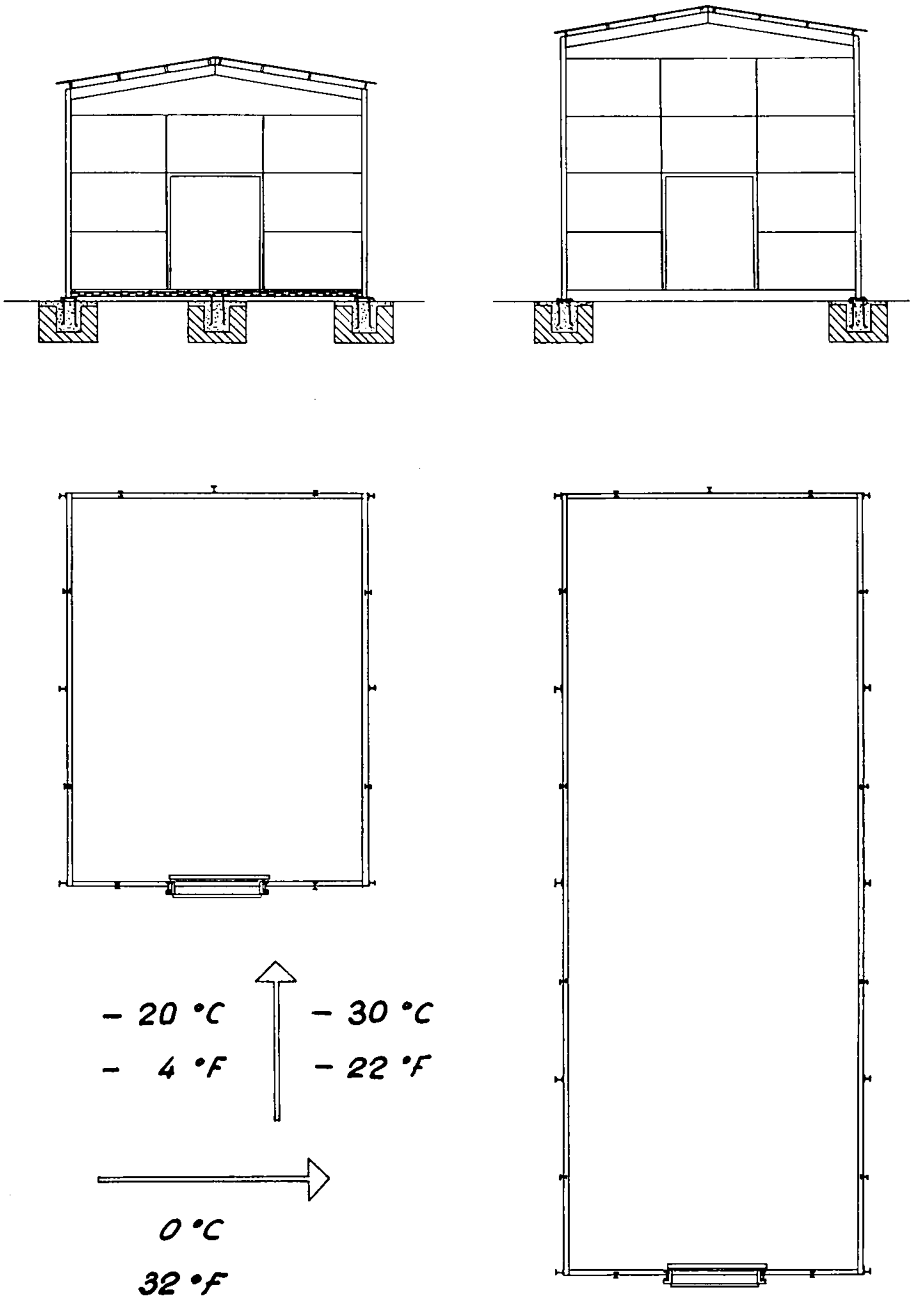
Centro Applicazioni del freddo—Comansider
Roma

The Contribution of Steel in Modern Equipment for the "Cold Chain"

(Translated from Italian)

During the last few years the increasing trade in perishable foodstuffs between the Common Market countries combined with the everwidening adoption of refrigeration techniques for preserving these products, has called for modernization of the full range of refrigerated storage, distribution and transport equipment. The aim is to ensure an efficient "cold chain".

Of the Common Market countries, Italy predominates in fruit and vegetable growing. The introduction of our produce into a single market of some 180 million consumers has created new requirements for refrigeration equipment which will ensure that our fruit and vegetable produce reaches the Common Market consumers in first-class condition. The need to obtain all the necessary equipment for the "cold chain" without delay has prompted the extension of prefabrication into this field with all the advantages that this can entail. The steel industry has already played an important role in supplying structural steelwork for the establishment of collecting centres and markets for fruit and vegetable produce as well as large storage facilities where food products are preserved and refrigerated. The industry has also promoted the design



Prefabricated refrigerating cells

and started production of prefabricated refrigerating cells, a Termomeccanica patent. These have a steel load-bearing structure, with walls consisting of thermal-insulation panels made from galvanized steel sheet *(Fig.)*. The basic features of prefabricated refrigerating cells are:

(a) no delay in supply,

(b) speedy and easy erection (in eight to nine days by a normal team of three erectors),
(c) can be enlarged later if required,
(d) can be dismantled and moved elsewhere, leaving only the foundation masonry,
(e) efficient thermal insulation using the most up-to-date insulating materials,
(f) low maintenance costs,
(g) low running costs.

Their construction on the module principle makes available a series of cells of similar type. Adequate refrigerating capacity is always ensured by means of standardized refrigerating equipment. These cells are produced either for an operating temperature of 0° to + 4°C, or to —20°C. It is envisaged that, in the near future, the second type will be able to operate down to a temperature of —30° C. The constructional features common to both these types of cell are:

(a) A steel load-bearing structure of prefabricated components which are assembled in situ.
(b) Walls and roof of sandwich-type insulating panels consisting of galvanized steel sheet with a medium-density rigid polyurethane foam filling. The panels thus have very good insulating properties; they are edged with PVC.
The panel contours have been given particular attention so as to ensure a perfect joint between one panel and another, and sealing is assured by a special highly-flexible jointing.
(c) A refrigerating plant having a Freon 22 compressor of the semi-hermetic type, two air-cooled condensers and one or two cold-diffusers. Every individual cell, and each element of a multiple cell, is equipped with one of these plants. It is thus possible to obtain a number of combinations from which the best for a particular service can be chosen so as to suit the quantity of produce to be preserved or to be kept at a definite temperature. The installation is, therefore, extremely flexible despite the fact that each plant has a standard refrigerating capacity. Each plant has a standard capacity of 20,200 kcal./hr., with expansion at —7° and condensation at +50° C. The plant and the cold-diffusers are suspended from the roof at the front of the cel. It is important to note that these cells are completely self-contained as far as water consumption is concerned, as the condenser is air-cooled and the defrosting of the evaporators is done electrically.
(d) Foundation plinths for anchoring the stanchions forming the vertical framing, which supports the cell roof. The plinths are of different designs according to the function of the stanchions and the position they occupy in the cell.
(e) A floor over which trucks can run, and which is therefore capable of supporting an ample unit area load. The insulating material is adequately waterproofed and protected from splitting.
(f) The roof covering is of corrugated Serralux or equivalent alternative. The ridges are of reinforced plastic or equivalent material. Fixing of the corrugated sheets to the purlins is effected by a system of rods, polythene jointing, and zinc plates; these parts are secured by galvanized steel nuts.
(g) The insulated door (1.60 by 2.45 m.) is sited preferably on the machinery side, but may be on the opposite side. It has two leaves.
Its construction is similar to that of the panels, but it is suitably reinforced on the inside with a larch frame. It is complete with post, handle-operated closing device, and electrical resistor.
(h) A lighting plant for each cell element. Illumination is by sealed ceiling-lamps.
(i) A standard switchboard for the whole of the electrical plant. This is in an accessible position on the front of the cell.

The new series of low-temperature cells in the course of preparation are additionally provided with a front antechamber having a flexible rubber door with two swing wings.

Cell types and volumes

As stated above, these prefabricated cells are designed for operation at 0° to + 4°C, or for low-temperature operation. By using single cells, made up of three, four (the standard form having the following external cell dimensions: 5.160 m. high; 6.000 m. wide; and 16.160 m. long) or five modules of about 120 m³ each, or by using multiple cells placed alongside each other up to a maximum of four units, it is possible to obtain a net total volume of 356 to 2,479 m³ which is refrigerated to a rated temperature of 0°C (see *Table*). This temperature is suitable for cells used for produce requiring a storage temperature of a few degrees above or below 0°C, a typical temperature for fruit and vegetables.

Series of cells, with their individual and total volumes.

(in cu.m.)

Designation	1st Cell	2nd Cell	3rd Cell	4th Cell	Total
C1S/474/1g	474.57	—	—	—	474.57
C1C/356/1g	356.00	—	—	—	356.00
C1L/593/1g	593.34	—	—	—	593.34
C2S1/970/2g	474.57	496.37	—	—	970.94
C2S/977/2g	977.44	—	—	—	977.44
C2L1/1213/2g	593.34	620.46	—	—	1,213.80
C2L/1221/2g	1,221.94	—	—	—	1,221.94
C3S2/1467/3g	474.57	496.37	496.37	—	1,467.31
C3S1/1473/3g	474.57	999.25	—	—	1,473.82
C3S/1480/3g o 2g	1,480.54	—	—	—	1,480.54
C3L2/1834/3g	593.34	620.46	620.46	—	1,834.26
C3L1/1842/3g	593.34	1,249.07	—	—	1,842.41
C3L/1850/3g	1,850.74	—	—	—	1,850.74
C4S3/1963/4g	474.57	496.37	496.37	496.37	1,963.68
C4S2/1970/4g	474.57	496.37	999.25	—	1,970.19
C4S1/1970/4g	977.44	999.25	—	—	1,976.69
C4S1/1983/4g o 3g	1,983.31	—	—	—	1,983.31
C4L3/2454/4g	593.34	620.46	620.46	620.46	2,454.62
C4L2/2462/4g	593.34	620.46	1,249.07	—	2,462.87
C4L1/2471/4g	1,221.94	1,249.07	—	—	2,471.01
C4L/2479/4g	2,479.14	—	—	—	2,479.14

Multiple cells can be arranged with or without dividers. Dividers can be of advantage when it can be foreseen that some of the space will not be used for long periods, when adjacent units are under different ownership, or when they are to be used for produce with incompatible odours.

The —20° cells have a different module, 96 m³. and can be single or multiple (the *standard form* has two modules totalling 192 m³. and the external cell dimensions are: height 4.16 m., width 6.00 m., and length 8.080 m.), the modules themselves being connected together at their sides or their fronts, or at their sides and fronts, up to a volume of 768 m³. It should also be noted that it is possible to assemble modules of different types so that different temperatures can be simultaneously obtained in adjoining but separated spaces (polyvalent cells).

These cells are extremely versatile as the following information will show. Those operated at 0°C are mainly intended for the precooling and preservation of fresh fruit and vegetable produce, in the area where it is produced, while it is awaiting despatch to the preparation and forwarding centres. These small sub-centres, which are complementary to the main fruit and vegetable centres, are for the most part run by producers who are associated on a cooperative basis. They enable batches of suitable size to be made up and sent to the main centres by an economical form of transport for onward consignment, to the consumer markets. The availability of these cells will, of course, also allow the producers to overcome temporary gluts on the market, with consequent substantial economic advantages. Thus, any quantity of produce can be made independent of market conditions and of transport to the markets or to the main processing centres, while quality is still maintained at the highest level. The other cells, operated at —20°C, may be profitably introduced into the "cold chain" in the production and distribution of quick frozen products. As envisaged for use outside the "cold chain", i.e. as fully independent units, these latter prefabricated cells provide a complete answer to the problem of distributing this type of produce. They can be used in small depots, and can also serve districts in medium-sized and large towns and cities, the producing industry either undertaking distribution right down to the retailers or supplying through wholesalers.

Working Party IV

Steel

in the Agriculture of Developing Countries, Especially Tropical Countries

Chairman	*A. Guillabert*
Rapporteur	*C. Gouzée*
Introductory Papers by	*J. Ferrandi*
	P. J. Zachariah
	G. Labrousse
	D. W. Hall and J. V. Stephen
	R. Bangs

Jacques FERRANDI

Director of the European Development Fund
Commission of the European Economic Community

Developing the Agricultural Sector in the EEC Associated Countries

(Translated from French)

The purpose of this Congress being to discuss steel in agriculture, I should like to quote you an example from an African country which can fairly be said to combine several of the aspects of this complex subject, the Islamic Republic of Mauretania.

Mauretania does not consist exclusively of the sandy wastes across which huge engines today haul endless trainloads of iron ore on their way to the new coastal steel plants of Europe. Since long before some geologist providentially happened upon the vast orefield that is now revolutionizing its fortunes, Mauretania has been a crop-raising and stockbreeding region, in which all the problems and obstacles and difficulties that tend to impede agricultural development in the African countries are noticeably apparent.

Recently, reading a long report on Mauretania's development prospects, I pored for some little time over a form of production with the odd and intriguing name of phoeniciculture, meaning the cultivation of the date-palm. The concentration of palms, it was stated, is usually too high, with the result that the yield averages only 30 kg. of dates per tree per annum, as compared with anything up to 100 kg. given proper spacing. Then why, I wondered, do the Mauretanian growers not plant their palms suitably far apart, since this would be directly to their advantage? The answer came a few pages further on, from a sociologist, who wrote, "when I pointed out to a young Mauretanian that his palms were too close together, he replied that they looked nicer that way, and that later on he would be able to rest in the shade there with his father." This revealing story contains a moral for those of our modern technocrats who imagine they can solve the problems of African agricultural development by proposing courses of action that are absolutely correct in themselves but divorced from the psychological and sociological, in a word from the human context. They generally meet with failure when they do not actually make themselves a laughing-stock.

In dealing with African agricultural development, then, we have to reason, as un-academically as possible, in two stages, seeking

(a) to establish the general characteristics of the agricultural sector in the countries concerned, by making a preliminary analysis of the environment in order to determine the motive forces of development;
(b) to establish the aims, means and principles of that development, by drawing on EEC's eight years of experience in helping to work up the agriculture of the associated African countries.

General characteristics and role of agriculture in African countries

Even if we confine our attention to the associated countries, which account for some 50 million of Africa's total 225 million inhabitants, we have to accept, before proceeding with the argument at all, that they are extraordinarily diverse in character. Analysing the environment really amounts mostly to listing the obstacles to its betterment, for in practice these countries have only one thing in common, the importance, or rather the predominance, of the agricultural sector in their economies.

All the disadvantages of size, and none of the advantages

With the exception of Rwanda and Burundi, which are small territories with comparatively large numbers of people living in them, all the EEC associated African countries are huge and sparsely populated. Ivory Coast has the same area as Italy but only one-twentieth the population. Mauretania is nearly as large as the Europe of the Six, with only twice the population of Luxembourg. The Congo is eighty times the size of Belgium and has only slightly more inhabitants. This is bad for agricultural development in a great many ways.

Produce has to be grown, but it also has to be sold. The tremendous distances involved and the long-drawn-out lines of communication add very substantially to agricultural production costs. Efforts to develop transport facilities are caught in a vicious circle : the more communications are extended the less remunerative they become, while the more they are concentrated the less the outlying country districts can be irrigated and the less prospect there is of agricultural production expanding.

Again, with such a scattered population it is exceedingly difficult to provide technical advisory services, and little is achieved in relation to the amount of effort deployed. To make matters worse, there are only a handful of advisory officers available, whether from within the country concerned or from outside. In the whole of the former French West Africa there were fewer than 100,000 Europeans (families included) as against 20 million Africans—the population of Maastricht or Grenoble distributed over four times the area of the Europe of the Six.

And then, too, the wide variety of natural conditions, climates and soils—ranging from desert to equatorial forest— is paralleled by a similar variety of races and tongues, since there were no fewer than 70 ethnic groups and 250 vernaculars in the former French West Africa alone. Obviously, therefore, improvement methods have to be not only quite different from those used in Europe, but specially geared at local level to the particular type of soil concerned. It is no use applying what may be generically termed "American" techniques in African agriculture. So these countries have all the disadvantages of size and none of the advantages, since their populations are too scattered for them ever to form big economic units or big markets.

Adverse natural conditions

They are unfriendly, unwelcoming countries, peripheral countries, far from the great regions where modern civilization and technology and philosophy have evolved—the Mediterranean, the North Sea, China, India. Landbound, solid, inward-looking, as it were sealed in upon themselves, they were summed up by the Roman geographer with a telling epithet, *Africa portentosa*.

The cruelly unfavourable climate, the general unhealthiness, the countless endemic diseases diminish productive effort. The African peasant too is caught in a vicious circle: he works poorly because he eats poorly, and he is underfed because he is underemployed. Tropical soils are unstable, for the action of the various erosive agents is enhanced by climatic factors. The soil is constantly changing—that is to say, deteriorating—and there is not enough arable land: a FAO estimate for all the overseas countries of the Franc-area puts the arable acreage at only 50 million hectares, a mere 6% of the total 835 million.

Equilibrium but no progress

Agricultural nomadism is at once the cause and the effect of brittle soil. With nature against him, with no equipment or machinery to help him, with his own strength sapped by disease and undernourishment, the African has evolved a technique also found in many underdeveloped countries in other parts of the world—itinerant cropping on ground cleared by burning, with long fallow periods to enable the soil to become fertile once more.

It has been objected—rather obviously—that this approach hastens soil deterioration, and makes it harder for the croppers ever to farm their land on a settled basis. A discerning geographer, Mr. Pierre Gourou, is rightly less categorical in his verdict. What else, with the means at his disposal, could the African do? Besides, he does go about the job to some extent scientifically: in particular: he is descriminating in the selection of his plants. And the traditional techniques do, after all, preserve a balance, at a given level, between the population and the land. But, as Gourou shows, this last is in the final analysis, what is wrong with the system: the man/soil balance achieved by tradition is a static one, allowing of no advance either in production, or in standards of living, or, least of all, in population. (Biblio. 1) Now, as a result of the welfare work of the colonial administrators, actively continued since independence by the new Governments, demographic pressure is becoming a major consideration in development. Statistical surveys have shown that population growth in the associated States is running at over 2.2% per annum, which would mean a doubling in thirty years. So, in thirty years, the present fifty-odd million inhabitants may well have become 100 million. And what will those 100 million live on?

The present low population density is no reassurance against these fears. Though the food problem is admittedly not so serious as in Asia, it is no use blinking the facts. The population density may be low overall, but it is very unevenly distributed: some areas in Upper Volta, Cameroun, Rwanda, Burundi and the Comoro Islands already have concentrations of 60-80 inhabitants per square kilometre. And above all, agricultural nomadism, with its concomitant practice of prolonged fallowing, make it necessary that the cropper should have at his disposal between five and eight times the acreage he actually tills in any one year or would require if intensive farming were practised.

Matters are made worse by rural underemployment, disguised as seasonal unemployment, the inevitable consequence of short crop cycles. Groundnuts are sown, raised and harvested in 110 days. In South Cameroun and Congo, where the growing of foodstuffs is women's work, the age-old division of labour in agriculture actually governs the organization of village society. In Cameroun cocoa-growing affords the men no more than 350 hours work per hectare per annum. In Congo the women produce the food while the men take jobs with European firms; the latter then, as Mr. Fernand Bézy has shown in a perceptive socio-economic study, regard their wages as "buckshee", to be spent on items unnecessary by customary standards; the marginal utility of earnings is low while the marginal futility of the work involved in obtaining them increases —hence the fact that the men ask very little in the way of pay, slack a great deal, and flit incessantly from job to job. (Biblio. 2)

Psycho-sociological factors

These are a double difficulty: in the first place it is not easy to be sure what will serve as an incentive, and in the second place incentives that do attract do not always attract in the direction of modernization. It is essential to grasp what makes the agricultural producers tick: operations organized with the utmost keenness and efficiency have come to grief owing to neglect of psychological factors. The psychological factors here involved are not the same as in Europe. Mr. Marcel Capet, the economist, has written, very truly, that the African has a tremendous sense of "depreciation of the future": he has had it explained to him that the gods are behind everything that happens, but not, usually, any more than that, and the main strand both in his life and in his working methods is religious belief.

"The traditional religions," says Mr. Capet (Biblio. 3), "are not only metaphysical and ethical systems: these aspects are subordinate, indeed sometimes non-existent. They are first and foremost an explanatory principle and a compact between a kin-group and the gods concerning that group's social and material existence. Consequently, it is impossible to dissociate what we see as the two elements of technical operation and religious ceremony. Millet grows because certain ceremonies have been performed which have pleased the gods, and it is then possible to sow it to good purpose; in fact, sometimes the operation and the ceremony are actually interwoven, as where, to please the gods, the millet has to be sown in a particular way.When land is brought under cultivation, there has to be a compact between the gods and the intending cultivator and his children and grandchildren, otherwise the land would remain barren. Everything a man does, whether for his own material purposes or as a member of society, has its religious implications. Every action quickly takes on a religious aspect and tends readily to turn into a ritual—which is one reason why working methods remain unchanged.Whoever leaves his group and his home region forfeits the protection of his gods; even those who stay enjoy that protection only if they do as the gods require, going through the proper ceremonies and respecting the often numerous and highly restrictive tabus."

Disadvantageous market conditions

The main element affecting the money side is the trading system, resulting as usual in a price structure characterized by cumbrous distribution channels, proliferation of middlemen, high cost of transport and services, and the burden of indirect taxation. The dweller on the land pays substantial amounts for the imported products he consumes, and does not always receive in return for his labours a fair, let alone a good share, of the end price charged for his produce. The sums concerned vary considerably according to how far he lives from the ports of shipment: the further he is from the coast the higher the prices he pays and the lower the prices he gets. The distorsion is inescapable, but it is bitter.

To make matters worse, agriculture is based on a handful of primary products intensily sensitive to the state of the world market. Senegal's exports consist of 78% groundnuts, Ivory Coast's of 62% coffee and cocoa, Chad's 79% and the Central African Republic's of 60% cotton, Somalia's of 60% bananas, Gabon's of 47% timber.

In order to obtain the means to pay for the industrial products they must have if they are to carry on at all, these countries are thus dependent, apart from investment of foreign capital, on the export of commodities the consumption of which is governed by the general business climate prevailing in the industrialized countries, and some of which, especially the agricultural products, rank as non-essentials. Whatever the expansion of consumption in the developed countries, coffee, cocoa and bananas remain, if not semi-luxuries, at any rate items the European consumer can easily cut down on if he finds himself with less to spend or prices go unduly high.

The African economies are therefore exposed to constant ups and downs. On occasion they experience big booms, which can entirely mislead as to the real position when, with equal suddenness, they plunge into a slump. There is a slump on now, and not in Africa only, either, since the index of terms of trade for the developing countries overall *vis-à-vis* the developed countries overall, taking 1958=100, has slid from 105.1 in 1953 to 91.1 in 1962 and 95.1 in 1964.

Agriculture remains the dominant sector

Handicapped though it is, the agricultural sector bulks far larger than any other in the African national economies. Take first its predominance in their gross domestic product. The national accounts of the EEC associated States indicate that the primary sector—principally agriculture in the broad sense of the term—covers 46.5% of Cameroun's national product, 45.9% of Ivory Coast's, 52.3% of Dahomey's, 62.3% of Upper Volta's, 49.4% of Madagascar's, 66.2% of Chad's and 74.7% of Rwanda's and Burundi's. Congo, with 25.9%, is the sole exception, owing to its unusually well-developed industries and mines. But even so the pattern is quite different from that in the developed countries, where the primary sector accounts for only a small proportion of the gross domestic product—11% in Germany, 7% in Belgium, 9% in the Netherlands, 4% in Britain and the United States, and no more than 13% even in Japan and Australia and 17% in Argentina.

Again, take the high proportion of agricultural to total exports—65.3% for the associated States taken together, and 82.3% if we exclude those outside the Franc-area. For the Congo is again the exception with a mere 30.4%, even though 80% of its population are still living on and mainly by the land.

Such, then, is the introductory picture of the impediments to the development of the agricultural sector, and the position of that sector within the African economy. I have felt it necessary to offer this introduction in order to bring out more clearly the urgency of the need for action to promote agricultural development, and also in order to give a better understanding of the aims, means and principles to be adopted in that action, towards which so much has been contributed in the past, by the colonial administrators of yesterday and under bilateral and Community assistance schemes today, both on the financial, on the technological and on the human plane.

Aims, means and principles of action to develop African agriculture

The problem of development, however hard to tackle in practice, is as a mental excercise straightforward enough. It rests on a few self-evident facts.

Where it is not possible, in an undeveloped country,to establish heavy industry by working mineral resources or natural energy—owing to inadequate geological information, a poor subsoil, an inconveniently remote location, or failure to attract capital— the desired industrial and commercial development has to be concentrated in the most promising parts of the sectors already existing.

In the absence of mineral or energy resources, agriculture is, with a few exceptions, the principal sector in which pretty well everyone works who works at all. Consequently, wherever agricultural modernization can lead on to even a modicum of industrial development, or to the building-up of a remunerative export trade in processed or unprocessed produce, the great object must be to bring it about. Prof. Arthur Lewis, asked by President Nkrumah to submit a plan for the industrialization of Ghana, replied succinctly: "Modernize your agriculture for a start."

Again, agricultural modernization must be given priority wherever it is designed to obviate the need to buy non-indigenous foodstuffs from outside, since from the point of view of the balance of payments an import eliminated is the equivalent of an export. It is also a "must" where it will help to reduce malnutrition, for as we have seen population growth is beginning to give cause for anxiety on this score.

Further, by reason of the ancillary activities it involves, it is now seen to be the great means of enabling the mass of country-dwellers to escape from underemployment, to in crease their purchasing power and to realize that they are in process of becoming better off, and a means therefore of securing their willing support for their Governments' development drive. And last but not least it is coming to be a political necessity for the Governments themselves, which are increasingly aware of the growing gulf between the administrative middle class that has arisen since independence, and the peasantry. (Biblio. 4)

These five straight facts all point to the same conclusion, namely, that development in Africa must be concentrated first and foremost on agricultural modernization, whether as the precondition for industrialization, if necessary in a small way, and for the improvement of the foreign trade position, or as a step in the direction of social progress and political stability.

Economic intervention a basic prerequisite

For life on the land in Africa to be thus remodelled, one main element must be accepted as basic to all the rest—economic intervention to support and regularize the market prices of agricultural produce for the benefit of the growers.

This has been extensively practised in the overseas countries of the Franc-area, as also in those of the Sterling-area, whose Marketing Boards, started before the war, served as a model for the later French Caisses de Stabilisation des Prix. The methods used varied widely according to the country and product concerned some involving more drastic measures than others; there was full market organization with guaranteed prices and sales, there was price regularization over each season or from one season to the next, with prices kept below their natural level at peak periods and supported during the intervening troughs, and there was "pairing" of procurements as a means of controlling foreign competition and ensuring that it did not disrupt the home market.

The methods employed in the Franc-area were criticized by free-market economists and advocates of laissez-faire. No doubt they were open to criticism in that they artificially and permanently maintained a price level, not higher than that in the world market—for the "world price" is one of those bits of moonshine that will have to be shown up as such one day—but unduly high all the same. Nevertheless, it is wrong to lump together a policy of supporting prices at artificial levels and a policy of stabilizing or regularizing them: the latter is perfectly right and proper and something to which all farmers in the developed countries consider themselves fully entitled.

There is no greater lack of incentive to growers than erratic price fluctuations over which they have not the slightest control. And there is nothing more disheartening and unproductive than a technical assistance scheme launched when times were good and then by ill luck overtaken by a recession just before it has achieved its aim. All too many cases could be quoted which have ended in failure for nc other possible reason, and have caused the peasant to lose faith in the advice given him. I shall not dwell further on this aspect, as time is short.

Work of the European Development Fund

The need for financial and technical aid to develop agriculture and bring the peasant croppers more into step with the times is less heatedly debated than that for assistance in organizing trade and commerce, although it is completely absurd, and will undoubtedly prove useless, to attempt the one without the other At all events, the European Development Fund, the Community's instrument for the purpose, established. by the Treaty of Rome and renewed by the Yaoundé Convention which took effect in June 1964, has to its credit extensive and varied activities in all the financial, technical and human fields affecting agricultural development in the EEC associated countries.

The original EDF, working with a grant of 581 million dollars under the Convention of Association annexed to the Treaty of Rome, admittedly concentrated mainly on projects for modernizing the economic and social infrastructure, and has been fairly enough described as primarily an engineers' and architects' fund. Nevertheless, close on 143 million dollars—26% of its total outlay—went on agriculture.

EDF II, which was renewed by the Yaoundé Convention for a term of five years and furnished with a $730,000,000 grant by the EEC member States, has somewhat shifted its sights in order to focus still more on agriculture. There is no question of an agonizing reappraisal of policy resulting in a sudden decision to stop bothering about the infrastructure, when in many cases inadequate or neglected communications are one of the big bottlenecks impeding the development of agricultural production. None the less, in only two years EDF-II has spent 109 million dollars, or 46% of its total outlay, on agriculture—indeed, if we further include appropriations for the support and stabilization of agricultural prices, the figure is 140 million, very nearly as much as was furnished for agricultural development by EDF-I in seven years.

Direct promotion

"Direct promotion" includes all EDF-I- and II-financed projects designed to benefit agricultural production directly. These may be subdivided as follows, according as to whether the emphasis is on human plant or physical agencies as the main production factor:

soil conservation, e.g. in Upper Volta (125,000 hectares), North Cameroun (25,000 hectares) and Dahomey (10,000 hectares);

hydro-agricultural schemes, primarily intended to ensure improved distribution of one of the main physical production agencies, water. Operations have been begun by EDF-I and II over some 53,000 hectares to develop the growing of rice, cotton, sugar cane and foodstuffs;

agro-industrial complexes, to streamline a particular line of production selected in consideration of its requirements as to cultivation and the prospects of breaking even. 66,000 hectares have been thus opened up under EDF auspices for the rational cultivation of palm oil (44,000 hectares), tea (3,000 hectares), dates cocoa, cotton, pyrethum and tobacco;

"integrated" development, aimed not so much at the produce as at the grower, by means of technical assistance and education: examples are the drive to reactivate agriculture in Kinshasa Province, the working-up of the Mayaga-Bugesera area and counselling of the Mayaga peasants in Rwanda, the institution of co-operatives in the Central African Republic, the development of the Yatenga in Upper Volta, and the improvement of the cotton yield in Chad;

improvements and rationalization in animal husbandry, including firstly action in connection with the health of existing stock (three rinderpest eradication campaigns covering 25 million head of cattle in all, establishment of veterinary and immunization centres and clinics and of inoculation yards and crushes in Cameroun, the Central African Republic, Gabon, Mauretania and Niger), and secondly action to improve the breeds for the future (introduction of trypanosomiasis-resistant stock in the Central African Republic, Gabon and the Congo, establishment of breeding farms and of a grazing ranch).

Indirect and supplementary promotion

This comprises EDF projects aimed either at educating the growers and providing the necessary cadres or at enabling infrastructural and other improvements benefiting agriculture to be carried out.

On the occupational-training side EDF aid has gone mainly to the building of premises for the purpose: these include the Ecole pratique d'agriculture in Cameroun, 10 training centres in the Central African Republic, the Institut d'études agronomiques de l'Afrique Centrale at Wakombo, the Collège technique agricole at Bambari, the Ecole technique d'élevage at Bouar, 10 boys' training camps in Ivory Coast, 225 training centres in Upper Volta and 5 in Madagascar, 104 seasonal agricultural colleges in Mali, the Institut d'économie rurale at Bamako, the Ecole d'instituteurs agricoles in Rwanda, the Ecole nationale des cadres ruraux at Bambey, the Ecole nationale d'agriculture in Togo, the Institut d'enseignement zootechnique et vétérinaire de l'Afrique Centrale in Chad, and the Ecole d'infirmiers vétérinaires et d'assistants d'élevage at Niamey. It is perhaps also allowable to regard as coming under the head of training the facilities EDF has financed for agricultural extension work such as 526 branches of agricultural provident societies in Algeria, 100 extension centres in Niger, and 28 "rural expansion centres" in Senegal.

As regards infrastructural improvements of direct benefit to agricultural development, EDF has launched a great many public works of specific importance to the rural areas. They include 230 bridges along the tracks of the Central African Republic, a road network in the cocoa-raising area of Sangha in the Congo, banana trails in Mayombe, bridges along the cotton trails in Chad, and tracks and cattle markets in the Central African Republic. Its biggest and most popular scheme, however, has been in connection with water supplies for the villagers and their beasts: achievements to date, 2600 wells, 160 boreholes, 1300 springs and 90 dams, in Cameroun, the Central African Republic, Ivory Coast, Dahomey, Upper Volta, Mali, Mauretania, Niger, Senegal and Chad.

Since, sooner or later, agricultural activities entail industries, EDF has also been building and fitting up a number of industrial plants for processing or preserving agricultural produce, including a slaughterhouse and cold storage at Bamako, regional slaughterhouses at St. Louis and Thiès, ten fish-curing establishments in Senegal, and tea and palm-oil factories forming part of the agro-industrial complexes I mentioned earlier.

I must apologize for the *Prévert*-like inconsequence with which I have rattled off this string of projects effected, in hand and planned. However, as I said at the beginning, they represent over 280 million dollars, and if the impression given remains one of a heterogeneous jumble, EDF's experience in this field is not only extensive but extraordinarily varied, since it has sought to bring into play every conceivable source of momentum, technological, psychological and human. Basing ourselves on this experience, and on comparison with the experience of other systems of aid which are daily encountering the same problems and the same difficulties, we are thus able to work out not so much a doctrine as a corpus of precedents and of lessons learned, which can stand as present and future working principles for agricultural modernization.

Principles on the technical side

In underdeveloped countries, the utmost caution must be observed as to the launching of big hydro-agricultural schemes, however attractive these may look on paper. The technical difficulties involved in actually carrying them out can always be overcome, but not those of ensuring that the desired use is made of them afterwards, even if in theory the prerequisites seem to be there—land tenure, crop-raising methods, adjustment to the human environment, adequate food and equipment for the workers, collective management, depreciation arrangements, marketing and processing facilities, to name only a few of the formidable problems that have to be dealt with by the follow-up developers. So formidable are they indeed that usually it takes several years before the splendid acreages thus expensively irrigated or drained can be settled and brought under cultivation.

Smaller-scale schemes of this kind are commonly more in line with the beneficiaries' requirements. They can often be carried out again and again, thus serving a population more satisfactorily distributed geographically. Nevertheless, they can only be brought off and repeated successfully given not unduly heavy depreciation and maintenance charges, appropriate collective organization, properly-thought-out cultivation and extension methods, higher productivity and assured prospects of paying their way. Collective mechanization is a temptation to be eschewed for so long as European-type operating conditions are lacking. Mechanization imposes a greater strain than the existing agricultural set-up can normally bear: it is seldom as efficient in practice as it should be in theory, and it is liable, unless conducted with strict regard for the necessary safety margins, to eat up the one great basic asset, the land.

Collective equipment drives can achieve their object of reducing the input of labour and stepping up the quantity and quality of production only if they are based on a supporting structure which will of itself deal with the administration, maintenance and replacement problems involved as they arise.
Any modernization scheme that interferes with the nutritional balance of those concerned is dangerous unless the imbalance can be made good by outside procurements obtained at a cost per head working out lower overall than the profits accruing. The main aim where no other kind of development is possible must be to increase the yield of the traditional crops, by the cheapest and simplest methods. Since this involves a great many operations needing to be carried out on a certain scale if they are to produce the desired economic results, and correspondingly difficult to organize and superintend, there is often reluctance to put money into it, which is a pity, for such schemes, if rearranged and co-ordinated into a manageable whole, are more of a paying proposition than their individual insignificance might lead planners to suppose.
In addition, the associated countries possess potentialities for crop diversification and stockbreeding which have never been properly turned to account because the problems involved have never been tackled in the round. The best example is probably meat. It is no use starting a series of unco-ordinated hydraulic-engineering and animal-husbandry projects in the sub-Saharan regions of West and Central Africa unless at the same time a programme is worked out covering the whole area and comprising feeding, slaughtering, preserving, sales outlets, the surveying and organization of the home and export markets, utilization of waste products, the possibilities for a hides and skins industry, packing and canning, and specialized transport. A pretty ambitious scheme, which would require a concerted stockbreeding policy on the part of all the countries concerned—but it is not a merely visionary one: the funds that would be needed, though substantial, are not altogether beyond what could be covered by Community aid, supplemented by private capital which would be sure to be forthcoming.

Principles on the human side

Modernization is not possible without the voluntary co-operation of the producers.Were they do not come in of their own free will, there will be no production. Every care must therefore be taken not to bewilder the peasant by introducing unduly sudden changes in his world as he knows it.
Techniques are only means to an end: they will not ensure success by themselves. Accordingly, modernization must always include education. That education must be administered to the producer as directly as possible. This means that there must be a sufficient staff of trained cadres who will be understanding, persuasive, with no axe to grind, seen to practise what they preach, and knowing more about practice than about theory. It is better in agricultural extension work to bring all available means to bear upon the most receptive sectors than to try to influence too many producers through too few cadres.
Any change in traditional methods, any group-level innovation involves various side-issues and after-effects which have to be taken into account in drawing up a modernization project or programme. Higher yields can give rise to storage, collection, transport and marketing problems which must not be allowed to leave the growers feeling baffled and helpless, but must be properly provided against as part of the scheme itself. Should the practical outcome be in doubt, the scheme, if nevertheless rated definitely worth attempting, should be carried out on a small scale only, the peasant selected as the experimental guinea-pig to be indemnified if it is a failure. It is a mistake to suppose that force of example produces immediate effects in technical education. Growers who are not included in a pilot scheme and do not have the benefit of the extension officer's advice or the assistance given to those who are so included envy the latter to begin with, but don't imitate them for quite some time, until they have seen for themselves how noticeably better off their neighbours have become.
It is also untrue that the traditional social and religious set-up lends itself readily to conversion into a system of economic co-operation: the concept of communal sharing of benefits is quite unknown among these people. Clan solidarity can, nevertheless, serve as the foundation for a fair degree of economic solidarity. It is no use thinking to organize agricultural communities by a stroke of the pen: the only effective function of laws or regulations in this connection is to support, assist or protect group associations which have grown up of their own accord, or thanks to the efforts of a trusted extension officer. In over-large groupings the sense of solidarity and responsibility is lost: such groupings will last only for so long as they are imposed by

authority, and after that will vanish as if they had never been. No more in the way of co-operation should be asked of any producer or community of producers than they are reasonably able to give, or disappointment will be the result.

Credit and debtor's responsibility are still purely "Western" concepts. The most careful calculations as to the solvency of prospective recipients of agricultural loans offer no real security. In the areas growing mainly non-edible crops, the inhabitants are so chronically in debt, owing to not having enough foodstuffs of their own, that they have not the slightest idea of thrift or saving, and consequently it is hopeless to expect them to purchase or pay off the equipment and services they need to increase their yields or diversify their crops until they have received the necessary instruction on the subject.

An increase in an agricultural community's purchasing power will not give the desired fillip to its development unless the facilities are available on the spot for it to better itself in the matter of technical equipment and social conditions. Every population unit in process of development should therefore have ready to hand the means needed to improve its performance, reduce the amount of physical labour involved, and raise the standard of its living accomodation. Consequently, promotion of small industry and business and decentralization of sales foci must be regarded as important elements in agricultural development.

And lastly, we must remember that every experiment that fails creates scepticism in those it was supposed to benefit. As the British say, once bitten, twice shy.

Not so much a plan for agriculture as a plan for agriculturists.

These little tips from everyday experience may perhaps seem pretty commonplace, not to say obvious. As I could not deal exhaustively with my subject, I have not tried to be original, simply to indicate some of the do's and don'ts in this long business of agricultural development.

There are various other useful markers and traffic signs to keep the developers working on the right lines—the lines adumbrated by intellect's poor relation, common sense.With these safety devices to help it, a development organization has no right to let itself be put off by difficulties: there is no challenge that cannot be successfully met by men of good will.

The task is admittedly no easy one, for the initial position is about as unpromising as it could possibly be. In Africa, where, as has been said, even the water supply can be a difficulty (here too little and there too much), where what is not brought to completion might as well not exist at all, where a moment's inattention causes fields to revert to jungle, there is such an infinite variety of possible methods and approaches that they may vary from moment to moment, and perhaps even from point to point, within a single agricultural community. Development consists of practical experiments, which have to be subjected to constant adaptation and adjustment. To create a good, efficient and intelligent corps of growers is a continuous job of many years. Nature cuts no corners and failures influence the whole process as much as successes do.

So the time factor is all important: we must not make the mistake of being impatient in our efforts to achieve striking results. I don't know about genius, but agriculture most certainly does mean "an infinite capacity for taking pains." Neither premature successes nor premature failures matter very much.

I am not the first to make the point that agriculture is "not so much an occupation, more a way of life." What Africa needs is not a Plan for agriculture, but a Plan for agriculturists. To make a real difference to the peasants, it is not enough to concentrate on the actual production factors themselves: we have at the same time to improve both economic and social conditions, increase yields and try to stabilize prices, press on with modernizing the channels of buying and selling and with establishing co-operative working systems —in a word, to co-ordinate into a well-compacted whole a mass of dispersed, diverse and discrepant activities, in order to frame a genuine "policy for the countryside" and to offer the African country-dweller not merely words of good cheer but a real and practical chance in life.

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P. John ZACHARIAH

Director Tractor Training and Testing Station of the Government of India
Budni

Development and Mechanization Programme of the Soil, with Particular Reference to Tropical Developing Countries

Cultivation of the soil held the attention of mankind ever since he started gathering more food than was needed for his day to day consumption. Significant increases in agricultural production have been achieved in many countries, but in most of the developing countries the gap between growth of population and agricultural production is widening. The desire to meet the minimum necessities of life comes first. When it is difficult to meet this, it creates social, economic and even political problems.

The economy of these countries is based on agriculture. Its improvement, therefore, is a fundamental condition to create and maintain a high rate of development.

Developing countries have very low levels of agricultural production. Farming is done by man and animal power, and often with inefficient tools. Significant increase in production can be achieved by introduction of better implements and machines, along with the necessary skills in a planned manner. Industries needed to cater to the requirements of agriculture and to process agricultural surpluses are scarce. Any programme for introduction of mechanical equipment calls for an adequate supply and use of steel. This paper, therefore, attempts to outline briefly the conditions as they exist, and the possible improvement of agriculture in the developing countries in the tropics. The climatic and socio-economic problems India faces are representative of most of the developing countries in the tropical region. It is now channeling its efforts for a more scientific and productive agriculture. Hence, it encourages the author to take its problems and prospects for elaboration.

Agricultural production versus population growth

The fear of malnutrition or famine threatens some of the densily populated developing countries.

The FAO Report (Biblio. 1) on the general features of the decade commented:

"The implications of the accelerating population growth in the developing countries and of the unsatisfactory nutritional levels of the bulk of their populations are now widely realized. There is also a growing understanding of the wider role of agriculture as a key factor in economic development. Inevitably, a review of world agriculture during this period must be largely concerned with the developing countries."

The main problem of developing countries is the annual increase of population. At what rate the population will grow? At what rate agricultural production can be increased? These are subjects for speculation and serious studies. Estimates on total world population run as high as 6,000 million by the end of this century. The Third World Food Survey (Biblio. 2) emphasizes the need for nutritional improvements which would involve increasing total food supplies in the world.

The average calorie supplies per capita and estimated requirements in the countries for which information is available show that the deficiency in per caput calorie requirements in some of the developing countries range from 9.2 to 17.6%. This deficiency in itself indicates the urgent need for increased agricultural production to meet the requirements of food. (*fig. 1*)

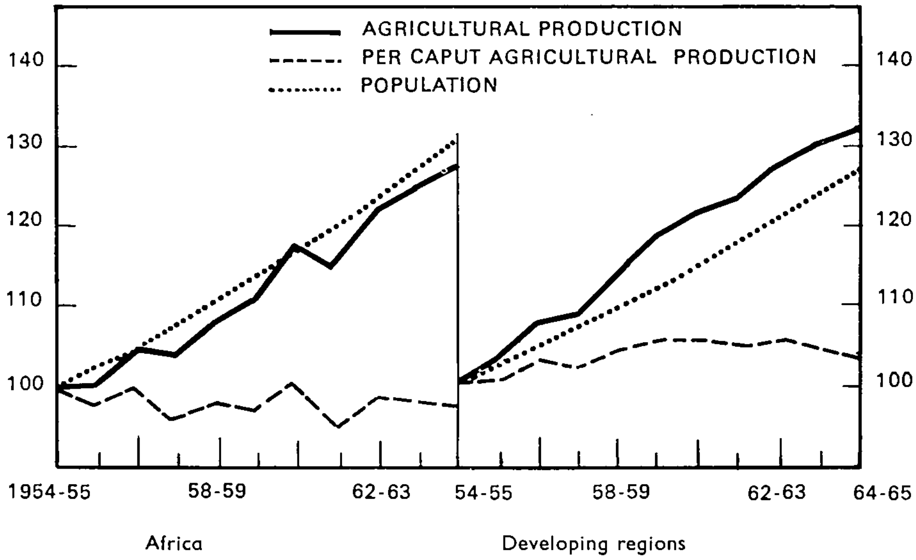

Fig. 1 — Regional trends in agricultural production and population in selected regions (Biblio. 1) Indices 1954-55 = 100

Farming in the tropics

Within the tropics there is no uniformity in climate and physical conditions. Temperatures are high, and rain occurs in torrential downpour. High temperatures and humidity accelerate decomposition and mineralization of organic matter. As a result of active microbial decomposition, the soils are generally low in organic matter content. The end results are depleted soils. Depleted soils, poor seeds, crude and inefficient tools, low level of power use, and farmers whose capabilities are influenced by tradition serve as a serious handicap for raising the general level of production to reasonable standards.

Rice is the main crop grown in high rainfall areas and to a limited extent in uplands. In medium to low rainfall areas, surgarcane, sorghum, maize, cotton, groundnut are the principal crops. Wheat, barley and other cereals are grown, where there is a temperate climate for part of the year. Coffee, tea, cocoa, spices of different types, cashewnuts are grown in areas of high rainfall. The existing method of farming in most of the tropical countries is one followed for centuries past, even though in a few regions, modern methods of farming are being adopted.

Some of the general problems

There is an increasing awareness for a more scientific and productive agriculture in all developing countries. This is more so in India and in some of the other countries in Asia where the food production is not commensurate with the immediate requirements. Some of the factors that stand in the way of increased production are climatic, socio-economic and technological.

Variation between humid and arid conditions within areas of the same latitude exists due to seasonal changes in the monsoon winds, position of mountains and proximity to sea. Either there is excessive precipitation which leads to devastating floods or periods of prolonged dryness causing drought conditions. For example, in India, the South West monsoon which accounts for 75% of the total rain, occurs between June and September. Depletion of soil due to erosion, loss of farming land by floods and formation of gullies is considerable. Substantial amounts of nutrients are also lost by erosion and leaching. The irregular and uncertain rain-pattern between years and within the season causes partial or complete crop failures. Variability of monthly and annual rainfall in certain regions are very high as can be gathered from the following table (Biblio. 3) relating to Hagari (India).

Because of the irregular and uncertain rainfall, tropical agriculture sometimes becomes a "gamble in the monsoon." The abundant solar energy, the average soil and atmospheric temperatures promote excellent

Table 1 — Variability of the monthly and annual rainfall at Hagari (average of 19 years)

	May	June	July	August	September	October	Total
Rainfall in mm.	36.5	32.4	38.0	71.0	110.0	120.7	398.6
Standard error	—	1.01	1.26	3.33	2.32	3.44	6.31
Variability (per cent)	—	79	84	119	53	72	32

vegetative growth where the rainfall is evenly distributed or where there are facilities for irrigation. The high temperature combined with excessive moisture promote quick decomposition of organic matter and affects its residual effect both from the point of fertility and improvement of soil structure. The nitrogen status of the soil is thus generally low. In the thickly populated developing regions, fragmented and uneconomic holdings, lack of professional approach to farming, low level of education, industry, and poor communications stand in the way of accelerated progress. The investment capacity of the average farmer is low and agriculture which is dependent upon the vagaries of nature, makes him reluctant to go in for heavy investments. Low price of agricultural produce as compared to other consumer industrial goods acts as a serious impediment to attract heavy investments as well as talent to agriculture. There is also a lack of institutions operating on a national scale to provide credit facilities at reasonable interest rates.

The need for tools and equipment

Better tools and equipment are prerequisites in the developing regions for increasing the productive capacity of men and animals, and to improve the quality of operations. Better tools in many cases can provide comfort in operation and thus permit longer hours of work with less fatigue. In many countries, the handles of tools for digging and spading are short, which strain not only the muscles of the arm but also of the back, whereas a longer handle would permit a more comfortable working position. Man is a poor source of power, because he can at best sustain 0.1 hp. for a continous working period of 8 to 10 hours. Tools adapted to synchronize with natural and easy motions of the body and at the same time meet functional efficiency are necessary for efficient working.

In most of the developing countries in Asia a wooden plow with an iron point is used for primary tillage, intercultivation and sowing. These and other indigenous implements are popular, not because they are efficient, but because their initial cost is within the means of the farmer. The raw materials for their construction and craftsmen to manufacture and repair them are easily accessible.

A pair of bullocks develop 0.3 to 1.5 hp. depending upon the size and the harness or yoke used. Observations made in India show that bullocks on the average when used with indigenous yokes develop 0.5 hp. (Biblio. 4). A man who can otherwise develop 0.1 hp. to guide and operate a 0.5 hp. animal unit appears incredible. A recent study made by FAO has revealed that in parts of South East Asia, it takes 7 man hours to produce 20 kg. of rice, while in Japan where extensive use of better implements and machines are made, only 7 minutes are taken to produce the same quantity.

This, of course, is not a valid comparison, because the yield in Japan is about four times higher, but is an adequate evidence of the considerable possibilities of reducing human and animal effort by using mechanical power. In the developing countries of Asia 50 to 80 man and animal hours per hectare are used for four to six repeat operations to obtain a good tilth.Whereas man hours per hectare (Biblio. 5) required for plowing by a 5 hp. walking tractor is only 20 to 30; 12 to 17 for rotary tilling with a 7 to 10 hp. power tiller and 5 to 8 with a 20 to 25 hp. tractor. Man and animal hours used for sowing, intercultivation, harvesting and other operations are also very high. Better tools, equipment and power are, therefore, indispensable to relieve farmers not only from drudgery but also to enable them to earn time for doing other things.

Mechanization indispensable

Since climatic conditions in some of the regions are uncertain, the success of farming is dependent upon the ability of the farmers to carry out the operations within the time limits dictated by climate. Low yields due to insufficient tillage for planting, loss of grains due to shattering by a delayed harvest, damage by insects and pests, are common. Deep plowing, land reclamation, land development, levelling, grading, terracing and other soil and water conservation measures are essential to maintain soil productivity. These are difficult to perform without resorting to mechanical power.

For example, in the dry farming belt in Central India, the last rain from South West monsoon is received by the middle of September. Since the soil is heavy clay, it takes about 15 days before optimum moisture condition for tilling is reached. This period and sowing time almost coincides and usually about a week is available for preparing the seed bed. Observations have shown that 20% to 30% more yield could be obtained by timely operations using tractor power.

A further increase in the cattle population for draft purposes in most of the developing countries is unthinkable because this will further aggravate the competition for food between man and animal. Mechanization would bring a gradual reduction in draft animals, thus releasing more acres to produce human food or to divert the available land to feed milch animals. Mechanization would also make it possible to produce more than two crops from the same area especially where irrigation facilities are available, thus increasing the productive capacity per hectare.

Stimulating factors needed for growth of mechanization

The growth of co-operatives and institutions for providing credit at nominal interest rates, Government subsidy on the initial cost of equipment are essential for progress of mechanization. Large and small scale industries should grow in the region to utilize agricultural products for manufacture of consumer goods. Development of processing industries and improvement in communications to provide better prices for marketable agricultural surpluses are necessary to stimulate mechanization. Above all, there should be rapid expansion of education to change the people to a mechanically inclined social pattern.

Degree and nature of mechanization required

An approach to mechanization should in the first instance include improved tools and machines that can be operated by animals, because they are the main source of power within easy reach of the small farmers and would continue to be so for several years to come. The size of holdings and crops grown to some degree are an index to the degree and extent of mechanization that may be adopted. In populated developing countries, though the average size of a holding is small, there are quite a large number and large sized holdings where machines can be used.

Equipment for small farms

The output per man and animal, and production per hectare can be increased substantially by introducing simple and moderately priced equipment. Animal drawn mould boards plows, cultivators and planters, manually operated sprayers, dusters, land smootheners, ridgers are some of the implements and machines that can greatly improve efficiency. Trials (Biblio. 6) conducted in India have shown that sowing with an animal operated 3 row seed-cum-fertilizer-drill can reduce sowing time by 39% over traditional methods, and 36% sowing time is saved by planting maize with a single row planter. Proper fertilizer placement and plant spacing in the row increased yields up to 40% in case of maize which was planted by an animal drawn planter and 12.5% in case of wheat. (*fig. 2*)

Besides higher yields and saving in time by using seed drills and planters, saving in seed to the extent of 30% depending upon local practice can be obtained.

Walking tractors or power tillers in 5 to 10 hp. range would be a welcome source of power on farms up to 7 hectares especially in the rice growing regions. Apart from catering for the requirements for seed bed preparation, intercultivation and transport, they could be advantageously used as a mobile power unit for working irrigation pumps, plant protection equipment, threshers, winnowers and other stationary

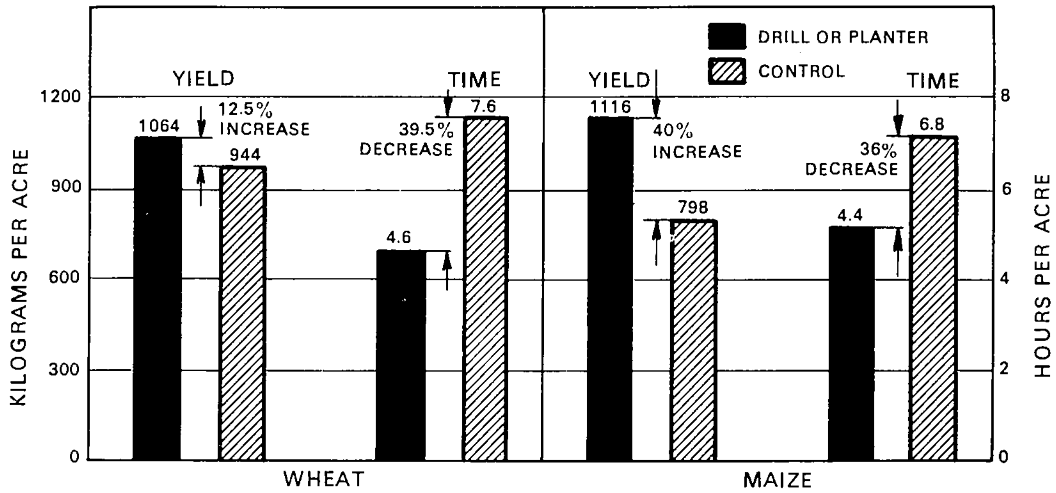

Fig. 2 — Average increase in yield and reduction in hours per acre secured by using fertilizer-cum-planters and seed drills (Biblio. 6)

machines. Japan is a good example where increased production per hectare from small farms has been achieved by intensive use of mechanical power. The trend in Taiwan shows that power tillers are gaining increasing popularity, and their numbers (Biblio. 7) have increased from 600 in 1958 to 3,057 in 1960 and to 7,504 by 1962.

In India, there are about 15.61 million holdings between 2 and 10 hectares which represent about 48.3% (Biblio. 8) of the total cultivated land. These holdings offer good scope for power units of 5 to 15 hp.

Equipment for big farms and land development

While tractors in the different power ranges would be required, tractors in the 20 to 35 hp. range would be ideal for medium and large farms. In developed countries, with the increasing use of power take off driven equipment and rise in labour costs, the trend is towards wheeled tractors of 50 hp. and above. In developing countries, however, due to high initial cost, tractors above 50 hp. will be used mostly by large scale mechanized farming institutions and for land reclamation and development.

Large tracts of land denuded by erosion, areas rendered unsuitable for crop culture due to poor drainage, areas which are cultivable but infested with pernicious weeds are present in tropical developing countries. High rate of rainfall offers considerable scope for storing and diverting the excess water for raising irrigated crops.

Sufficient information on the area of reclaimable land, the nature and extent of reclamation and development required and the economy of operation are not available for all the developing countries in the tropics. In India alone, there are 18.1 million (Biblio. 9) hectares of cultivable waste. The number of machines and man power needed to reclaim and develop this land is enormous. If only 50% of the above area in India is to be reclaimed and developed, it would require thousands of 100 to 150 hp. tractors with a complete range of complementary equipment to work for over a century.

Land reclamation and development involve very high initial investment on equipment, survey of land capabilities, and assessment of type of reclamation and development to be adopted. These require a high level of careful planning and organization and call for action by Governments or international institutions. Reclamation and development of land suitable for agricultural purposes in the thickly populated developing countries in order to reduce the pressure on land, and to increase total production, cannot be over emphasized.

Growth of mechanization in India

In a number of areas throughout India, the effects of use of improved implements and agricultural machines can be easily seen. The absence of industries engaged in the manufacture of tractors and other equipment in sufficient numbers and the limited imports of equipment necessitated by lack of foreign exchange are serious handicaps to farmers with a progressive outlook and investment capacity for adopting mechanized farming. This is one of the difficulties which most of the developing countries are facing to-day. The growth of some of the agricultural machinery is given in *table 2.*

The use of oil engines, pumping sets, and other farm machines has increased three to five times during the past decade and the increase would have been much more but for restriction on import of raw materials and other essentials due to foreign exchange shortage.

Table 2 — Number of agricultural machines in India (Biblio. 9)

(in 1,000)

	1945	1951	1956	1961	1966[1]
Oil engines (with pumps for irrigation purposes)	12	82	123	230	250
Eletric pumps for irrigation purposes	9	26	47	160	180
Tractors (for agricultural purposes only)	5	9	21	31	50
Power tillers	—	—	—	—	12

[1] Estimates based on available data

A beginning has been made in India in the production of tractors, power tillers, tillage implements, threshing machines etc. but it forms only a very meagre portion of the repuirements. In 1965, 6318 tractors were manufactured in India. Production capacity is very much dependent on the import of high grade alloy steel and production machinery.

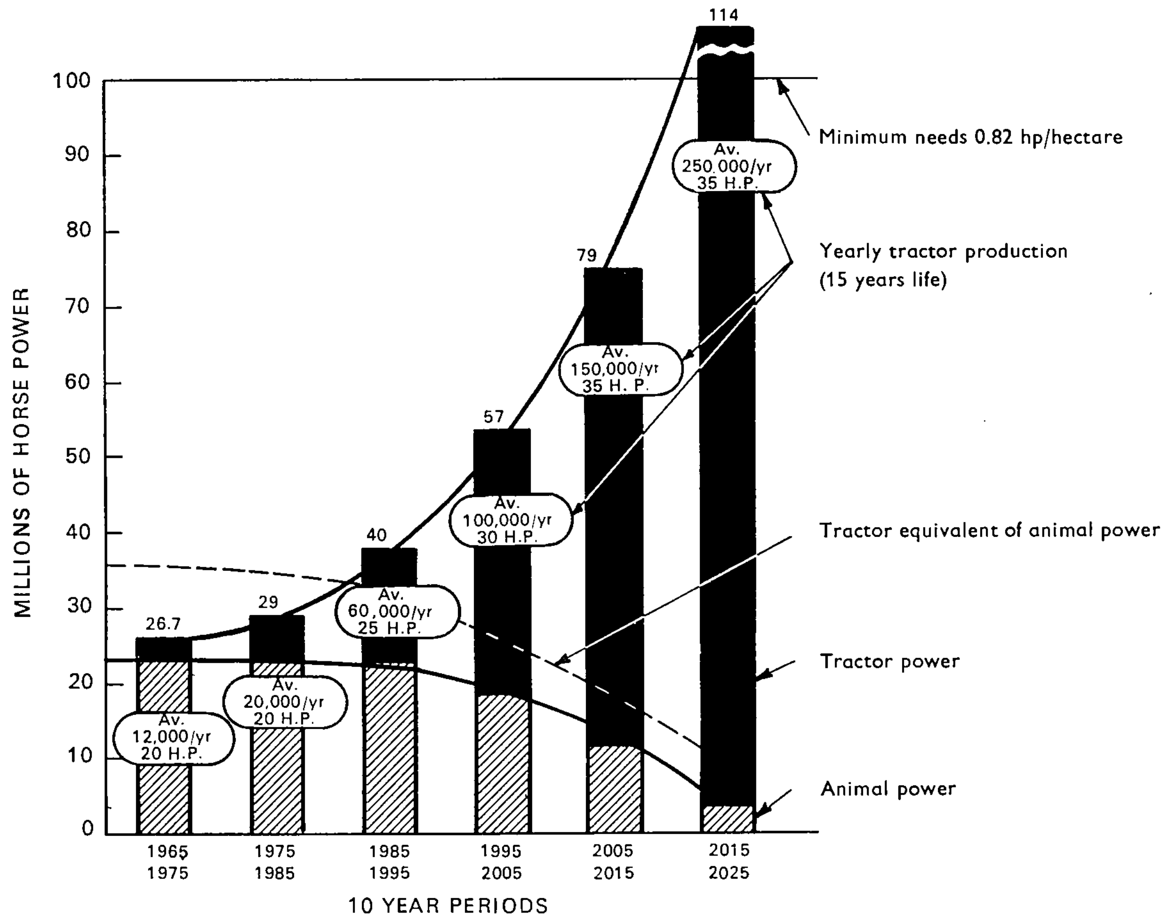

Fig. 3 — Power plan for India to reach 0.82 hp./hectare and estimated trend in utilization of bullock and tractor power (*Biblio. 6*)

Horse power requirement per hectare would vary with the cropping pattern, type and number of tillage and other operations performed on the farm. The minimum requirement for a reasonably satisfactory farming for conditions existing in India has been estimated to be 0.82 hp. per hectare (Biblio. 8). Thus about 114 million hp. will be required to achieve the level of 0.82 hp. per hectare. As against this, the tractors currently in use for agriculture provide about 1.25 million horsepower and animals about 22.0 million hp. Assuming a steady increase in tractor production and a decline in draft animals, it would take about 50 years to reach the 0.82 hp. per hectare level. A similar trend, perhaps, would exist in other developing countries. The potential for growth of industry in the country, capacity to earn foreign exchange for importing equipment and raw materials, educational levels and changes in socio-economic conditions would influence the rate of introduction of farm machinery. (*fig. 3*)

Steel for agricultural development

Steel is the major material in agricultural implements and machines. From history, we find that the very progress of humanity has largely depended upon the diverse uses to which steel was put. When man was looking for food, the one who replaced the sharp edged stone on his spear with a steel blade, became a better and efficient hunter. So also, the man who made a better plow with steel was able to raise more food than the one who had only a pointed steel bar on his wooden plow. The progress of civilisation is closely interlinked with its ability to produce and process steel. Steel is not only the foundation of a progressive industry, but also of a progressive agriculture.

The countries which have made substantial progress in agricultural production are those which have a high rate of steel production and have mastered techniques of extraction and alloying.

In the developing countries, the immediate need is not only to provide improved implements of steel for the available animal power, but also to plan and create an environment for introduction of farm machinery. Requirement of steel for agricultural purposes would increase steadily in the next few years. If only wooden plows, throughout the developing countries, are to be replaced by implements of steel, the quantum of steel required would be considerable.

Capacity of developing countries in the tropics to meet the requirements of steel for industry, agriculture and public amenities is limited. This would be evident from the production of iron ore and steel in these countries.

Table 3 — Iron ore and steel production in some of the selected countries as on 1964 (Biblio. 10 and 11)

(1,000 tons)

Country	Iron ore	Pig iron	Steel
Algeria	2,339	—	—
Ghana, Kenya, Burmah, Ethiopia, Indonesia, Uganda, Tanzania	—	—	—
Liberia	10,456	—	—
United Arab Republic	447	—	—
Pakistan	5	—	5
Philippines	1,367	—	—
Taiwan	7	62	300
Malaesia	6,569	—	—
Thailand	15	5	7
India	20,541	6,670	6,140

The requirements, therefore, for agricultural and other purposes will have to be met from imports, and the demand for steel in these countries would assume staggering proportions during the next several years to come.

The total annual demand (Biblio. 12) for steel in India by 1970-71 is estimated to be:

	(Million tons)
(a) Steel	
(i) Rolled mild steel	13.594
(ii) Ingot	18.287
(b) Alloy and Special Steel	
(i) Finished	0.966
(ii) Ingot	1.610
(c) Pig Iron (foundry grade)	3.462

Accurate estimates of the total requirement of steel for agricultural implements and machines in India are not available, but the requirements for agricultural purposes are estimated to be from 2.5% to 3% of total consumption. Until a few years ago, manufacturers of irrigation pumps, engines and animal drawn implements were the major consumers of steel in the agricultural machinery sector.With the commencement of production of tractors and implements and other agricultural machinery, there is a sharp rise in the steel demand. Production of agricultural implements and machines, in view of the urgent steps that are being taken for stepping up agricultural production is likely to rise faster than other industries. (*fig. 4*)

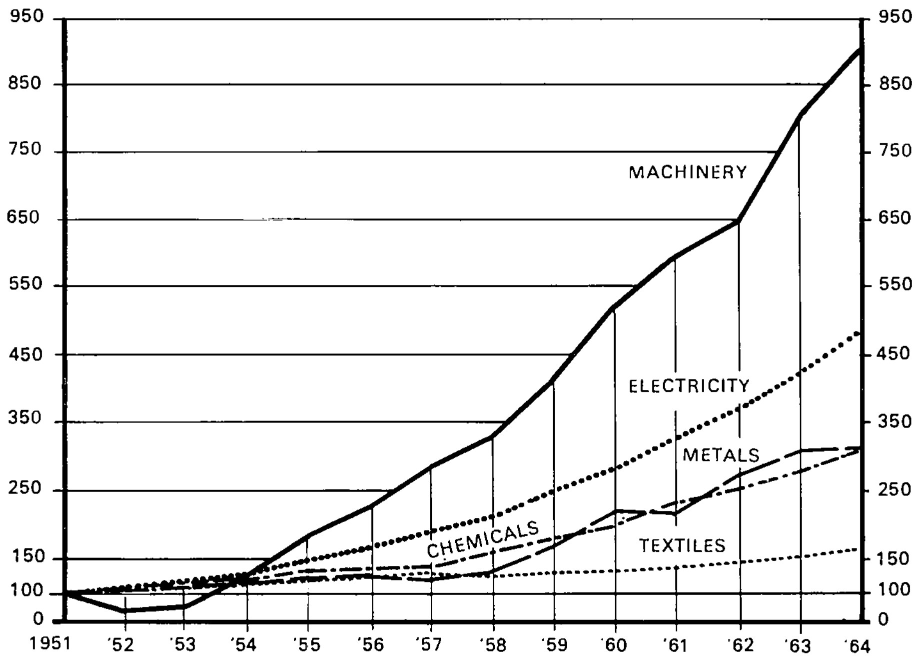

Fig. 4 — Growth index of selected industries in India (Biblio. 11) (base 1951 = 100)

The requirement of wheeled tractors in different horse power ranges of 15 hp. and above is estimated to be 30.000 per year by 1970-71. Taking the ratio of tractors in the different horse power ranges, the average requirements of steel per tractor would be 1,185 kg. of the following types of steel:

	Weight in kg. per tractor
Carbon steel	75.5
Alloy and special steel	23.5
Sheets, plates & strips	122.0
Castings (Grey and malleable)	714.0
Steel forgings	250.0
	1,185.0

The growth of farm equipment industry as well as other industries suffer from lack of special grades of alloy steel. The estimated demand for 1970-71 and anticipated output of alloy steel show that there will be a deficit of 387.700 tons.

The deficit in all types of steel will have to be met by imports. The total import (Biblio. 13) of steel has risen from 875,631 tons in 1962-63 to 1,026,749 in 1963-64.

Majority of the developing countries in the tropics do not either have, or offer immediate scope to be self-sufficient in steel. Therefore, the progress of mechanization would depend on their adopting any one of, or a combination of the following methods:

(a) meeting requirements by import of farm machinery,
(b) by developing manufacturing potential from iron and steel to be imported,
(c) by developing capacity for extracting and processing steel from iron ores available in the country or to be imported.

Table 4 — Estimated demand and output of alloy steel in India by 1970-71 (Biblio. 12)

(tons)

Type of alloy steel	Estimated demand in 1970-71	Anticipated output from sanctioned schemes	Deficit
Free cutting steel	116,000		
Spring steel	132,900	126,200	122,700
Tool and die steels	86,100	56,600	29,500
Alloy constructional steel	200,000		
Low alloy high strength steel	100,000	162,300	137,700
Stainless steel	80,000	66,600	13,400
Electrical steel sheets	176,400	92,000	84,400
Total	891,400	503,700	387,700

Developing countries depend heavily on imports for maintaining and expanding communication systems and other utility services. Some of the consumer goods are also imported from other nations. Industries being not developed, a major portion of their foreign exhange earnings are through export of traditional items of goods. If industrially advanced countries increase the trade with the developing countries by importing commodities that are produced by them in exchange for machines and steel, it would contribute to the general progress of developing countries.

Resources, agricultural and industrial, differ from country to country and region to region. Machines and power enable us to harness these resources. Steel gives strength to industry. Tools and machines made of them, enable us to increase production of food and fibre. Exchange of steel and capital equipment for producing machines, sharing of skills and technology to produce better farm tools and equipment, would help accelerate the growth of mechanized farming. Machinery in turn, would not only increase agricultural production but also fulfil its function as a major factor in the improvement of human welfare throughout the world.

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Delegates' Papers and Comments

P. K. SEN

Dean, Faculty of Agriculture of the University of Calcutta
Calcutta

Steel in the Agriculture of Developing India

In India steel came into use in agriculture almost simultaneously with Nile Valley and neighbouring civilizations, as the metal was discovered and began to establish itself as a material for making weapons, tools and implements, either fully or partly replacing stone, wood, bronze etc. During the period of about a thousand years before Christ and until about a hundred years ago India kept pace with the rest of the advanced countries of the world in its use of steel in all activities of life. In warfare steel was extensively used for making arrows, spears, swords, armour, fort gates, chains, cannon, guns, etc. Also in agriculture, fishing, hunting and transport steel brought about a new era by providing the plough, shears, axe, hooks, spear blade, sickle, hoe, spade, cart axles, wheel rim and so on. The majority of the people were cultivators. Developments in the use of steel in agriculture marked progress in social and economic development. With the use of improved tools and implements with steel parts tillage, sowing, harvesting and all kinds of agricultural operations were improved. This brought India its legendary prosperity. But methods of steel extraction and toolmaking remained more or less static through almost the whole of two millennia while in the meantime the population increased and prosperity was slowly replaced by poverty. With a net cultivated acreage of approximately 313,058,000 acres the country has a population of 407,000,000 over 80% of whom are engaged in agriculture even today struggling to exist at a subsistence level. The total food production in the country is only 80 million tons providing approximately 16 oz. of food per head. This is only about half of the requirement. Production per acre is low and in most cases crop yields are less than half of those in the developed countries. This is primarily attributable to improper tillage, impoverished soil and want of irrigation. Agriculture in India still largely continues in the traditional way with human and animal power employing implements which were known hundreds of years ago. A couple of country ploughs, a harrow, half a dozen hand hoes and sickles, an axe, a couple of spades and choppers are all that the majority of cultivators possess. A country plough is made of wood except for its steel shear which varies in weight from half a lb. to 12 lbs., depending on the type of soil, the crops and the stage of development of the cultivating community. Harrows are, but for their steel tines varying in weight from 4 to 26 lbs., also mostly made of wood. The steel blades of hoes weigh on an average 6 oz. each, that of a chopper varies in weight from 1/2 to 2 lbs, of axe and spades the steel parts vary from 1 to 4 lbs. In all these implements mild steel is in use.

The manufacture of steel for these implements depended on old methods of smelting, and village artisans fashioned them.With growth of population, increase in area under cultivation and subdivision of holdings the demand for steel constantly increased. The absence of sufficient supplies of steel by modern methods not only proved a handicap in the way of development of better agricultural implements but also caused deterioration in the quality of the existing ones. There was no improvement introduced in India as in Europe and America with the development of modern steel industries in those countries by the turn of the eighteenth century.

However, following a series of Famine Commissions towards the latter part of the last century, when it was considered necessary to reform agriculture, major attention was drawn towards tools and implements of cultivation with the object of bringing about improvement in tillage and all kinds of agricultural operations. Following examples of some of the advanced countries even power driven tractors along with accessories were brought in for experimentation. An all round improvement of agriculture, introducing manuring, irrigation, crop improvement, plant protection measures, storage, transport and marketing, was conceived. An agricultural service was created, agricultural experiment stations, demonstration centres and schools and colleges to train scientific workers were established. As a result of the last about seventy years of concerted effort, a change in the methodology of agriculture has been visualized in which better implements capable of working with human and animal power for tillage, interculture and harvesting operations, irrigation, transport, plant protection, storage and processing are being introduced. These implements require appreciably larger quantities of steel in a variety of forms and also as alloy steel to suit the requirement of their different types. The instruments recommended include:

1. Tillage—mould board ploughs, disc ploughs, different kind of harrows (spring tine, peg tooth, spike tooth, disc harrows etc.) levellers.
2. Seed treatment and sowing—seed dresser, seed drills.
3. Interculture—cultivators, wheel hoes, paddy weeders.
4. Harvesting and processing—thrashers (for paddy, wheat etc.), winnowers, cane crusher, groundnut decorticators, oil presses etc.
5. Plant protection—sprayers, dusters.
6. Irrigation equipments—persian wheel, mote, done, water lift pump.
7. Transport—the improved cart, wheel barrow.
8. Animal husbandry and diary equipment—chaff cutters, feed grinder, manure carts, urine carts, milk pales, milk pans, cream evaporator, butter churner etc.
9. Horticulture tools—budding and grafting knives, secateurs, sheaving knives, hedge cutters, pruning shears, lawn mowers etc.
10. Preservation equipment—canning machine, cans, bottling machine, sterilizer, steel knives etc.
11. Poultry equipment.
12. Fencing and farm house building mateı ials—cattle shed, storehouse etc.

A definite change has been initiated in these directions with the establishment of steel industry in the country and with imported steel. However, not even 10% of the farming area has as yet got the benefit of these improved implements as until recently supply of steel either through import or local manufacture was limited, and the major portion of available steel is utilized for house building, transport, including railways, industries and defence purposes. Moreover the agricultural community being in general poor and not well organized can hardly get the due share. The Government are fully conscious of the needs of agriculture and are trying to organize development of local industry for the manufacture of improved implements and also to provide monetary assistance to the cultivators for their procurement. Already there are about a thousand small and medium forms established in manufacturing various improved implements such as ploughs, harrows, levellers, cultivators, wheel hoes, paddy weeders, seeding and planting machines, thrashing machines, sugarcane crushers, oil presses, groundnut decorticators, persian wheels, water pumps, sprayers, dusters etc.

Although it is a fact that the country has not yet been able to introduce improved human and animal driven implements sufficiently a perceptible shift towards power driven agricultural implements is being noticed along with the new trend of industrialisation initiated since independence. As the process of national development, through the five-year plans, has advanced there has been a serious shake up of the old economic structure and peoples' attitude.

With expansion of industries and communications and increasing adoption of mechanization and electrification and with extension of all kinds of social services including education and health necessitating large programmes of house building and instrumentation and associated works, thus creating an unprecedented tempo of activity drawing an appreciable amount of labour, on better wages, away from the rural sector, agricultural labour is becoming restive. It is becoming more and more uneconomic to pay increasingly higher wages for agricultural labour with production not increasing commensurately. The large number of animals competing for food with the increasing population is also proving difficult. Prices of food andf eed are naturally rising beyond the capacity of the common man and creating all kinds of problems.

In these circvmstances, however, it is reassuring to note that a realization is growing in the country that our progress is inexorably bound up with the use of the most efficient technological processes and a change over to modern methods of agriculture is as essential as it has been in defence and industries. The Government has launched sizeable schemes of irrigation, land reclamation, soil conservation and mechanised farming, and it has been demonstrated beyond any doubt that agricultural production could be increased manifold not only making the country self-sufficient but also capable of making exports if modern scientific methods of farming were adopted. Enterprises have already come up in crops like sugarcane, cotton, groundnut etc. which lend themselves to industrial methods of processing and can attract capital. Some enterprising farmers, though very few as yet, have taken to tractor cultivation realising its sure prospects and the needs of the situation. The overwhelming fact of a tremendous number of small farmers with fragmented holdings and little input capacity doubtless presents itself as a baffling barrier. The examples of Japan, which had a similar social background, making it possible to introduce mechanically driven implements to small holdings, employing small tractors, suggests a sure way possible to be emulated also in India. Thanks to our well wishers all over the world and to the new leadership growing in the country, our Government has seriously taken up all round agricultural reconstruction including mechanization and with the cooperation of the Government of Japan a number of model farms especially for rice cultivation have been set up in many parts of the country.

To begin with a programme of importing small tractors and accessories has been taken up and medium farmers who have reasonable wherewithal are being encouraged by the Government with monetary and technical assistance to take them. This has created a great enthusiasm and indicated a new dimension in agriculture and rural life. The demand for such tractors is already very much greater than their supply. The farmers find it remunerative not only because they can now command their farm operations more easily and timely but also can hire their machines to neighbours thus opening for them an additional source of earning. In a country of over 400 million people even if only 20% carries out agriculture, on an average owning about 15 acres of land, we should need to maintain at least 16 million tractors together with their accessories. India has already gone in for tractor manufacture and three firms have already started work. She must develop these industries on a proper scale and extend them.With her extending steel industries manufacture of agricultural machines and tools must be extended to provide all kinds of improved implements for cultivation, plant protection, processing, preservation, storage and transport and for animal husbandry and dairy production. As a sufficient number of farmers begin to own their tractors and hiring enterprises develop local service cooperatives will grow up in the country-side leading towards a self propelling process of development compatible with the needs of the times and the country's ideal of democratic socialism. A developing country such as India needs the cooperation of the progressive world.

G. H. Morhaus
Ingenieur

Hoofdinspecteur, Koninklijke Nederlandsche Heide Maatschappij
Velp

Programme for Development and Mechanization

(Translated from Dutch)

Professor Joosten, of the Agricultural College at Wageningen (Netherlands), gives the following definition of agriculture: "Human activity aimed at the raising of vegetable and animal produce, which, by working on the natural growth of plants and livestock, so modifies them as to make them more abundant and better suited to supplying the wants and well-being of mankind."
According to this definition, the following activities can be classed as agricultural:
1. preparation of the soil;
2. use of the soil;
3. storage and processing of produce.

This last item comes under the heading of agriculture, because labour can be used to prevent damage during storage by insects, vermin or mould, and because the labour used in processing enhances the value of the product in supplying the wants and well-being of mankind.

Preparation of the soil

Under this heading come: scrub clearance; reclamation of lakes and marshes; reclamation of coastal areas exposed to tidal flooding; irrigation of regions with a low rainfall; drainage of areas exposed to freshwater flooding and silting (silted areas).
Scrub clearing by the inhabitants of tropical countries, consists of felling trees (leaving the larger ones standing), stacking the wood roughly and, when it has had time to dry, setting fire to it. The use of steel is negligible in this process, being confined to the tools used to cut the wood.
Since the war scrub clearance has been carried out mechanically in a number of countries, including Indonesia (the Sukadana project), the Philippines, Thailand, Ceylon and the Ivory Coast. By this method a large area can be cleared very quickly, with the incidental advantage that no stumps are left in the ground to impede subsequent working. Thus, mechanical clearance can be successfully used to prepare land for large settlement schemes (such as irrigated rice cultivation), or for laying out plantations. In contrast to the method used by the local inhabitants, mechanical scrub clearance employs a great deal of steel. To fell trees and push timber out of the way calls for a large number of heavy tractors, ship's chains, and steel Hi-balls. The tractors must be equipped with bulldozer blades, rock rakes, stump pullers and tree dozers. The upkeep of these calls for quantities of spare parts and a well-equipped workshop.
The polder process, practiced in the Netherlands for some hundreds of years, has in the last few decades been used successfully in Egypt, Korea and Pakistan, among other places. In most cases the execution of these projects has only been possible with financial help from international bodies such as UNSF, the EEC, or through bilateral aid. In densely populated countries in particular, where there is a real land hunger, such projects should receive help from the industrialized countries. The construction of dikes and canals calls for bulldozers and draglines. Water control requires sluices, culverts and pumping stations. Such projects, therefore, are big steel users.
The local population carries out irrigation on a modest scale, by damming streams, which requires very little mechanical aid. Now, however, development aid is enabling many countries to undertake major schemes. Densely populated countries should, again, be the first to receive aid, so that their rapidly growing populations may be fed.

Contractors prefer using bulldozers and draglines for making irrigation and drainage channels, rather than having the work done by hand. Steel will also be used for the sluices, culverts and pumping stations.

Use of the soil

Under this heading fall all the activities necessary to the raising of vegetable or animal produce, including the preparation of the soil, sowing and planting, cultivation of the crop and harvesting it, where vegetable produce is concerned, while for animal produce, the stock must be fed and tended, and the produce collected and delivered.

These basic tasks are performed in many different ways, from the most elementary method using the simplest tools to the highly intensive using the most complex machinery. It is therefore worth asking whether the primitive farming methods of developing countries can be brought to the stage of mechanization in which the use of steel assumes importance. The question calls for a distinction to be made between developing countries with a large population and those that are not so densely populated.

The densely populated countries

Some examples are Indonesia, India, Pakistan, Thailand, Burma, Egypt, China and Japan. Thanks to better hygiene and medical care, the populations of these countries will rise more and more rapidly, unless something is done about birth control. In most of them, between 60 and 80% of the population work on the land. There is virtually no possibility of extending the existing agricultural area, which already includes relatively unproductive and topographically unsuitable land.

This phenomenon is most obvious in more or less isolated communities. The Indonesian island of Java may be taken as an example, with hardly a square yard of cultivable land left untilled. Land hunger is so great that woods and hillsides have all been stripped in order to gain an extra little piece of agricultural land. With the disappearance of the trees, their regulating action on the water supply has also vanished and the destruction of fertile land has begun. The result is flooding in the rainy season and water shortage in the dry season.

The continuing growth in population, combined with rapidly advancing erosion of the hillsides and everything this involves, will further reduce the already scarcely sufficient amount of agricultural produce available per head.

To maintain the existing standard of living and, if possible, raise it, measures must be taken to make better use of the soil and to preserve its fertility. These measures demand capital and labour. There is plenty of labour to be had, but its quality needs to be improved by means of training and advisory services. However, the farmers can barely produce enough to provide their families with the necessities of life, and possess no capital.

Capital can be made available by

(a) exploiting mineral wealth, such as oil, iron, bauxite, etc;
(b) growing crops for export;
(c) establishing industries to export manufactured goods;
(d) providing development aid.

In this connection the Japanese experience is relevant. There, the enormous expansion of industry has drawn many workers away from the land, and the need to feed this industrial population has made it worthwhile to mechanize agriculture.

Development aid can be used to establish industries, but it is also available for financing agricultural projects. These projects are intended to increase yields per acre. This object can be pursued by using chemical fertilizers, insecticides, fungicides, and weed killers, and by the introduction of new varieties of crops, but technical improvements will also help. These include

(1) provision or improvement of irrigation;
(2) provision or improvement of drainage;
(3) soil conservation measures (by provision of dikes and catch-channels);
(4) protection against flood.

Although some of this can be done by hand, heavy plant and equipment is often also necessary. Apart from such machinery steel is of course always used in the actual structures in the case of sluices, bridges, culverts, etc.
Mechanization of the indigenous agriculture in densely populated countries is hampered by two major difficulties:
(a) the small amount of work per farm makes the use of tractors and machinery uneconomic;
(b) there is a traditional bond between the village inhabitants, enabling even the poorest to earn a share of the crop.

The sparsely populated countries

Where the population is sparse, the climate and/or the soil will usually be unfavourable. The inhabitants have adapted themselves to their circumstances and practice a system of shifting cultivation in which, after felling the trees and burning them, letting the ashes serve as fertilizer, they cultivate the plot for a year or two and then let the land revert to nature, when it develops a wild vegetation which restores the soil's fertility. The last period may extend over 10 years or more. There is no question of the land being used intensively, nor is the labour available for that.
There will eventually be an increasing poqulation in these regions too, thanks to better medical care and improved hygiene. A start should be made now to bring unused areas into the productive cycle, then the 10-year fallow period should be shortened, and finally the switch made to settled farming. In the long run this intensive use will lead to a rapid decline in yields, unless steps are taken to prevent the exhaustion of the soil, by applying farmyard manure or chemical fertilizer, for example, or by rotation of crops, or perhaps by irrigation.
Local farmers are primarily concerned with providing the necessities of life, but there is a distinct trend towards growing cash crops for export. Examples of this are: cocoa in Ghana, palm oil in the Ivory Coast, rubber in Liberia and coffee in Brazil. Beside the individual cultivation of cash crops, plantation-type farming has been strongly encouraged. If the produce continues to earn a good export price, this development will provide a foundation on which the developing countries can build.
Heavy tractors and machinery must be used for clearing virgin forest. Irrigation and drainage channels are dug by bulldozers and draglines. New roads require heavy equipment. With wages rising all the time, maintenance work on the plantations should be increasingly mechanized. As their acreage increases, individual farmers will also need to improve their techniques, and this can be expected to lead to a certain amount of mechanization.
In many (though, alas, not in all) sparsely populated developing countries progress is possible, provided the price of the produce exported remains reasonable. This progress will lead to an increase in the use of steel.

Storage and processing of produce

Crop storage is mostly quite primitive, and consequently a high percentage deteriorates or is eaten by vermin. The use of ordinary silos would save a great deal of waste. How far steel can be used for this purpose, I am not in a position to judge.
To conclude, it is true that there is still very little steel used in the agriculture of the developing countries, but there should be an increase when expected developments take place. The rate at which this happens will vary from country to country, depending on the different factors I have mentioned.

R. M. RIVERO

Ambassadeur de la rèpublique du Venezuela
Bruxelles

(Translated from French)

The designing of agricultural machinery in line with the needs of the developing countries must be based on co-operation between the countries already industrialized and those aspiring to become so in the near future.

The need for machinery adapted to the practical requirements of agriculture on the spot was definitely apparent, in varying degrees, in Latin America. For sugar cane, for instance, there were no really suitable mechanical cutters, which made harvesting more expensive because such a large labour force had to be employed, and he believed a similar problem existed regarding the cleaning of coffee.

He wondered whether consideration had been given to the idea of setting up a body to go into these matters.

Jean René BAILLY

Faculté des sciences
Université de Toulouse

(Translated from French)

Previous speakers urged a big increase in the availability of tractors and other agricultural machinery in the developing countries, as this would make it possible to dispense with a number of animals and turn the pasture over to crops for human consumption; on the other hand it has also been pointed out that organic matter in these countries was scanty and tended to decay very quickly.

There is therefore surely a risk that mechanization on these lines would reduce the amount of organic matter still further, and that the benefit of having a larger area under cultivation would be cancelled out by lower yields. In that case it might be better to retain the draught animals and work them with more efficient equipment, such as metal yokes and metal ploughs: in this way there would be no loss of organic matter for use as manure, or sometimes, as in India, as fuel.

Georges LABROUSSE

Ingénieur en chef du Génie rural
Directeur-adjoint du Centre d'études et d'experimentation du machinisme agricole tropical
Antony

Requirements for the Mechanization of Agriculture in Developing Countries

(Translated from French)

In temperate countries the industrial revolution introduced the use of machinery to all sectors of the economy. More and more machines are now being used in agriculture. This mechanization is essential to increase the productivity of labour and output in a world where fewer and fewer farmers have to feed a growing number of consumers; it is also psychologically essential as a means of improving farmers' living standards. Experience shows that this trend cannot be reversed and the rate of agricultural mechanization is rising steadily. It would therefore be logical to conclude that farming should also be mechanized in the developing countries but we must first consider the state of agriculture in those parts of the world.

Most farmers, forming virtually the whole population, are still engaged in subsistence farming. While bearing in mind that agronomy is first and foremost the science of places and that the dominant feature of the tropical regions we are considering is the wide variety of ecological and living conditions, some attempt can be made to identify the main characteristics of tropical farming.

The first is that, subject to certain essential qualifications, the average area farmed is smaller than it reasonably ought to be. Holdings, which generally vary from a single hectare cultivated by hand to several hectares worked with animals, are usually farmed by families.

The second main feature of tropical agriculture is its almost exclusive concentration on food crops, largely for the growers' own use with only a small proportion of cash crops. Fewer kinds of produce are exported, but the list includes quite a large number to which some industrial crops have now been added. The third point is that plots are farmed extensively so that, with few exceptions, yields are very low, even if a precarious balance is maintained between farming and soil fertility.

In these circumstances the problem is to decide what kind of mechanization is necessary to improve this type of agriculture. In 1955 the following definition was worked out at the first Conference on the mechanization of African agriculture, held at Entebbe (Uganda):

"It should cover manual, animal-drawn and power-driven implements and machinery used on individual holdings or by small producers' co-operatives at all stages from clearing the land to the preparation, storage and processing of products. The relevant problems should be considered from the technical, economic and social standpoints."

The field is therefore extremely wide and varied and many experiments have been undertaken in a number of countries with different results. A further international conference, attended by machine users and constructors, was held to try to resolve outstanding problems.

In March 1961, the International Technical Congress on Farm Machinery was held at Unesco in Paris. It was attended by representatives from 48 countries, including some of the uncommitted nations, who discussed " how the mechanization of agriculture could help in raising living standards and specifically how it could assist the developing countries." The Congress decided that the mechanization of agriculture should be used, in conjunction with any measures suggested by agronomic research, as the principal means of raising living standards in the countries concerned. The machinery used would have to be specially designed to solve the dractical problems involved.

The dominant features of farm mechanization in these countries are indicated in some of the Congress reports:
(1) hand implements, in many cases made by local craftsmen, are very important;
(2) the proportion of animal-drawn as compared with powered farm machinery is much higher than in the industrialized countries of the temperate zone; these machines come from a variety of sources;
(3) powered machinery has been introduced in certain areas only, particularly when used at the stages before and after actual cultivation; it is brought in through relatively few schemes run by variously-constituted authorities;
(4) farm tractors are used for a number of purposes including forestry, public works, etc.

We shall allow for these points in discussing certain requirements relating to the mechanization of farming in the developing countries, under the following headings:
(a) training
(b) specially-designed equipment
(c) after-sales service
(d) finance

dealing with the special features in each case.

Just as we shall not be considering all needs and all types of machinery we shall similarly confine ourselves to experiments carried out in countries where France had certain responsibilities and particularly to tropical Africa and Madagascar.

Training

Any systematic development of mechanization involves training for all who are directly or indirectly concerned. We shall briefly consider the main features to be observed generally and more particularly in the tropical countries.

The first point is that mechanization has not yet become a special subject in France and is even less so in the French-speaking tropical countries. There is, in fact, only one, fairly old, book, in English, on the mechanization of tropical farming and a periodical devoted specially to "Machinisme agricole tropical" (Tropical Farm Machinery), published regularly by the Ceemat which is only now starting to offer practical courses on limited subjects.

Again, in tropical Africa, agriculture is not regarded as particularly important and mechanization with its unavoidable practical implications has even less status. Our report deals in turn with the appropriate forms of education and vocational training.

Agronomists have recently acknowledged that "mechanization" is a complicated special subject calling for agricultural, mechanical and economic knowledge because machines can only be used if they earn their keep. However, we shall not dwell on the complexity of the studies that will have to be undertaken by the men who will be responsible, in various ways, for the development of mechanization in both temperate and tropical countries. It will suffice to note, that apart from lectures given in the "Grandes Ecoles", as a development of the general course in Farm Engineering, the Government Training Centre operated by Ceemat did not come into being until 1955.

In the case of the tropical African countries, the question came up at the Entebbe Conference, with special reference to the training of machine drivers. Changes have since taken place and courses are now provided for engineers, works engineers and junior supervisory staff (foremen and instructors) both in France and overseas.

In France

Since 1950 courses have been available at various schools, and a number of special training courses began about the same time.

A number of African and Malagasy engineers concerned with technical assistance are taking courses on the mechanization of agriculture; a smaller number are receiving instruction concerned more specifically with

mechanization in the tropics. The same applies to rural and agricultural works engineers due to the mistaken impression that this is not a specialist subject.
Under the heading of training courses, it may be noted that 150 trainees from different countries and with varied educational attainments have come first to Nogent and later to Anthony to receive general or special training for periods of very varying length, according to their employers' administrative needs, their basic knowledge and the particular aim. As might be expected, the lecturers are Ceemat engineers employed because of their special qualifications or as part of their duties. Fairly good results are obtained on the theoretical side, particularly from trainees. More is needed however. All engineers working in tropical agriculture should take special courses on mechanization; there must be the certainty that the special knowledge acquired by trainees is put to good use; trainees must be able to verify their theoretical knowledge by long periods of field work under tropical conditions; and everyone concerned must take "refresher" courses.

Overseas

Local courses in agronomy and agriculture now provide training for the four groups already mentioned whereas only instructors and leaders were originally trained locally.
In the existing Colleges now run by the Ministries of Agriculture or Education, either separately or attached to universities (Tananarive, Dakar, Yaoundé), or shortly to be set up (Abidjan, Bobo-Dioulasso, etc) such courses are generally combined with those on rural engineering. Intermediate training of the type provided for leaders is given by agricultural technical colleges and the like, which also train junior supervisors, such as instructors, at agricultural apprentice schools or centres which are frequently attached to the colleges themselves.
In this connection, the specialist is struck by the fact that even in the rare cases where the mechanization of tropical agriculture is a subject, the course is almost never adapted to local ecological and economic conditions. Moreover, the lecturers are general agronomists who themselves have never received any special training on the subject. This applies to all teaching staff except engineers from the Ceemat.
Again, as there is usually no demonstration equipment, practical work, which is in any case disliked by most students, cannot be carried out in the proper conditions, when in fact it should be very detailed and conclude with a genuine examination like the theoretical part of the course.
The result is that schemes for the mechanization of tropical agriculture lack the qualified staff they need for successful development. This has been observed in particular by qualified membres of technical assistance missions who have witnessed crude mistakes in demonstrations by engineers even with simple animal-drawn implements and crop-protection equipment. Futhermore, papers submitted by candidates for the French Ecoles d'ingénieurs or Ingénieurs des travaux (Engineering and Works engineering schools) show that the level of theoretical knowledge on the subject is very low. Happily the same does not apply in all cases to vocational training.

Vocational Training

The first points are that this kind of training was originally obtained "in the field" by all grades of workers when there was no other provision and that schemes now in hand cover all aspects of mechanization. There are many examples of initial and further vocational training through courses in France and elsewhere in Europe, such as those provided for foremen, shop foremen and skilled mechanics, by the Ceemat. For various reasons, however, it is now generally regarded as more expedient to give such training locally.
When schemes were launched for the mechanization of production methods after the last war, some of the leaders had to obtain "home-made" training which they immediately passed on to their subordinates. On sites run by, for example, the CGOT and the "Office du Niger", a whole generation of staff ranging from engineers to tractor drivers and processing-machine operators were given practical training on the spot. Public works firms taking part in such schemes had their own skilled teams, recruited elsewhere, who gave on-the-spot training to drivers of machines used for clearing and reclamation. For the development of animal traction, trainers and drivers of oxen were trained together with the animals. Since then various other

measures have gradually been introduced, with uneven coverage of the different types of labour and job. Without giving a complete list, a number of characteristic examples may be quoted.

Farmers:

Vocational training is known as agricultural extension and the interesting fact is that the men responsible, such as instructors, often have educational diplomas and have received special training so that they can do their job properly. The most effective procedure is to concentrate on fairly small areas where production is developed by farming methods requiring a few selected machines.

This brings in technical assistance organizations such as the CFDT which is concerned with cotton growing and trains farmers in the use of animal-drawn ploughs and ridge-ploughs and of knapsack sprays in many parts of several countries; the Satec. which gives help with export and food crops, including rice, with multi-purpose or specialized puddling equipment in Senegal, Upper Volta and Madagascar; and the BDPA which applies similar means and methods in a number of countries (Madagascar and elsewhere).

Success depends on providing the requisite "cadres," generally estimated as follows:

1 junior leader for 10 to 15 families;
1 assistant leader for 25 families;
1 senior leader for 50 families.

Ministries of Agriculture act along similar but less concentrated lines and therefore with relatively less success.

Other examples include similar or less intensive action by bodies of a more or less religious character such as the CIDR which trains farmers (Dahomey, Togoland, Upper Volta), demonstrations of farm machines by FAO experts (Niger and Madagascar), Farm training centres set up by the ILO (Senegal), Rural Craft Centres operated by Unesco (Ivory Coast) which are of indirect interest to farmers, schemes run by the Volunteers for Progress in many places, and so on.

In all cases, except schemes for limited areas growing crops with a few types of machinery, two main ideas now seem to emerge. First, there must be a period of "promotion" to prepare the local farming population and select pilot-farmers who will later bring in their neighbours. Secondly, future junior leaders should not be intellectuals, in view of the inconclusive results obtained with graduate "instructors" who generally show little aptitude for demonstrating how to drive machines and advising farmers.

From the technical standpoint, although machines are obviously one among many means of increasing agricultural productivity and output, it may be regretted that "leaders" at the various levels and from various sources have not always had special training despite the efforts made in several countries, particularly by Ceemat.

Drivers:

It should be borne in mind that animal traction is an important element in the use of machines. Special mention should therefore be made of the training of drivers for animals, particularly oxen, who then train the animals and familiarize farmers with driving methods at animal training centres and on farms. Observers find that the animals are generally trained and driven properly but that the machines are not always completely mastered. Training is mostly given under the schemes described above. Field training in the use of powered machines is still provided under development and production schemes; it covers the whole range from lorry drivers who do not always benefit from retraining to labourers who unfortunately often give up tractor driving for something "better" or more highly paid. Some of these drivers stay on however and later train new recruits. Machine suppliers come in at this stage by running driving schools for the men who will later drive the tractors they supply. This applies in particular to large orders placed with established importers. However, there are not many special schools for future instructors. One opened by a French manufacturer in the Republic of Congo deals with public works machinery as well as lorries but has too few trainees; there is also the Centre de mécanisation agricole at N'Djili, Kinshasa, where an FAO expert trains instructors in the driving, maintenance and repair of farm machines. Dahomey also has a centre promoted by the Swiss Technical Assistance Foundation. In another direction training is given by a private entreprise in the correct use, maintenance and repair of the animaldrawn farm equipment which it manufactures but this is unfortunately the only scheme run by a firm.

Indeed, such activities are on a minor scale and there is no guarantee that they will be continued. Without dwelling on the results achieved with animal traction, it may be noted that while drivers of powered machines are often quite skilful, they dislike maintenance and some of their attempted repairs are rather fanciful.

Craftsmen:
We shall later discuss the important part craftsmen have to play in the maintenance and repair of farm machinery. Unfortunately, whether they work in wood, iron or leather, in most countries they are completely unskilled in the matter. Training schemes are limited and very scarce, with something of an honourable exception in the case of Madagascar. Vocational training schools only provide such instruction indirectly and most unfortunately their former students do not take up work connected with agricultural machinery, because of the known low status of farm work. Subject to possible correction, the only schemes available for practising craftsmen would appear to be those operated by Satec in Upper Volta (all types of harness and machine maintenance), Ceta in Madagascar (maintenance and repair of hand-operated and animal-drawn implements and machines) and by a firm in Senegal (refresher courses for craftsmen connected with its distribution network). Cemat, has also recently introduced a scheme in Senegal.
The ILO has for some years been running a scheme for trainee craftsmen in Chad but so far it has reached only a few dozen young people and there is no certainty that many of them are interested in farm machinery.
The outstanding fact is that there is no general policy for education and training in the use of farm machinery and practical measures largely depend on somewhat limited development programmes. The necessary means are not always provided and where they are there is no continuity of action.
Ceemat, which is the only specialist organization in the field, is active in all the relevant sectors both in France and Overseas; its work appears to be bearing fruit but its resources are inadequate. The governments should harness all the available resources and take such steps as are necessary to resolve the training problems on which the spread of mechanization depends.
This is only one element in agricultural training. However, unless the status of farming can be raised, all efforts will be of no avail because unfortunately this work does not attract the best young men in tropical Africa. If the authorities wish to take proper steps to remedy this state of affairs they will, of course, have to start by training more instructors; then the whole farming population will have to be reached through leaders and extension services, bearing in mind that the mechanization of farming is a special subject. In this respect, it would be well to follow the pattern of training adopted in certain temperate countries, which has produced results that can only be attained by employing competent men at all levels. Future instructors must be able to serve for a fairly long time without their knowledge becoming obsolete. We are only too well aware that local training centres find it difficult to obtain staff and equipment.
We therefore consider that education should continue to be provided, as part of technical assistance, by institutions with special knowledge of the tropics but based in temperate countries. They alone can provide all the resources required for the proper training of students or trainees who already know the needs of tropical farming; training would of course be completed on mechanization schemes in tropical countries —preferably more than one so that trainees can make useful comparisons.
After training, these young leaders will be able, with the help of their instructors, to organize local training centres in accordance with Government requirements. These centres will in turn train future instructors, site foremen for mechanization schemes and machine drivers, all of whom would be drawn from non-academic circles.
In the case of repair mechanics, some trainees should continue to visit the industrialized countries for further special training so that they will be technically equipped to give special instruction to men leaving vocational training schools, motor-vehicle mechanics, machine drivers and craftsmen. These different specialists will then take part in extension schemes directed first to carefully selected pilot farmers, who will in turn influence their neighbours.
The whole process will depend on decisions to set up State co-operatives or similar bodies which will be responsible for development schemes based on mechanized farming or the promotion of agricultural production in a given area.

Specially-designed equipment

Fortunately, the time is now past when constructors in temperate countries exporting to developing countries claimed in advance that as their products had proved satisfactory in home farming they must necessarily do so overseas; but there are still people who tend to do so when dealing with the problems under consideration. Nevertheless those who have found markets in the overseas countries have admitted the need for a choice of general-purpose equipment and for special machinery adapted to the particular problems involved.

We shall consider in turn hand implements and machines, animal-drawn machinery and two examples of the use of power-driven machines, while indicating the serious obstacles to the widespread use of powered machinery.

Hand implements and machines

A list of the hand tools used by farmers in French West Africa was drawn up in connection with the first major demonstration of farm machinery in Senegal. There was a considerable variety and this outstanding feature may be attributed to differences of race, ecology and farming methods.

The second point to strike anyone who has studied farm equipment is that most of the tools are made locally by village blacksmiths, mainly with metal recovered from various "sources." The result is that the tools may satisfy the customers' tastes and skills but are not always of adequate quality; hence the success of the few implements which they make from imported semifinished products.

Edge-tool makers in the industrialized countries have tried to meet these customers' requirements; in addition, the first small centres for making these tools locally have recently been established. In many cases, types supplied by edge-tool makers are given to village craftsmen for "conversion" before they are used.

This report could not hope to deal with this subject, even superficially, for all the regions under review. It will be sufficient to mention the existence of a wide variety of knives, many types of digging hoes, axes, hatchets, spades and shovels, including the "angady" in Madagascar; with this limited equipment the farmer deals with almost every problem connected with clearing his land and growing and harvesting his crops. Efforts have been made to improve supplies and reduce the number of types of tools, but while recognizing that this is very important we doubt whether even tools more adapted to their jobs and handlers would greatly improve farming in the countries concerned.

Other hand implements

These open up hitherto unknown possibilities for farmers as regards work which they could not easily handle with their traditional tools and operations they had never previously considered. Implements of this kind are used for sowing, cultivation, crop protection, harvesting and processing.

Sowing and planting: there are several kinds of hand sowers such as drills, discs, rollers and hand-propelled planting-up machines which are still in the experimental stage. Rice transplanters seem to have met with more success.

Cultivation: in addition to the traditional implements, manufactured tools for the cultivation of rice sown or transplanted in rows have been in use for a short time in Madagascar; they are rotary mechanical hoes originally imported from the Far East.

Crop protection: these implements are relatively complicated and, quite apart from economic considerations, farmers find it more difficult to master the use of advanced apparatus because of their general lack of mechanical knowledge.

However, economic considerations are a very important factor and the result is that a very wide market is now being opened up for simple devices, costing as little as possible and used more particularly on "export" crops for the protection of stored products (seed or for sale) and for actual crop treatment.

This is due to the fact that crop treatment produces the most immediately visible results.
As regards types likely to become popular among farmers, it would appear that any product can be effectively sprayed by an imported apparatus which can sometime be made at least partly by local craftsmen.
The types concerned are bulb dusters (made by craftsmen), rotary sprays (imported) and knapsack sprays (from industrialized countries) which are either pressure-operated (continuous or previous) or in some cases pneumatic. The latter are at present the most advanced type usable by one person.
Harvesting: traditional, mainly multi-purpose, tools are used for harvesting tubers and root crops (yams, sweet potatoes, taros) and underground fruits (groundnuts).
Specialized tools such as knives, sickles and sometimes scythes are only now coming into use for cereals and are more commonly used for rice.
Processing produce: it would be impossible to consider every kind of equipment used in preparing, preserving, storing and processing produce.
The first collectively-used equipment was imported for the preparation and processing of export produce; this was followed by farmhouse appliances replacing the pounders used by women in preparing food.
Three points should be noted. Most of this equipment is imported. Farmers are beginning to buy machinery for family needs and for processing certain customers' produce on a contract basis; the value of a power drive is immediately apparent. Some types of equipment can replace the utensils and structures traditionally used for storing and preserving farm products; but their introduction is too sporadic and uncertain for any facts and figures to be given.
This class of equipment includes pedal-operated transplanters (rice), pulpers (coffee), various shell and husk removers (groundnuts, maize, rice, coffee), multi-purpose winnowers, crushers (palm-nuts), mills producing wholemeal, etc.
In view of the various technical, economic and psychological requirements (quick, efficient work, higher earnings for farmers and less labour) it is virtually certain that the use of such farm equipment will spread more rapidly by way of imports and local production which is now starting to supply the large market concerned.
The wider and more rational use of hand tools, implements and machines can already raise farm productivity quite substantially by increasing quantities harvested and their market value. They have the dual advantage that they involve no major changes in the farmer's work and no excessively high outlay.
Nevertheless they offer only relatively limited possibilities.

Animal traction and suitably designed equipment

We are convinced that although animal-drawn machinery is not in all cases either a feasible or desirable intermediate stage on the way to mechanization, it is nevertheless an innovation and has many advantages, if it is rationally applied, using every type of equipment that will save labour, increase productivity and raise incomes over large areas of the tropics where climatic conditions should favour the spread of such equipment to large numbers of farmers.
We cannot go into details of all the conditions for a rational development; we shall confine ourselves to the main requirements.
The first problem is to overcome tradition and persuade the farmer to use, house and feed animals and keep them fit so that they can do the work required of them. This calls for systematic action by the authorities. Healthy, "improved" strains of animals must be provided and trained by specialist departments. Next, to use an expression from current mechanization jargon, the tractor must be harnessed to the tool in the most efficient manner possible. While it is fairly easy to train craftsmen and even certain farmers to make neck yokes, it is more difficult with breast harness, collars and other more complicated types of harness. Experience has shown that the actual equipment must be of suitable type i.e. must be light, strong, simple and cheap.

(i) light, to be used by the available tractive power;
(ii) strong, because:
 (a) the animals are not always very well trained;
 (b) the farmers are not always very competent;
 (c) the ground has generally not been very well broken in;

(iii) simple, because users have only the most rudimentary mechanical knowledge and are rarely adequately trained;
(iv) cheap, because the farmers have little money.

The second and third conditions are incompatible with the fourth and sometimes with the first. Measures have therefore had to be taken so that all can be fulfilled simultaneously. Animal-drawn machinery can only be used if the ground has been cleared as completely as possible. This is done with hand tools, chemicals, fire and powered machines. Almost all types of actual cultivation are involved.

We could write at some length on machines used for the normal preparation of the soil, such as various types of plough and ridge-plough and equipment used for skim ploughing and surface working. It would also have been useful to give details of sowing-machines, with special reference to accurate single-row types, with or without manure spreaders, and of equipment for the cultivation of row crops, etc.

We shall, however, merely indicate that all are increasingly of special design or made for particular needs in the same way as equipment used in paddy fields for thinning out and puddling during sowing and transplanting.

Special reference will be made to multi-purpose equipment designed for farmers with little money so that a single machine can handle all cultivation operations. These machines comprise:
(a) a frame (or tool-holder) common to all uses;
(b) a tool for each individual operation.

These multi-purpose cultivators, drawn by donkeys or oxen, have many uses including various types of transport. Nor must carts be overlooked. More and more are being used and are a major psychological, technical and economic factor in the growth of animal traction.

Moving on from the various types of machine drawn by animals, the problem becomes more complicated when animal power has to be applied to stationary equipment. This involves the use of gins, particularly the type with the animals moving round a circular track on the ground. A team can generate from 0.3 to 0.6 hp. with the available animal power and speed and the mechanical efficiency attained. This is not enough to drive farmhouse machines but can cope with certain pumping apparatus or sugar-cane mills on which the available power is adapted to needs by means of an additional transmission or control of supply.

Having briefly reviewed the sectors suitable for animal traction which are rarely all found on a single farm, we should stress that the departments concerned with the systematic extension of this form of power must gradually take steps to change the pattern of farming. Otherwise, animal traction will only be used partially at certain stages and for a limited number of operations, and some of the expected advantages will not be obtained.

The pattern of individual farms must be changed and this is the obstacle to the spread of animal traction just as it is to the use of new types of machinery in Europe, but on a different scale.

Powered farm machinery

Within our initial definition of the mechanization of tropical farming, many power-driven types can be used in preparation, cultivation and subsequent stages. Some have very general uses but must meet certain requirements, particularly as regards direct use by individual farmers; others are very specialized for a given crop. The main consideration, however, appears to be the method of use, with operation of several machines on an industrial scale at the one extreme and individual use of a more or less specialized machine at the other.

Industrial-scale farms

There can be no question of defining all the circumstances in which powered machines are used at the three stages listed above. We shall therefore start from the inaccurate assumption that research centres, seed propagation centres, land development and reclamation schemes, mechanized farming schemes and a few industrial farms in the full sense (sugar cane, sisal, etc.) are all equally well-placed as regards powered machinery i.e. they have adequate technical resources (at all levels) and well-trained drivers capable of using the many different kinds of machine properly (tractors or self-propelled).

Under this heading we shall consider differences as compared with the mechanization of farming in countries with an advanced type of agriculture.

(a) Tractors

For such operations as land clearance and reclamation, certain rice-growing operations, heavy work (subsoiling, ridgeploughing for manioc, cotton etc.) and quick cultivation operations (perennial plantations — sisal and others), tracklaying tractors provide a large proportion of the total and are generally much more powerful than in temperate climates. This leaves aside forestry operations.
Among wheeled tractors, two wheel drive types have ceased to be unusual because models over 50 hp. are now becoming common in the temperate countries. The use of boom tractors for pineapple and less frequently cotton, should increase and high-clearance fourwheel drive types are specially useful for sugar cane.

(b) Implements

The powerful track-layers are fitted with various types of land-clearing devices (bull, angle and tree-dozer; ripper; stumpers; root-rake, etc.) and all kinds of special grubbing, clearing and undergrowth-removing equipment have been tried. Under the heading of soil preparation, it may be said that most tractor fitments and special public-works machinery are used in agriculture taken in the widest sense. Mechanized cultivating and harvesting machinery will not be dealt with here because the various crops must be set in their context. It will suffice to indicate for example that rice and sugar-cane need special equipments for preparation and harvesting, that some perennial plantations use soil-preparing equipment for cultivation work, that aerial equipment is used for dressing banana plantations and that there is a tendency to use special equipment to carry products to the plantation "factory" or to the group centre.
Processing, even on the plantation, will not be discussed here.
Strongly-built and relatively simple machines are generally preferred because of the difficult working conditions, even though the drivers are reasonably skilful. A special point to note is that tractors must be built for tropical service with special cooling (high temperatures), filtering (much dust which is frequently abrasive) and electrical systems (changes in temperature and humidity), etc.
It would, of course, be useful to consider how all these machines can be used economically so that farming will be profitable. We shall simply note that in the testing and supply of selected seeds the service provided is of vital importance and similar considerations apply as regards certain types of soil protection. Actual production-runs on an industrial scale prove that efficient operation is possible provided preliminary studies are properly carried out and all possible obstacles have been eliminated.

Use of powered machinery by African farmers

We shall now briefly consider a number of general factors, some of them economic.
Between 1946 and about 1955, the countries still having responsibilities in the regions under discussion made strenuous efforts to develop a number of export crops by means of wholly mechanized schemes. These experiments left no traces of any consequence. Some major technical difficulties were overcome but the results were economically inadequate even though all the prior conditions for success were gradually fulfilled.
However, this rarely happens when the individual farmer turns to mechanization. Let us briefly recall these conditions. The necessary means must be available, the users must be reasonably competent and the terrain must be of the right kind.
The necessary means are primarily financial and will be discussed later. Over and above the minimum mechanical skill which the farmer is unlikely to have, the systematic use of machinery calls for knowledge of intensive farming which is practised virtually nowhere. The only way that has yet been found of providing this mechanical and farming skill is through "pilot-schemes" under which farmers are trained by qualified technicians who remain in the area for some time until their trainees have acquired sufficient knowledge to continue working with less close and continuous supervision.

A second point is that in the bush the technical conditions without which a tractor is quickly rendered unserviceable are not fulfilled. Distances are long and roads often bad; services are a long way from farms. The farmer is forced to store fuels and crafts men are still incapable of making even temporary repairs to any machine which breaks down.

However, the dominant economic factor at farm level is that most crops — food crops in particular — cannot give a return on an expensive form of agricultural mechanization. Unit yields are mainly low as are unit selling prices. To return to the schemes mentioned earlier, the position was briefly that if the yields obtained by mechanising groundnut farming had exceeded 2 tons per hectare and the price per kilo had exceeded CFA 30 some farms would just about have broken even.

In some areas, fairly large numbers of machines have been introduced because the economic situation was fabourable; they are very few and far between however.

Even assuming that general conditions improve as hoped, views are still very divided as to the type of machinery farmers should have. As with animal traction, the machines must of course be adapted to local needs, available resources, type of crop etc. Here it is more than ever a matter of special cases.

Everyone has different ideas concerning the type and production of tractors suitable for tropical conditions. The simplified tractor of course has the virtue of simplicity but is still more or less in the prototype stage and production runs will be short; it will therefore be fairly dear and its tractive power is limited.

The current standard tractor, which cannot be used properly and to the full without considerable technical knowledge, has the advantage of long-run production and is therefore relatively cheap and more likely to be backed by after-sales service.

The motor cultivator which is rather difficult and tiring to use is generally not as strong as a tractor but is quite dear. Trials do not appear to have given satisfactory results. The countries under review have some industrial-scale farms using mechanized equipment at various stages, but schemes using powered machines to help the African farmer seem to be hanging fire despite new developments. This is demonstrated by the figures for numbers of machines (see *table*)

For the future the individual use of such machinery would appear to be the important point. Experiments along these lines are in progress in areas where there are proportionately more machines than in others because of the more favourable conditions. It is too early to draw conclusions but it would appear that if a profit is to be earned it will be on the basis of hire work by small contractors who may be farmers. At the moment mechanized farming has reached relatively few native African farmers in the tropics.

After-sales service

While the mechanization of farming might just conceivably be started without any special training for all the many people involved and with equipment not specifically designed for the particular duties and needs, no machinery can possibly work without being maintained and repaired. This means that all forms of agricultural mechanization depend absolutely on an efficient after-sales service.

Here again, we must consider the main factors which have determined the existing pattern. To summarize, the technical and economic infrastructure is inadequate, there are few machines but quite a number of types and there are almost no local manufacturers.

The various kinds of machine have never been distributed in any way comparable to the long-established system used in dealings with farmers in the industrialized countries. In those parts of the world, farms are close to the producing centres and ditribution networks have been set up as more and more machines have been bought. It has simply been necessary to extend and improve the existing infrastructure, with the local blacksmith-farrier who also repaired farm equipment forming the last link in the distribution chain by becoming a dealer-repairer for farm machinery and later a seller of imported equipment. There is a complete private organization, headed by the manufacturing companies or general import agencies, each branch having its own special responsibilities and activities as regards workshop repairs and the supply of spares stored at all levels. As a result the farmer can keep his machines in working order.

Dealers

In the developing countries there was no basic organization when plans were made to import the first machines from temperate countries. As a result, farm machinery was generally handled by import-export

Numbers of farm machines in French-speaking tropical Africa and Madagascar (excluding Guinea), 1965

		Senegal and Mauretania	Mali(1)	Niger	Upper Volta	Ivory Coast	Dahomey	Togoland	The Cameroons	Republic of Congo	The Gaboon	Central African Republic	Chad	Madagaskar	Grand total 1965	Grand total 1957	Remarks
Powered farm machines	Motor cultivators	62	9	6	12	87	32	7	68	28	32	15	10	75	443	145	
	Tractors	392	120	39	34	824	17	6	573	186	350	167	20	1,750	4,478	5,200	The 1957 figure included some track-laying tractors used in forestry
	Combine harvesters	60	21		2	14				15		5	3	40	160	219	
Animal-drawn machines	Ploughs	5,316	100,000	650	2,070	1,000	247	109	10,520	124	13	1,600 (2)	10,700	46,000	178,349	78,000	
	Hoes	40,640	82,000	1,297	8,792	250	56	50	100		2	62	1,347	400	134,996	5,800	
	Multipurpose cultivators	5,000	(3)	2,000	10	80	25	200	20	10	1		12	350	7,708	750	
	Sowing machines	100,000	82,000	500	230	100	70	10	95	30	2	23	460	200	183,720	41,700	
	Carts	10,500	50,000	480	600	25	80	10	1,300			1,200 (2)	4,400	40,000 (4)	108,595	13,800	
Crop protection	Sprays and dusters	4,550	32,000	310	1,020	13,300 (5)	1,539	76	30,000	400	60	2,000 (2)	2,850	2,500	90,605	16,150	
	Aircraft	10	6						4					6	26	21	
	Helicopters								3						3	0	
Processing Equipment	Mills, crushers or grinders			2,800			393	785							?	4,200	Very fragmentary data for 1965
	Coffee pulpers					1,500	21	263	1,300			37			?	2,300	
	Groundnut shellers and rice hullers								400			21			?	1,400	

(1) The Mali figures for animal-drawn machines and crop protection include current equipment programmes due to be completed in 1968.
(2) Including a current BDPA scheme in the OUHAM region.
(3) Hoes and multiporpose cultivators all included in the previous figures of 82,000.
(4) A relatively large proportion of carts are made locally.
(5) Including some 2,000 pneumatic knapsack sprays.

companies exporting farm produce and selling popular types of manufactured imports. There are still very few firms which deal only in such equipment. At best, the industrial division of a large firm has a farm machinery section with no independent facilities. In most cases, ploughs and sprays are catalogued with "enamelled ware" and tractors with vehicles.

These firms obtain their supplies through the central departments of the parent companies operating in industrialized countries in conjunction with machine manufacturers. It was a very long time before these departments set up an agricultural section to deal with such machinery.

The firm's local head office, usually at the port of disembarkation, receives the farm machinery, after all the delays inevitably associated with distance and trans-shipment; the farmer then gets his equipment from trading posts in the bush run by people who have to handle every type of merchandise. Even if these posts can supply the right type of equipment, with all the difficulties arising from an inadequate transport system, the necessary spares are much less frequently to be found.

Special organizations

To remedy these shortcomings, particularly in the French-speaking African countries, Provident Societies introduced the system of group buying. They took over responsibility for after-sales service from the manufacturer and the importer, who lacked the necessary staff and did not make enough sales to justify providing such a service. A special local organisation was thus created to select, purchase, distribute and maintain equipment for farmers acting together. With the introduction of farm mechanization, the same organizations quickly set up "hire" departments to undertake ploughing, spraying, threshing, etc. on their members' holdings. These extension services were systematically organized by special sections of the Provident Societies headed by farming experts. The different types of activity are continuing under a variety of names.

Simultaneously, some importers improved their organization and facilities to meet the needs of semi-Governmental development bodies and private companies requiring tractors for public works, forestry and farming. As a result, large workshops with substantial stocks of spares were set up, but unfortunately only in the capital or at large ports in most cases. A very small number of manufacturers began to prospect markets directly and systematically but took no part in organizing an embryo after-sales service and did not engage in continuous publicity as they do in the temperate countries.

Finally, shortly before or after achieving independence the countries concerned set up bodies to promote the sale of national products and purchase capital goods, including farm machinery. There are quite a number of such authorities constituted in a variety of ways.

The outstanding point as regards keeping existing machinery in working order is that the various farming organizations had to set up repair workshops and stocks of spares, on a varying scale, because commercial workshops and stores were, at best, a long way off and the few lorries travelling round the major production centres could not visit the whole of the vast area which they theoretically served.

Workshops

Apart from the workshops opened by the Provident Societies for various purposes, facilities on a substantial scale have largely been provided through the major development schemes.

The biggest of all is the Office du Niger's base at Markala which, as far as agriculture is concerned, was responsible for maintaining the equipment of the mechanized rice plantation at Molodo (6,000 hectares) and of the factories (rice and cotton) in the industrial centres where these products are processed. In addition, this base handled work for machine and tractor sections when their small workshops were unable to repair machines hired out to farmers.

Another example is the CGOT base at Sefa which at one time had to maintain a large number of land clearing and reclamation equipment as well as powered farm machinery for groundnuts and rice. It also kept the shelling and hulling equipment in working order.

These very well-equipped workshops with a large, skilled labour force could handle every type of work from the timing of Diesel engines to complete overhauls, including refitting tractor tracks, grinding crankshasft and so on. These workshops—more particularly the one in Niger—also made machinery and miscellaneous types of farm equipment.

Similarly, major workshops also had to be established at the Bloc de Kaffrine (Senegal New Territories), in various areas where palm-groves were being restored (Ivory Coast, Dahomey, Cameroons, etc.) at the Agricultural Mechanization Centre at Loudima (Congo), on certain CRAM in Madagascar (PC 15, Andilamena) and others. On the other hand, there are few mobile workshops of the kind operated by the Agricultural Mechanization Section in the Upper Volta which is responsible for developing land where rice can be grown.

All these facilities were governmental or semi-governmental; but many private firms had to follow suit, and quite apart from owners of small and medium-sized plantations who set up their own tractor repair shops and small processing plants, the biggest workshops of this kind are associated with the production of sugar cane, sisal, manioc and rice in Togoland, the Congo, the Central African Republic and above all Madagascar. Their size varied and still varies with the number of machines and the distance from other facilities.

When the volume of work became large enough, the sections of Provident Societies and other authorities handling hire work on farms also had to open workshops of varying size so that their machines could work properly at the right time. The most important of the many possible examples are the CER in Senegal, the Macina Section in Mali, the Siguiri and Kouroussa Sections in Guinea, the Semry at Yagoua in the Northern Cameroons, Plantation A at North Bongor in Chad and so on.

To make our list reasonably complete, we must not omit the "pilot schemes" discussed in the section on "training". Even though these are concerned only with popularizing animal-drawn implements, knapsack apparatus for crop protection and processing equipment, maintenance facilities have had to be provided; these automatically include a small workshop which sometimes makes simple implements on an appropriate scale to meet the members' requirements and suit their pockets. In addition to schemes already mentioned, facilities for crop protection equipment have been provided by Satmaci (Ivory Coast) and the SEM Centre (Cameroons) and for processing equipment in Mali.

Stocks of spares

One of the conclusions of the Entebbe Conference applies particularly here: it is better to buy equipment less well adapted to the specific operation if one can be certain that the after-sales service will be better.

Workshops have to have spares in order to provide a proper service, especially as regards repairs. Importers, more or less inspired by manufacturers wishing to keep their markets, have always been more active in this direction than in setting up workshops.

In addition, because of the reputation and size of certain international and world companies, local importers sought appointments as agents for well-known types of equipment while the manufacturers insisted on the formation of fixed stocks of spares. This led to difficulties because here again experience showed the problems to be specific.

Thus, import firms' main centres were fairly well stocked with equipment for infrastructures, farm transport and well-known makes of farm tractor. This did not mean, however, that spares arrived on the spot at the right time, especially when, for various good reasons, the equipment came from smaller manufacturers. In some cases, importers did not hesitate to use air transport to supply an urgent order from a customer; in many others, however, machines had to remain idle for a whole farming season through lack of spares, often of a very minor character. As a result, users were once more forced to act for themselves and keep stocks covering the estimated requirements of workshops on the spot.

We cannot go into technical details of these stocks or even give a brief list of "schemes" for which repair shops had to be set up. It can be stated, however, that distance from the appropriate supply centres is a major factor, as are transport difficulties, particularly during the rainy season, and that the size of the stocks held was normally proportionate to the number of machines and different types. Here, it should be remembered that in the absence of qualified research and testing organizations, capable of supplying useful information on methods using tested equipment, many "schemes" were forced to carry out their own experiments and therefore had to establish large stocks of parts for machines whose weaknesses in difficult working conditions were unknown.

The conclusion has now been reached that the initial stock of spares must be equivalent to at least 20% of the value of all new equipment when there are several types of machines. It is not surprising, therefore, that with large numbers of machines, sometimes worth more than 1,000 million F- CFA, spares sometimes had to be held to the value of several hundred million F- CFA.
This applies equally to private "industrial" plantations and to the special sections of various organizations handling "hire" work for African farmers.
The same is true for organizations which supply farmers with machinery. In the almost total absence of craftsmen capable of doing repairs, ploughshares have to be replaced rather than beaten out, the blades of husking machines have to be changed because they cannot be reground while the plungers on knapsack sprays are destroyed by the products used to protect certain crops and so on. These replacements have to be made, otherwise the equipment cannot be used. Unfortunately, although some steps have been taken to distribute spares among the governmental and semi-governmental bodies which provide services undertaken by private firms in temperate countries, the farmer rarely gets his machinery repaired in time. This may endanger the harvest as work such as sowing, spraying, cutting, etc. cannot be done at the right time. Nevertheless, the provision of an after-sales service comprising workshops and spares considerably increases running costs for every machine used on any type of work and this is one of the factors holding back all types of farm mechanization in the countries under review.
Apart from some items made by craftsmen as already mentioned, there is virtually no local production and it would be as futile as trying to square the circle to try—with any hope of being heard—to persuade manufacturers in industrialized countries to launch a sustained effort at great distances, involving the use of costly skilled labour, when sales are usually small, irregular and hard to increase and are moreover hampered by various restrictions. The number of machines will almost certainly grow, but this will take time.
Government action is therefore essential. Quite apart from what has already been done directly or indirectly by governmental and semi-governmental bodies—over and above what private firms have been forced to do—steps must be taken to remedy the shortage of craftsmen. In addition to providing special training, the authorities must ensure that craftsmen have equipment, small workshops and stocks of spares so that they can offer some of the services expected by users—as has been done in Madagascar, for example.
Where there is as yet no place for skilled craftsmen, breakdown lorries, allocated to specific areas and carrying small stocks handled by a skilled man, offer an effective solution, as has been found in Mali, for example.
Action is being taken elsewhere on similar lines; the cost is not high and good results have been achieved. It seems likely that the problem would be less complicated if an entirely objective selection were made of a limited number of machines for general use by farmers. This means setting up an organization to carry out tests and experiments with machines; its findings would have to be considered by a qualified authority including representatives of all concerned with the development of every kind of farm mechanization; this Committee—or Commission—would submit specific recommendations to the Governments for decision.
However, manufacturers can already take useful steps to give technical assistance to local importers. Existing requirements are not large in each category but cover a substantial range of equipment used at all stages from ground clearance to processing.
As manufacturers generally specialize and no-one can offer the whole range, they must work together as a group. The combined range may then justify the cost of direct action and the group's interests could be handled by versatile skilled technicians, capable of helping importers in many ways (advice, choice of suitable machines, demonstrations, etc). Such specialist services are also useful for essential liaison with local firms now starting to manufacture under licence and with the representatives of local users.
Indeed all available means must be used pragmatically until there are enough machines to justify the cost of setting up a special trade organization to provide normal after-sales service.

Finance

The introduction of machines automatically calls for special finance, particularly in developing countries which must be able to equip themselves in all sectors including—we would say primarily—agriculture. The funds so provided must enable farmers to make individual purchases—which raises another problem.

Even in industrialized countries with a developed agriculture its solution involves various forms of State action, including subsidies for the purchase of equipment, import regulations, special farm loans, introduction of special fuel for farmers, etc; private action in such forms as hire purchase is also necessary. The whole problem comes under the heading of aid to agriculture which is very frequently subsidized.

In the countries under discussion, very few farmers go to the trading post to pay cash, with their own money, for some item of equipment.We shall, therefore, consider how farm machinery has reached tropical Africa and how farmers have benefited from the use of certain types of machinery and have been able to acquire a basic minimum.

Introduction of machines

In none of the countries and regions concerned can it be said that the provision of farm machinery was generally regarded as a subject requiring special attention from the outset.

Provident Societies used money received from the local Governments and members' contributions to buy equipment, chiefly for collective use; in addition certain stations, centres and development schemes received Government assistance. Some schemes were however financed directly by the administering power, as in the case of the *Office du Niger*.

Later on farm machinery was provided under plans financed with money provided by Fides. Without going into the various methods in detail it may be stated that fairly large quantities of mechanized equipment were provided under various schemes for African farmers either through the General Section, as for the CGOT, and Sofico, the ON and so on or through local sections as for the palm-grove restoration authorities, the rice plantations, the SEM Centre (Cameroons), the mechanization sections etc.

It was not until 1955, however, that African farmers in general were brought more directly into schemes for financing agricultural development in areas of varying size. Thus the local sections financed the purchase of equipment by the CRAM in Madagascar, the SEM in the Cameroons and the CER in Senegal, while the first Technical Assistance companies such as the BDPA or the CFDT were supplied under schemes operated in the Northern Cameroons or at Sakay, for example.

At the same time, Ferdes used funds allocated under the general, local and municipal budgets and some assistance from Fides, to finance the purchase of various types of machinery, especially for rice growing, chiefly in French West Africa but also in French Equatorial Africa. In reality, apart from major special schemes, agriculture was not affected quickly or appreciably by the general development plans with the result that the individual farmer saw little substantial improvement in his equipment. Nevertheless, a fairly large number of machines, many of them powered, were brought in.

After independence FAC took over bilateral assistance from Fides and very quickly used the available funds to finance "integrated" or specific schemes; measures were taken either directly, by the development of local action, or through technical assistance companies to provide farmers with more and more machinery. Money was also made available for the purchase of jointly-owned equipment for certain types of hire work.

Multilateral aid appeared at roughly the same time. Full details cannot possibly be given of action taken by the United Nations either directly through the Expanded Programme, the Special Fund and the UN Development Programme or indirectly through the specialized agencies FAO and Unesco. It will suffice to say that at the study stage, preliminary investments were used by farmers to purchase small farm implements with Government participation. Such purchases were also assisted by long-term loans at very low interest under special development projects of the BIRD.

The First Scheme of the European Development Fund (EDF) financed, for example, the equipment of ON Seasonal Schools and farmers (Mali) while the Second Scheme, and more particularly aid for the development of production and diversification of crops, included subsidies used to equip certain groups of farmers in the eighteen countries which signed the Yaoundé agreement. Furthermore, under a Decision of the EEC Council of Ministers, the Overseas Territories which still receive aid from Fides and Fidom have benefited from subsidies from the EDF which is also used as a source of special loans.

Finally, all or part of certain major national mechanization schemes have been financed directly or indirectly by the Governments. There are few such schemes, however. First, the Cocoa Support Fund has been used to buy mechanized equipment for use in each Sub-prefecture for various operations of interest to Ivory

Coast growers. Again, a loan guaranteed by France has been used by Mali to provide the first instalment of equipment for 100,000 farms, with part of the cost covered by the FAC. Senegal has set up the Senegalese Development Bank to finance the planned development of the use of animal traction, with help from the EDF. Thus, the amount of agricultural machinery has been increased since independence by outside aid, by funds supplied by the Governments concerned or by a combination of both methods.

Bilateral and multilateral aid has been mainly provided for integrated agricultural development schemes in particular areas; credits specifically allocated for the purchase of equipment can only be identified in a very few cases. These include tractors and towed implements (SAED, Senegal, FAC), animal-drawn machines (farm schemes in Niger, FAC) cleaning and shelling equipment (ON, Mali, EDF), animal-drawn machinery and storage equipment (Senegal—EDF). Schemes financed directly by local Governments can be followed in more detail.

Altogether, however, little systematic effort has been made to finance the use of more farm machinery despite its great importance for the progress of agriculture.

Methods of providing African farmers with machinery

The machines obtained in the various ways described are made available to African farmers by two main methods—by the hire of jointly-owned machines and by individual purchases.

(a) Hire schemes

We shall not discuss further the constitutions of the various State, co-operative, semi-governmental and semi-co-operative bodies through which machinery has been acquired for collective use. It is more important to consider briefly how the various types of loan are repaid. The main purpose of such schemes was of course to enable farmers to enjoy the benefits of mechanized equipment: they included land clearance and reclamation (ON, SRP, Section de Daloa, CRAM, etc.), ploughing, dry-crop spraying (CER in Senegal, SEM in East Cameroons), irrigated rice-growing (Section de Macina, Semry in Cameroons, SAED in Senegal, Setam at Marovoay in Madagascar, etc.), crop-protection (Special section of the RCA, Cata at Mungo, Satmaci in the Ivory Coast, etc.), processing of produce (Cameroons, Mali). However, examples could also be given of such schemes operated with multi-purpose animal-drawn equipment, mainly by private firms.

In any event, in order to interest farmers at the start of such schemes, a bargain price was generally charged or the work was even done free of charge. The promoters intended to make increases until farmers were finally able to pay the cost price. It must be admitted that this method has not proved successful because farmers do not always feel directly concerned and are reluctant to join the scheme.

The policy of partly or completely free "gifts" has in fact failed. Furthermore, even when fairly successful efforts were made to recover the cost price, schemes had to be indirectly subsidized because of the management methods applied by general Technical Sections and because cost calculations (mainly estimates and not factual) overestimated hourly output and did not include certain items, such as overheads which are most important.

There are some examples of financial success but they relate mainly to overall schemes where profits earned on processing, for example, more than offset losses on mechanized farming (Semry) and to "co-operative" schemes, where, after a slow start, hire-work by farm machinery was paid for in kind when the harvest was processed (SCAER at Siguiri). It must be admitted, however, that it has generally been difficult to cover the heavy cost of providing infrastructure, buildings and equipment and of recruiting large numbers of fully-skilled workers. It would appear that when general conditions are suitable the solution lies in a strict choice of such schemes or in the intervention of small private entrepreneurs, who may be farmers, working the growers' land or processing their produce under contract. The second method involves the individual purchase of equipment.

(b) Individual purchase of equipment

The funds needed for the purchase of machinery are held by Governments or bodies specially set up for the purpose. Arrangements must be made for loans to farmers and for their repayment. Distribution is easy

but the recovery of money lent is not so simple because, to the farmer, the cost of buying an animal-drawn plough with a pair of oxen, or even a continuous-pressure knapsack spray, is proportionately much the same as the cost of buying a combine harvester to a farmer in Beauce.
The problem is complicated by the fact that borrowers have to offer securities for their loans and the farmers concerned are virtually unable to do so. Special schemes and arrangements are therefore needed. As already noted, the Provident Societies were the first to act; in addition, some equipment was distributed in the form of a partly, completely or disguised free gift for propaganda purposes. Later, the authorities in charge of schemes of a more or less integrated character intervened either directly or through various intermediaries.
Here we may again note that the CFDT purchases and distributes equipment and then recovers the sums advanced by interest-bearing instalments spread over a number of years and collected when the farmer's crop is bought. An interesting method was at one time used by the SEM-Centre whose Heads of Farm Stations encouraged the formation of small "mutual credit associations" with all members giving a joint guarantee. More than 1,000 such associations were formed and loan repayments were made regularly. The Farm Equipment Centre at Tananarive operated a similar scheme through the Groupements du Collectivités, CRAM, etc.
There are usually similar arrangements in a number of countries. In Senegal, for example, machinery is distributed through the OCA, the CRAD and the Co-operatives while the Senegalese Development bank recovers the annual instalments through the Co-operatives. In Mali, the Equipment Division allocates machinery through the Rural Expansion Areas and then to the Co-operatives, while the SCAER of the Mali National Bank, which has special funds for the purpose, promotes the Co-operatives through which repayments are made. The Equipment Centre at Tananarive operates through very similar channels in conjunction with the Madagascar National Bank. In practice, authorities responsible for an integrated scheme covering a limited area find it easier to distribute machinery to the right place at the right time and to recover the loans which they advance because they can recoup loans against payments for marketed produce when the farmers' crops are bought. In these cases particularly we find a slow growth of mechanization. With "crash" schemes there are bottlenecks at all stages of distribution and of repayments especially when two separate bodies are involved; further difficulties arise from the fact that in such circumstances the return that the farmer is likely to earn from using machinery is not always properly estimated.
In any event, there are very few farmers who buy machinery direct with their own money and the problems associated with financing purchases and repaying loans when equipment is provided on credit are difficult to resolve in countries with few budget resources, where farmers, who constitute the main body of taxpayers, have little chance of saving and do not always increase their yields appreciably by using machinery. In general, since savings are inadequate, most purchases still have to be financed wholly or partly with outside aid, despite the fact that experiments in the matter have been going on for some time.
Regardless of their actual legal form, hiring schemes can at best make only slow and minor progress because the profits earned are not sufficient to finance further expansion. Furthermore, the farmers using such schemes very rarely save enough to buy their own machinery. Local, or more general, purchases of equipment by individual farmers, even if well organized technically and financially, can spread only very slowly if the extra money earned by the first "mechanized" farmers is not saved for further investment. The same applies even more strongly to other farmers who can acquire only a very small number of machines.
However, the benefits of mechanization cannot reach *all* farmers through outside aid. A choice must therefore be made of the schemes (hiring or distribution) most likely to succeed technically, financially and socially. Once the choice has been made, the selected schemes must be very strictly implemented and managed and all necessary steps must be taken to encourage the farmers concerned to save as much as possible. In this way prosperous farming areas could spread relatively quickly. Other farmers will only be reached gradually as the country itself advances.

Conclusions

Agricultural questions concerning the developing countries have been discussed in the special Committee of this Congress. We have examined some of the requirements for development of all forms of mechanization, discussing in turn the stage now reached, the obstacles encountered and the special methods which seem necessary to encourage the increased use of farm machinery which is a vital necessity.

In order to bring about this increase, enabling the tropical African farmer to enjoy the normal benefits of mechanization, the status of farming must also be raised and future instructors, extension officers, skilled craftsmen and even users must be given better training; farm machinery and farm animals must be introduced or increased more quickly in each country, the machines selected and manufactured must be better adapted than at present to the animals that will work them as well as to soil conditions, crops and farmers' resources and abilities; finally, there must be a satisfactory after-sales service.

All this means that substantial financial resources must be earmarked for the various schemes which must be carried through in order to resolve present problems, without of course trying to reach all farmers in the countries concerned immediately. The continuation and expansion of outside financial assistance seems to be desirable. This being so, all machines must be used so that they will give the highest possible return both on individual farms and in pilot schemes designed to promote the use of machinery in each of the countries under discussion. Fortunately there are a fair number of examples giving grounds for reasonable optimism in this matter. Results can be summarized by saying that two new forms of mechanization should be adopted in certain conditions. They are animal power wherever possible and the use of powered machinery wherever justified or essential, not forgetting the possibilities offered by certain hand tools and implements. A pragmatic approach should be adopted so that powered machines, animal-drawn equipment and hand implements will be used for the various crops grown according to their relative economic efficiency, regardless of the actual type of scheme.

It may perhaps be thought that if all the necessary elements are brought together by the concerted efforts of all the experts employed (technicians, administrators, financiers) by the various public and private authorities concerned, the progress achieved in certain directions will be speeded up and will also encourage progress in other fields. We have given a table summarizing the numbers of farm machines available. From a very low figure in 1946, they had reached quite substantial proportions ten years later with a marked increase in the number of powered machines. After a further ten years powered machines had made no more progress but there had been a very substantial increase in the number of animal-drawn machines, in crop protection equipment and in various types of hand implements. However, spontaneous acceleration is still only a distant prospect and the general movement will only spread to all farmers when machines are present in considerable numbers.

The time has now come for the various lines of action to be transferred to new hands. First, the machine-building industry (foreign and local constructors and importers) can take over the after-sales service and provide some of the necessary advance finance, vocational training and extension services, helped by co-operatives or trade associations, as in Europe. Government and semi-government action will still be very important as will technical assistance, but will be more concentrated than at present on sectors where they are particularly effective, especially for the competent and continued training of farmers on the widest possible scale. Only then will it be possible to raise all farmers' living standards appreciably and to improve their countries' economies so that they can increase their trade with the industrialized countries.

There are no grounds for the over-optimistic belief that agriculture will soon be completely mechanized in these countries, but the systematic progress of certain mechanized schemes and the extension of animal power would constitute a great step forward. Finally, as the social aspect is the most important it must be hoped that concerted efforts will ultimately be successful.

Delegates' Papers and Comments

Vittorio BONISCONTI

FIAT—Divisione meccanizzazione agricola
Torino

The Tractor in the Developing Countries

(Translated from Italian)

The tractor first made its working debut in the 1920s, but it did not come into general use until the 1950s, when it rapidly took over in all the industrialized countries. The development of traction machinery has taken two courses: machines for agricultural production and machines for use in the factory. These two types of tractor have progressed independently; and in the rural areas of the industrialized countries the industrial tractor has rarely been directly responsible for introducing the tractor to farming; this operational independence has now taken a definite shape and is growing visibly with increased modernization of agricultural management.

Many developing countries, even in the '60s, have made little progress in the use of traction equipment; in fact, in many countries which have recently gained independence the use of the tractor, especially in agriculture, has slipped back, as a result of outside factors.

In the "industrializing" countries of the world, power farming is reckoned to be the most efficient way of improving production, especially from the point of view of expansion (increased productivity of labour); however the progress of power-farming is largely connected with the execution of other essential functions, in areas where farming is difficult, as an instrument of progressive and agricultural development (intensive farming—that is, greater production per unit of area). Especially in tropical countries, where in addition to climatic difficulties, there is also the problem of pupulation movement, these two functions are necessary to overcome the inadequacies caused by the traditional use of the land.

Thus the use of the tractor throughout the world is still very much localized. Although only a small proportion of the 15 million tractors in use are to be found in the developing countries, this need not necessarily imply an imbalance, if the problem of agricultural production could be boiled down to a matter of mechanization costs on one hand and the cost and necessity of using manual labour, on the other.

The central problem is the low level of food supplies, often getting worse rather than better, and it is this which usually makes it necessary to go over to mechanized farming. In the majority of these countries it is just as inadvisable to delay the introduction of power farming as it would be to undertake a large-scale programme of farm mechanization. In the latter case, the infrastructure is inadequate and the workers are

neither sufficient in numbers nor properly trained: by infrastructure can be understood (if somewhat inaccurately) administration (governmental, co-operative or private), technical assistance facilities (servicing and repair shops, stocks of spare parts etc.). It is therefore imperative that the process of agricultural mechanization should be a gradual process backed up — with the support of the promoting organizations, local administration and supplying manufacturers — by adequate research (choice of equipment to be used: type of motor and auxiliary implements), suitable concentration of equipment in the areas of greatest productivity: by training of personnel in the use and serving of the machinery; and by first of all providing suitable auxiliary facilities (stores, stocks of spare parts, servicing and repair shops and mobile repair units).
The European Economic and Social Progress Committee Cepes recently published a study entitled "International Trade and Economic Development" in which it considers the problem of progress in the development countries in relation to the world economy. The depth of the study and the important place occupied in it by agriculture have encouraged us to use some of its conclusions as guide-lines.

Alternative theories on agricultural progress

In the developing countries there are two obstacles in the way of agricultural progress and the availability of income per head of the population: the population and limited productivity of labour. There are two opposing theories on this question, one based on rural economics, the other on sociology. The first holds that the problem of under-production is all-important and can only be overcome by mechanization; the second maintains that priority must be given to full-employment, over a reasonable period of time, during which emphasis should be laid on agricultural reform, which is considred less costly than mechanization. Since the vital functions of an economic system, like those of a living organism, are carried out simultaneously, the answer would appear to lie somewhere between the limits of the two theories and, the Cepes report in fact supports the idea of simultaneous agricultural and industrial functions with the emphasis first of all on linking agriculture with the home market and setting up services for the supply of capital equipment.
Although the policy of large-scale mechanization is attended by the limitations and risks which we have already mentioned, a policy of forced full employment slows down development and prevents gradual assimilation of technological know-how and so accentuates the lack of skilled labour.
Recent surveys, based on the theory of the "priority of developing the internal market", show that the economic approach follows a chronological series of active priorities and that No. 1 priority must be given to modernization of agriculture. We have already given the reasons why agricultural modernization must be achieved through a gradual process of mechanization: if we accept that theory it follows that the means required for this gradual mechanization must be imported into the country from abroad and not made locally. The reasons for this are all the more obvious when we have realized why mechanization has to be progressive.
An industrial production line cannot be devised and established unless the necessary material and human infrastructure is already present in the country. In any case the low quantitative demand would not be enough even in industrializing countries, where some fundamental infrastructures already exist, to produce both economically and at the required standards of quality. Another factor which has to be taken into account is the continual technical innovation in machinery design and production.
Experience gained in some countries has shown that attemps to establish local production have resulted in very high-cost products of a quality not capable of standing up to rough agricultural usage. This has resulted in protectionism and feather-bedding, which in any case did not last long, because agriculture in the area just could not afford to carry them.

How tractor mechanization works

The whole idea of the parity of agriculture with other occupations in the developing countries scarcely arises, because unfortunately the prospects for alternative occupation are still very few. This is the main reason why in these counties there has been little spontaneous pressure towards tractor mechanization; and the reason why this trend did not develop in Europe until the '50s, when labour supply began to fall off. So in the developing countries, and especially in tropical countries, the introduction of power farming depends at present on factors which would not apply in the case of industrialized countries. In short, mechanization is motivated by the imperative need to produce more both for home consumption and to pay for vital imports of capital goods.

Although, as we have seen, the use in agriculture of so-called industrial machinery (especially bulldozers) in industrialized countries occurs only during a phase of improved management (business extensions, re-organization of premises and services), in the developing countries there are obvious technical reasons why the use of such machinery should be given top priority.

Conclusions

Though the majority of developing countries accept the principle that agriculture should be developed and brought up to date, a thorough examination should be carried out on the following basis:

(1) the impossibility of large-scale tractor machanization;
(2) the advisability of gradual mechanization preceded by detailed study of all factors likely to affect the use of tractors;
(3) the importance of ensuring that mechanization is backed up by all the elements (from the choice of equipment to the training of personnel and technical facilities) which the surveys show to be necessary;
(4) the inappropriateness of starting local production of machinery before the necessary infrastructure and sufficient and sustained demand are present.

So it is really a question of basic planning, and this requires the closest possible cooperation of the international organizations concerned with the progress of the developing countries, as well as that of the governments and administrations of the countries themselves and the greater manufacturing capacity of the West.

J. GUILLARD

Bureau pour le développement de la production agricole
Paris

Harness Cropping in French-speaking Africa

(Translated from French)

In the primarily agricultural subsistance economies of Africa, the introduction and rapid extension of export crops, in conjunction with social and infrastructural development, has induced some degree of incipient economic take-off, shown in particular in the movement towards a trade/market economy. Farming with animal-drawn equipment is now gradually displacing the old modes of cultivation based on human muscle-power, and by burning and the mattock, as it were, is bringing further and perhaps still more radical changes in agricultural production and hence in the economy generally.

Following various attempts at mechanization, some of them failures and all fraught with difficulties and carried out on a small scale only, "harness cropping", i.e. the use of animal traction with appropriate implements, is now taking root in a big way in many Black African countries.

Some recent figures may give a clearer idea of the scale of this "agricultural revolution", which has been achieved thanks to the development of suitable steel appliances, to the co-operation of the public authorities in making these widely available, and also, in large part, to aid from Europe. But the problems have not been entirely overcome: I propose to list briefly some of the many difficulties still remaining. The process of change is by no means over; there is still any amount of scope for expansion and improvement.

Success of harness cropping in French-speaking Africa

While I do not suggest that I am putting the stages of development in present-day Africa on a par with those in Western Europe in the eighteenth and nineteenth centuries, it is a fact that for Africa the use of animal traction is a very considerable technical, economic and indeed social advance. Efforts to introduce large-scale motorization of agriculture have pretty well come to grief everywhere in the African countries given their present stage of infrastructural and economic development, in spite— and perhaps also partly because— of the very large sums of money spent on them.

Harness cropping on the other hand—at present confined chiefly to tillage proper—though it got off to a much slower start, is now a great success.

The first experiments go back a good many years, to the early years of the century in Senegal and to the nineteen-thirties in Guinea and Mali. But with a few exceptions, as in the case of the *Office du Niger*, these tentative projects met with little response from the country people. It was not until the fifties that the popularization of harness cropping really got under way.

In Senegal, in 1959, there were 3,700 hoes in service, and sales amounted only to 400-500 a year: in 1963 the sales figure was 11,300—twenty-five times as high as three years before—and Senegalese agriculture is now estimated as owning a total of 28,000 hoes, 86,000 seed drills, 33,000 carts and 3,500 ploughs.

In North Cameroun, where harness cropping was unknown in 1954, the change has been startling:

Implements in service	1955	1960	Beginning of 1966
Ploughs	7	4,100	11,400
Carts			1,130
Hoes and Ridging attachments			330

In Chad, the trend began slightly later but has moved even faster: between 1958 and 1961 the croppers there acquired 1, 128 ploughs and 519 carts, but by the end of 1965 their stock totalled 8,600 ploughs, 4,400 carts and 240 hoes. Thus while the number of ploughs in North Cameroun has increased 2.8 times in five years, the number in Chad has increased sevenfold, making up for lost time.

Some of the French-speaking African countries are thus well ahead; in others harness cropping is still practically non-existent although conditions are very similar. However, the tremendous expansion in Chad, a country very poorly placed economically, shows that any lag can be speedily made up.

Problems not yet overcome

It might appear from these few examples that the complete answer had been found and that all that remained to be done in order to provide every African peasant with the necessary equipment was to go ahead and market it. However, this would be a great mistake, which could easily endanger both the progress of harness cropping and the management of the enterprises engaging in it.

Draught animals—obviously an essential factor—are one problem. These include first and foremost oxen, to a lesser extent horses (mainly in Senegal), and lastly donkeys. The large numbers of these in the different countries would seem to indicate that plenty of draught animals would be available, but unfortunately in many parts of Africa the ravages of trypanosomiasis are such that even if the beasts do not actually die they become unfit for regular work. Though some success has been achieved in the judicious introduction of trypanosomiasis-resistant animals and their use in harness, for instance in the Central African Republic, in all probability harness cropping will be confined for some considerable time yet to the savannas, North African Littoral and South of the Sahara, where the disease is unknown.

To turn a usually semi-nomadic grazier into a settled farmer equipped for harness cropping is generally difficult; to turn a hand-hoe cropper into a harness cropper, though somewhat easier, is quite tricky enough. The introduction of livestock into a peasant economy which does not go in for stockbreeding, and the use for draught of animals hitherto regarded exlcusively as meat or milk producers, investments or prestige symbols, involve profound mental, social and economic changes for the families concerned.

Harness cropping equipment in service in some West African countries in 1965.

	Senegal	Mali	Maure-tania	Niger	Upper Volta	Ivory Coast	Togo	Daho-mey	Total
Ploughs	3,500	45,000	(¹)	150	3,500	100	45	60	52,355
Ridgers	—	—	—	400	—	—	60	—	460
Harrows	10	4,000	(¹)	10	520	25	10	(¹)	4,578
Seeders	86,100	—	—	120	100	—	—	(¹)	86,327
Combine drills	400	—	—	—	—	—	—	—	400
Hoes with or without ridging attachment, Canadian cultivators, other cultivators	28,000	1,000	150	100	8,800	5	(¹)	28	38,083
Groundnut lifters	1,000	—	—	—	—	—	—	—	1,000
Animal-drawn carts	33,000	5,000	10	300	1,000	25	20	10	39,365
Multi-purpose appliances	1,000	—	—	220	350	7	30	—	1,607

(¹) A few (precise number unknown).
Multi-purpose appliances which are in fact put to one use only are included under the appropriate single-purpose item.

Working animals have to be properly fed and tended, and this raises fresh technical and sociological problems which have by no means all been overcome.

Again, a pair of oxen plus the necessary basic equipment costs sometimes several times the cropper's normal yearly budget, so that he is obliged to borrow, in economies in which cash transactions are only now becoming current and which have practically no arrangements for individual guarantees.

The animals can usually be found locally, but the equipment has mostly to be imported, and its end cost to the cropper is extremely high, what with substantial transport and distribution charges, and also, unfortunately, heavy import duties. Ploughs and similar items are, it is true, duty and tax-free, if imported from EEC or OCAM countries, but even they are liable to various flat-rate import dues and specific charges amounting to anything from 6.5 to 32 % of the cif-value; on carts the duties and taxes payable work out at 15-20 % of the cif-value, in addition to which there are flat-rate and specific charges of 9-53 % of the cif-value plus duty. A similar array of taxes are charged on spare parts.

It is true that in many countries harness cropping equipment is subsidized in varying degrees under the national development plans, and is available on exceptionally easy credit terms. The sale prices of the various appliances have long differed considerably from country to country, but they now appear to be moving towards a more or less similar level, which is, notwithstanding, a high one given the croppers' present capital availabilities. The bare minimum of a plough, cart and hoe costs roughly 30,000—50,000 CFA-francs (FF 600-1,000), for holdings bringing in from 20,000 to 50,000 CFA-francs a year.

After a good deal of trial and error in the first few years, with equipment that proved unsuitable, too heavy, too elaborate or in some cases too comprehensive for the initial stages of development, it now appears that each area is being offered standard models of approximately the types it needs. But the supply of spare parts is not always properly organized. Inadequately serviced ploughshares, blades and hubs can wear out very quickly in the often highly siliceous soils, so that the working parts need to be frequently replaced (in Cameroun, for instance, a share is only good for 3 to 6 hectares). If spare parts are available the cost to the cropper over the year is quite high and if not available the appliance is put out of action altogether, which is even worse. Although something is being done in this direction by organizing mobile workshops and maintenance teams, it has been found that harness cropping equipment in general is not receiving the necessary regular attention, prompt repairs and overhauls to enable it to be used efficiently. The only real answer is to train village craftsmen.

Tentative estimates of the economic results of introducing harness cropping on holdings indicate that:

(a) the increase in area tilled per holding and per worker, while substantial, in every case, varies considerably from region to region;
(b) the area given over to cash crops is still increasing fairly fast, which raises the problems of land availabilities and soil conservation;
(c) on the other hand, though harness cropping has not made much difference to the productivity of the soil, it has brought changes for the better in cultivation methods (which could actually have been made without it).

Generally speaking, the productivity ratings of the holdings equipped for harness cropping are not so high as theoretical calculations might have suggested. However, we must bear in mind the slowness of change in an environment previously almost untouched by progress, the direct benefits unconnected with the holding itself, such as the introduction of contract ploughing and contract haulage, which play a major part in economic take-off, and the basic movement thus caused towards a better partnership between growers and stockbreeders. Practically everywhere the agricultural revolution is only in its initial stage, the stage of partial mechanization of operations.

Future outlook

The emergent states' early enthusiasm for motorized farming and expensive equipment in the form of tractors and specialized implements quickly evaporated in face of the technical and economic difficulties involved by Government or co-operative action on behalf of independent croppers or by experiments in large-scale farming. Harness cropping, which is recommended by experienced agricultural engineers and by many technical-assistance organizations, is now increasingly favoured by the authorities, as is evident from the official development plans. These are setting their sights high.

For instance, Senegal aims in its second Four Year Plan (1965-70) at bringing into service 87,000 seed drills, 53,000 hoes, 12,900 groundnut lifters, 15,550 fertilizer spreaders, 20,000 ploughs and 29,000 carts, representing a total capital expenditure of 2,662,000 CFA-francs. Chad hopes by the end of 1966 to have over 14,000 ploughs and 10,000 carts—about double the numbers at the end of 1965. Cameroun's 1965-70 Plan provides for an additional 22,000 ploughs and 4,300 carts.

Some Governments were planning at one stage that every holding should have its equipment, but the difficulty of paying off the capital cost on small separate parcels of land, the low utilization rate over the year resulting from the fact that the actual operations are concentrated in short seasonal bursts, and the heavy burden of debt involved, soon caused them to think better of this rather starry-eyed idea. One plough to about ten non-harness holdings—ideally, one to 20-25 persons—and one cart to six or eight ploughs would appear to be about right pretty well everywhere.

There are four main points to be borne in mind in guiding this progressive development of harness cropping.

(1) Proper maintenance of the equipment and adequate arrangements for the supply of spare parts are essential if the position now reached is to be kept up and further increases achieved.
(2) Partial mechanization of particular operations is not in itself the complete answer to African croppers' needs. Other measures, both practical, such as seed treatment, crop protection and so on, and educational, such as the popularization of better techniques, improvement of knowledge, and instruction of the croppers in technical and business methods, are quite as important and "remunerative" if not more so.
(3) This initial stage in the introduction of harness cropping, the provision of the basic implements, is only a start: once the process gets under way, the equipment needs to be diversified. With increasing numbers of harness hoes in use to help in the care of the growing crop, operations need no longer be cramped by the larger acreages to be looked after or by the excessive demands on labour at peak periods of cultivation and weeding: where there are not yet enough of them they should be a top priority. But then as well there will have to be other types of equipment, for harvesting, for treating the crops, both before and after harvesting, for soil preparation, for transport, before the holding can be said to be properly

fitted out. Naturally all this will have to be done by easy stages, in order not to saddle the holdings that are thus modernizing but have not yet reaped the benefits with a crippling load of debt.

(4) Obviously, the complete technological and economic change entailed by the switch to harness cropping cannot be effected on every holding. In fact, it would be dangerous to try to introduce it for every holding in a given area. Everyone must have his chance to achieve the new status, but it is not desirable that everyone should actually do so. Proper utilization of the equipment is only possible given a much larger acreage than that of the present individual holdings; a system of contract labour will be needed to enable the capital cost to be paid off faster. The change-over will in addition allow individual croppers to better themselves, and foster the go-ahead spirit that is essential to speedier development.

Conclusions

The rapid spread of harness cropping which has been made possible by the designing of steel equipment specially suited for tropical conditions, and by the public authorities' eagerness to promote it by organizing popularization drives and credit facilities, is a major turning-point in African agriculture.

Over and above its immediate technological advantages, the process is serving:

(a) to develop a trade economy and channels of money circulation which are highly beneficial to economic growth;

(b) to break the habit patterns of centuries and make life easier for men and women. For it is not just a matter of going over to wheel and ploughshare: probably most important of all, there inevitably follows a whole series of radical changes in methods, customs and economic conditions.

At the same time, the advance still needs to be guided, followed up, extended on a broader and broader front. The provision of equipment yet better suited to African needs and purses, of technical assistance for the popularization and maintenance of that equipment and for the working up of other agricultural production factors, of financial aid to enable the responsible authorities to sustain and stimulate the trend, all these are vitally necessary and indeed to the advantage of the countries that are at present supplying the equipment and will in the future be supplying the steel—steel, the product which, moving at the heels of plodding beasts, is pressing its way more and more into the life of the African land.

P. LEBUGHE

Secrétaire général à l'agriculture, république démocratique du Congo
Kinshasa

(Translated from French)

What I am going to say is both a point for your consideration and an appeal to the European Development Fund to re-examine the criteria it has employed up to now regarding aid to the developing countries. Obviously, the organizers of this Congress, and all of us here in this Working Party, want the occasion to produce results. But if there are to be results, some prior conditions need to be fulfilled in each of the countries concerned before the intended action is begun.

In my own country, the Congo Democratic Republic, the economic and financial position has not yet been stabilized. I need not tell you that its potential is enormous, but for all that it produces copper, uranium, diamonds, gold and tin—to mention only the minerals—as well as cotton, rubber, palm-oil, coffee, tea, pyrethrum, cinchona and so on, nevertheless it still has an adverse balance of payments. And lacking currency for trade purposes, it consequently lacks capital goods and even basic essentials. So you see not all the prerequisites are there for the Congo to embark, at present anyhow, on the large-scale mechanization of agriculture, let alone contemplate putting up agricultural buildings of steel.

Until such time as the new Government's efforts to put the country on its feet economically begin to bear fruit, EDF should step up its aid to the Congo for the modernization of agriculture. What is more, EDF aid to the Congo so far has been very small indeed compared with what other countries have received, despite the Congo's huge size and very considerable agricultural potential.

Agricultural mechanization is coming in slowly but surely in some of the better-off regions, under carefully-thought-out programmes for highly profitable crops such as cotton, sugar cane, tobacco and so on, organized to ensure that the cropper hiring a tractor and coming to realize what a boon it is shall first of all be able to pay for its hire and thereafter increase his earnings. So mechanization is not as yet in progress anything like all over the country. Nevertheless, what EDF could do for us is arrange for the introduction of minor items of agricultural equipment to facilitate some of the operations involved in the cultivation, transport and processing of the crops.

M. Labrousse drew attention to one other very important point which tends to be overlooked, namely after-sales service. When awarding a contract for two tractors recently in the Congo, we were surprised to see that an EDF inspector attached little importance to this aspect.

Dr. D. W. HALL
Miss J. V. STEPHEN

Ministry of Overseas development, Tropical Stored Products Centre
slough

Steel and the Storage of Agricultural Produce in the Tropics

During this Congress, important papers on the catalytic effect of agricultural development in the economic growth of countries have been given and the commercial potential which exists, with mutual benefit to the developed and developing areas of the world, perhaps does not require further emphasis.

The tropical areas of the world contain a predominance of developing countries. In some of these, stress on industrialization has taken precedence over agricultural development, from which policy economic and social problems accrue. Agricultural development is an essential forerunner or counterpart of industrial development.

Where attention has been given to increasing agricultural production there are excellent examples of the successful outcome of mechanization, fertilizer use, water control etc. With increases in crop yield, improved price structures and marketing outlets are necessary to ensure that the producer and the consumer obtain maximum benefit. Since however, harvested produce deteriorates unless efficient methods of harvesting, drying, storing, processing and transporting are used, the growing of greater quantities of agricultural produce in itself is insufficient to meet the increasing food requirements of the human race throughout the world. It is essential to have in operation a "regulatory valve" to ensure a controlled flow of high quality produce over a time scale which caters for partial or complete crop failures. Efficient storage and transportation are the keys to the effective operation of the marketing of produce on district, national and international scales.

In the past, emphasis has been given to difficulties in obtaining produce from the tropics without contaminants such as earth, stones, moulds, insects and rodent hairs, without discoloured grains or without weight changes occurring due to moisture loss. Equally, locally, the farmer has realized from experience that if he tried to keep produce, much would deteriorate; consequently produce is sold at harvest when prices are low. It is now reassuring to note that during the past five years there has been a growing awareness perhaps for nationalistic reasons by organizations within tropical countries, that it is essential to ensure that export produce must be of higher quality than in the past; also if the problem of subsistence agriculture is to be tackled, the farmer must be given the means to feed his family and domestic animals on produce which he can retain in good condition i.e. uncontaminated by mycotoxins or undamaged by insects and rodents, to enable him to obtain maxima prices from trading concerns. Increased agricultural production through local "Improved Farmers Schemes" immediately highlights the importance of storage to the farmer.

Losses to produce occur at the farmer level, the trader level and at the large collecting or storage centres operated by Government, quasi-Government or well-established commercial organizations. These losses are cumulative and of course vary in extent in different countries; a number of examples of such losses are given in *Table 1* and it can be seen from the selection recorded that gross wastage occurs.

It is in an atmosphere of growing realization in the tropics for the need for improved methods of storage that it is perhaps more than pertinent to consider the role of steel in the storage of produce. In doing so, it should not be forgotten that in some tropical countries, steel output has been increasing e.g. in India, Nigeria, Venezuela, Saudi Arabia and Colombia.

Table 1 — Examples of Storage Losses

Country	Produce	Loss tons	%	Total Crop (tons)	Level of Storage	Value of Loss US $	Cause	Bibliographic references
Congo	Maize	32,000	10	319,300	FTC		Desiccation	Buyckx, et al
Kinshasa		32,000		320,000			Insects and	1957 (Biblio. 1)
	Paddy	8,500	5	179,200			Rats	
				198,100				
	Groundnuts	27,000	15	187,400				
		26,000		175,300				
	Peas and Beans	6,900	10	69,800				
		7,600		76,170				
	Wheat	100	5	4,100				
		100		3,930				
	Other Cereals	2,000	5	40,100				
		2,000		37,420				
Germany	Cereals	255,000	2.5	10,200,000	FTC		Insect (weevil)	Cornwell, 1964 (Biblio. 2)
Ghana	Beans	6,000	19.4	31,000	FTC	1,000,000 or 2,500,000 (mean retail value)	Insect (Bruchidae)	Hayward, 1964 (Biblio. 3)
India	Paddy	152,160	1.5	10,144,000			Insects	Ghose et al 1960 (Biblio. 4)
	Milled rice	164,840		10,989,300	C		Insects	
Japan	Rice	350-400,000	7-8	5,000,000	FTC		Insects and other factors	Angladette 1959 (Biblio. 5)
	Milled rice	250,000	5	5,000,000	C		Insects	Angladette 1959 (Biblio. 5)
Mexico	Maize (for 1954)	225,000	5	4,500,000	FTC	10 million	Insects	Parkin, 1959 (Biblio. 6)
Nigeria	Cowpeas	20,000	10	200,000	T	2,232,000	Insects (Bruchidae)	Ezedinma, 1961 (Biblio. 7)
Northern Nigeria	Sorghum (for 1962)	115,000	4	2,875,000	FTC	7,334,910	Insects	Giles, 1964 (Biblio. 8)
Pakistan	Pulses	25,000-50,000	2.5-5	1,000,000	FTC		Insects (Bruchidae)	Hogue, et al 1964 (Biblio. 9)
Pakistan (East)	Wheat (imported)	192,386	30.4	632,850	C	19,238,600		Weitz-Hettelsater 1964 (Biblio. 10)
(Estimate for 1970)	Milled rice (imported)	92,660	18.7	544,850	C	12,509,100	Insects, rodent and moisture damage, pilferage and transit loss	
West Indies	Paddy	12	2.5	480	F	753	Insects	Hall, 1955 (Biblio. 11)

Key: F — Farmer Storage
T — Trader Storage
C — Central Storage Depots

General use of steel in storage

Steel is currently used in different types of storage which may be described as transit storage, general produce storage, special produce storage and silo storage. The relevant properties of steel are summarized in *Table 1*. It has not been possible to obtain statistics on the quantity of steel used (e. g. by British manufacturers) in relation to these different forms of storage and this is a serious gap in the wealth of steel statistics available. It would seem that the manufacturers of steel buildings are not always aware of the ultimate purpose to which the buildings are put; this is a contributory factor to the fairly extensive use of general purpose design buildings for the storage of produce.

Table 2 — Relevant properties of steel in relation to its use in storage structures

Factor	
Strength	Unrivalled strength/cost/weight ratio. Resists high pressures from floor-stored grain. Withstands accidental or malicious damage better than any other sheet materials. No other sheet metal gauge is as strong as steel. The superior strength and stiffness means that lighter gauges and wider spacing of supports can be specified. Used efficiently the strength-to-weight ratio allows for costs savings, structurally, in transportation and site erection and often permits lighter foundations. Reinforced concrete: steel is incorporated in the concrete partly because steel is equally strong in compression and tension, and also because both steel and concrete have practically the same coefficient of expansion. In the future, the high tensile advantages of the new compact annealing progress may be applied to sheet gauge steel.
Precision	Ideally suited to mass production techniques. Wide spans of roof can be covered without supporting pillars.
Durability and Corrosion	New developments in coating sheet steel have produced wall cladding of exceptionally high corrosion and weather resistance. The fabrication of new cladding profiles combined with the development of corrosion resistant finishes has lead to a wider adoption of steel sheet cladding in agriculture; commercial firms have developed a range of coatings which claim to provide hard wearing durable and corrosion resistant surfaces. The least (Biblio. 15) successful method of preventing corrosion is site painting (i.e. after contamination by salt etc.) over steel angles, bars and sheets, while prefabrication combined with adequate factory painting (using special tropical resistant paint) offers the most hope of success. Galvanised structures appear to be preferred to which a zinc coating has been applied (to each side) and a calcium plumbate primer for very corrosive conditions.
Economy	Steel is one of the most versatile and effective materials available to the designer today; design and sales services are said to be of a higher standard than for other materials. Steel sheet components are economic by repetition of manufacture, speed of erection and maintenance. Greater span buildings with steel (in which the perimeter wall length is reduced in relation to the floor area) result in reduction in cost per sq. m.
Maintenance	Steel, specially treated for on site brush painting. Corrosion resistance is stated to require virtually no maintenance.
Insulation	Steel cladding has a low 'U' value (total thermal conductivity of the structural unit in the thickness in which it is normally employed) but this can be improved by (a) Metal Fixing System with Insulation Board, (b) Sandwich Construction and (c) Sprayed Plastic Materials.

In erecting storage buildings there is an attempt at providing coverage for a given floor area to give protection from the elements, to make pilferage difficult, and to maintain reasonably equable conditions for men in which to work. Buildings often consist of steel framework on which there is steel sheet or other forms of cladding, including brick or concrete. The use of braced beam or portal construction has enabled the spanning of floor areas of up to about 43 m. and 60 m. respectively, thus avoiding the need for supporting stanchions within the floor areas. This increases the total storage capacity and avoids stacking and disinfestation problems. The permutations of length, span and height are almost endless, and there are also variations in design loadings for wind, earthquake, etc. and the loads imposed by claddings of different types. Such buildings frequently have permanent ventilation at eaves level (sometimes fitted with one inch square wire mesh) and extensive door areas as well as numerous ledges or angles.

In a number of instances buildings are stated to be designed specially for grain storage but such buildings do not have incorporated in the design, features which especially in the tropics are essential to the protection of produce viz. protection from fluctuations in temperature and moisture, infestation by insects and fouling by rodents. Special features incorporated are usually confined to a design which will accommodate the produce in bulk and facilitate its loading and unloading. Attention should be given to methods of controlling the physical and biological factors which cause deterioration in quality and complicate handling, but generally these are neglected.

One firm has indicated that some 60 per cent of its output of steel buildings is specifically for grain storage; another has stated that during 1965 some 3,500 tons of steel were used, of which 17 per cent was for the erection of warehouses for fertilizer, tobacco and sugar.

Although costs of warehouse storage vary considerably with design, size, constructional detail and the country in which erected, it would seem that steel structures for warehousing purposes can be erected for a minimum of about £2 per ton of produce stored (e.g. about £2.5 per square m. of covered area for steelwork—stanchions, rafters, purlins, bracings, eaves, beams—on a prepared foundation, plus about £1 per square m. of sheet steel and £9.75 per square m. of door area involved).

Silo storage of produce is an aspect of this subject which has received a considerable amount of special attention. Generally, such special units for the storage of produce in bulk consist of metal sheet cladding on steel supports (rolled steel joists and angles) about 50 per cent of the steel used forming the supporting structure. At present certain firms in Britain use some 500-1,000 tons of steel annually for silo construction. Design features have been based mainly on rectangular or circular patterns, using corrugated sheet steel for strength. The steel sheet used may be galvanized, vitreous enamel or paint finish. Variations in the steel thicknesses of walls are used according to the design and height (e. g. 10-16 gauge for silos up to 15 m. high) and the weight content of grain per ton of steel used appears to vary from about 25-70 tons. Metal silos of the panel type reduce transportation costs and enable erection on site usually by bolted construction. The use of mastics at the overlaps of panels and at bolt points was introduced in an attempt to provide improved weatherproofness and the possibility of achieving successful fumigation or a degree of airtightness. Costs of steel silo storage vary with design, capacities and country concerned but the capital outlay is probably in the order of £2-£15 per ton stored.

In some instances attempts have been made, by special attention to the design of the filling and outlet spouts and to using welded, in place of bolted, construction to attain airtightness and rely on the principle of hermetic storage to prevent the continued development of micro-organisms, moulds, and insects during the storage period. Unless all joints are welded and special attention is given to securing airtight seals on the loading and unloading hatches a sufficiently effective form of hermetic storage will not be achieved which is essential if produce with a moisture content in equilibrium with more than 65-70 per cent relative humidity is being stored.

The most stringent conditions of airtightness are required to prevent aerobic mould development since these types of organisms can survive in an atmosphere containing as little as 0.2 per cent of oxygen or if 0.05 per cent per day of oxygen enters the container. Insect life requires a concentration of 2 per cent oxygen and if the atmosphere is maintained at this level or lower, there will be little if any insect survival. With a moderate initial infestation this can be achieved if the entry of oxygen does not exceed 0.5 per cent by volume per day. In constructing a silo for gastightness (as distinct from airtightness) to enable an effective concentration of fumigant to be maintained for 24-72 hours, the leakage tolerance is greater.

It is interesting to record that in 1850, in France, Mr. Doyere successfully used steel lining for concrete underground silos to achieve airtightness; storage periods of up to five years were achieved. In the early 1870's above ground silos which were not airtight made the technique unpopular but in 1937, Mr. Blanc in France proved the efficiency of welded steel silos.

Temporary storage is possible in round silo units of welded steel mesh lined with loose curtains of hessian, plastic (including butyl rubber) or paper, preferably under some form of roof (e. g. inside a building); when not in use these units can be readily dismantled and rolled up.

Examples of use of steel in the tropics and problems

Statistics on steel consumption in the construction of warehouses, silos and ancillary equipment for the drying and movement of produce in the tropics have not been readily available. One can therefore only refer to a number of examples of the use in the tropics of steel structures for storage and to discuss the problems which have been encountered with a view to considering future developments.

Transit stores

In practically every overseas country, steel framed buildings are used for the receipt of produce and its temporary storage in bags prior to distribution either within a country or by exporting.

These stores usually are wide span buildings, sometimes with considerable areas of the roof through which light can enter, with a permanent gap at the eaves, rough texture walls, gaps round the doors, and drainage pipes adjacent to walls, all of which are undesirable features. Table 3 gives certain details of transit sheds built overseas in which the capital cost per cubic metre of storage space was £2.5-£3.5 when steel was utilized.

General produce warehouses

Warehouses for the storage of bag produce are similar in design to transit sheds. Steel frame buildings with walls of brick, concrete, asbestos, aluminium or galvanized sheeting, with roof of asbestos or galvanized sheeting and a concrete waterproofed floor are used. Commonly, the steel structure consists of cold rolled steel strips, sometimes made into girders or tubes (for strength) which are spot welded into trusses and column halves for assembly by bolting on the site. Erection times for steel buildings are stated to vary between 500 and 1,500 manhours exclusive of special sealing precautions.

In Central Africa, open sided steel frame buildings are used at up-country buying centres while steel frame buildings with either plastered brick walls or metal cladding are in common use by Produce Boards at main collecting points. These buildings are capable of holding up to about 200,000 bags of produce (e. g. 173 m. long by 30 m. wide). There are two designs of steel frame warehouses in use, one with a lattice type frame which for a given set of overall dimensions provides less storage space than the more recent solid frame design. Typically they consist of eleven portal frames (fabricated from reinforced steel joists) of 18 m. span spaced at 5.5 m. centres to give an overall length of 55 m. Without side cladding the erected cost of a 50,000 bag capacity warehouse (about 5,000 tons of produce) is approximately £ 8,000 (including about £3,000 for floor, concrete footings and drains). These steel portal frame buildings are stated to be at least 5 per cent cheaper per bag of storage, than a brick built shed. Additional examples of cost etc. are given in *Table 3*.

The design of these buildings is usually such that there is permanent ventilation, often of such a nature that sheet cladding is fixed permanently at an angle to the vertical at the floor level and mid-way up the walls to increase normal ventilation. Such design features make rodent proofing virtually impossible and insect control extremely difficult; in addition, buildings of this type are not only in use in the dry areas of the world but also in the wet or humid areas where produce in store is exposed to high humidity air. The reabsorption of moisture which takes place accelerates biological activity in the produce, especially in the outer layers of bags and results in deterioration and loss.

The temperature conditions inside steel clad buildings fluctuate more than those in buildings clad with a material which has insulating properties. In the hot dry areas where surface temperature is extremely high, produce stacked within 1.0 m. of the roof or close to the walls becomes hot; with canned produce, such high temperature is responsible for obvious disfigurement of the cans known as "blown," which due to local difficulties in establishing the biochemical changes which have or have not taken place within the cans, results in much of the canned produce on the outer surfaces of the stack, particularly on the top, being condemned.

In the tropics, insect pests are numerous and produce can become infested during storage as a result of insects flying into buildings from adjacent stores or vegetation. Since insects are particularly active during the times of the day when the temperature has dropped and the humidity has risen i. e. when man is not normally loading or unloading warehouse depots, all spaces through which insects could fly should be protected with fine gauze (of less than 5 mesh to the cm.).

Special bulk storage warehouses

Architects and consulting engineers have been responsible for the erection of a number of types of steel storage warehouses for produce in bulk. These are usually designed to handle the produce mechanically, and to maintain heaps of bulk produce at a particular temperature by ventilating the air space above the produce. In some instances, air circulation within the bulk of produce is considered to be necessary and this is effected by a system of steel ducting on the floor designed to distribute air evenly through the bulk of produce loaded over the ducts.

Although floor ducting techniques have been used in the temperate parts of the world for drying and cooling produce, in the tropics the system has been used mainly in paddy storage, to minimize it is claimed, problems of heating, by blowing ambient temperature air through the bulk.

Systems designed to ensure the storage of bulk produce without changes in temperature and humidity, are likely to be extremely costly and have not been fully developed. Until methods have been developed of im-

Table 3 — Unit Costs of Storage Buildings

	Transit sheds						Warehouses		
1. Place and Number Date	Barbados (Biblio. 2) 1960	Mombasa 1960	Mombasa 1961(4)	Port Swettenham (Biblio 3) 1961(5)	Port Swettenham 1963(5)	Lagos (Biblio 4) 1966(4)	Lagos 1961(4)	Lagos 1962(4)	Lagos (Biblio 2) 1966(4)
2. Framework	All Steel	R.C. frame Steel Trusses	R.C. Frame R.C. Trusses	All Steel	All Steel	Prestressed Concrete	All Steel	All Steel	Prestressed Concrete
3. Walls	Concrete Blocks	Concrete Blocks and Corrugated Steel	Concrete Blocks	Corrugated Steel	Corrugated Steel	Concrete Blocks	Concrete Blocks	Concrete Blocks	Concrete Blocks
4. Roof Cladding	Corrugated A.C. Sheeting	A.C. Trough and Watford Tiles	A.C. Watford Tiles	Corrugated Steel	Corrugated Steel	Corrugated A.C. sheeting	A.C. Trough	Corrugated A.C. sheeting	Corrugated A.C. sheeting
5. Cubic Capacity (cu. m.)	31,639 28,309	84,746	55,000	30,176 27,661 30,176	32,690	51,699	60,750	101,250	56,194
6. Net internal floor area (sq.m.) (1)	7,290	10,935	9,000	12,330	4,633	24,570	6,075	10,125	12,150
7. Inclusive cost (2) (in £stg.) per sq.m. of internal floor area (1)	£27.75	£33.0	£14.9	£13.0	£14.6	£22.8	£36.3	£33.6	£26.75
8. Cost (in £stg.) of building per cu.m. of useful storage space (3) excluding cost of foundations and floor	£2.7	£3.5	£2.2	£1.9	£2.2	£1.9	£2.6	£2.4	£2.0

(1) Excludes areas covered by canopies.
(2) Area costs are the actual finished costs and include foundations, floors, framework, walls, roof, canopies roof lights, natural ventilation, doors stormwater drainage and lighting protection, but not electric lighting nor internal offices.
(3) This is to eaves level and does NOT include roof space or space under canopies. The rate is therefore NOT the "estimators cube" used by architects and surveyors. The cube rate is for the building only and excludes the costs of foundations and floors.
(4) These buildings had piled foundations.
(5) Built on wharf deck and excludes cost of foundations and floor.

proving the sealing of sheet clad buildings and of achieving at low cost a lowering of the humidity of air it is unlikely that such systems of bulk storage will be extended beyond being used for the relatively expensive commodities of sugar and tobacco, to being used for lower cost produce such as maize, sorghum and paddy. One type of mechanical flat storage has steel walls and sloping galvanized corrugated sheet roof, some 42 m. long and 21 m. wide of storage capacity 2,625 tons and mechanical handling at 80 tons per hour by buckets and augers, with arrangements for aeration.

A larger type, some 169 m. long and 45 m. wide has steel roof trusses, corrugated asbestos roof sheeting, reinforced concrete retaining walls (4.8 m. high) and a concrete floor; the height from floor to apex is 31.5 m. and the produce is stored to a height of 24 m. The cost per sq. m. of floor areas was £44.6, that per cu. m. of gross volume was £2.4 and that per ton of produce stored was £148.75 (these costs exclude the conveyor tunnel and conveying machinery costs).

Silos

A range of sizes of conventional type metal silos, of bolted construction, are in use in many countries in the tropics. Agricultural Departments have encouraged the use of steel or aluminium silos of up to about 200 tons capacity on Farm Settlement schemes etc. These silos are formed of prefabricated galvanized sheets and usually are erected on a prepared concrete base. In some cases, as e.g. at certain Farm Schools in Togoland, the galvanized sheet steel is treated with aluminium paint.

These silos have given varying degrees of successful storage, depending on local factors. In some instances, the sealing of the silo on to the concrete plinth has been inadequate and water has seeped into the produce; also the concrete plinth has not been adequately waterproofed and water vapour from the damp concrete has permeated into the silo and been absorbed by the grain in contact with the floor of the silo. In other cases the produce has been infested with insects at the time the silo was loaded and because of the inability of the silo to hold a concentration of fumigant for a sufficiently long period to kill the insects the produce has become badly contaminated.

When fluctuations of ambient temperature occur, particularly during cool or cold periods in the tropics, in produce stored in a metal silo condensation takes place and in areas of produce, moulds are able to grow or the produce becomes so moist that the grains or kernels germinate.

Caswell and co-workers in the Nigerian Stored Products Research Institute (Biblio. 12) have compared, in Nigeria, the use of bins of about 14 tons capacity made of concrete block or steel. In these tests the steel bin had a gap between the wall and the roof which was absent in the concrete bin. After nine months the maize in the steel bin generally had lost 0.5 - 0.7 per cent moisture while that in the concrete had increased by 0.4 - 2.0 per cent. The steel bin (at about £12 per ton stored) cost 2.5 times the cost of the concrete stave bin, but it was assumed that with both types the depreciation would be comparable, the steel bin lasting 2.5 times longer than the concrete. What was clearly shown was that while the grain was purchased at about £18 per ton it was sold some eight months later at about £32 per ton which they state was a return on capital of about 13 per cent or about 17 per cent over a 12 month period.

There are a number of larger silo units, referred to as elevators, constructed of steel in the tropics (e.g. in Uganda and India). Each bolted steel silo may hold between 300 and 700 tons of produce (in units of diameter 6 - 7.5 m. and height 21 - 27 m.); usually the mechanical handling capacity is about 100 tons per hour with drying facilities of about 10 tons per hour. Such installations may have total storage capacities of 10,000 tons. In India, it is stated (Biblio. 13) that "steel elevators are costlier than wooden ones but cheaper than concrete bins. These do not however afford protection against spoilage due to seasonal variations in temperature etc. and therefore the current practice is to build durable and fire resistant elevators of reinforced concrete. These latter are costlier to build and require greater engineering skill but they do ensure the maintenance of grain quality for longer periods". This quotation may perhaps summarize the view held in many countries in the tropics with respect to large steel elevators.

Problems of condensation have undoubtedly occurred (the severity of which appear to depend on the moisture content of the produce) as have difficulties in obtaining a satisfactory seal between the roof and walls, particularly in circular silos. In silos of the larger size there are also difficulties in ensuring the adoption of a fumigation technique which will provide a 100 per cent kill of insect pests present in the produce. Overall adequate penetration of a gas in a 27 m. by 7.5 m. cylinder of grain can be affected by the existence of temperature gradients and severe convection currents due to differences in temperature between the metal sides of the bins and the grain; with certain fumigants this means that a circulatory fumigation system must be used. If no such system has been incorporated in the design of the silo, there is the problem of applying fumigants in liquid or tablet form to such a quantity of produce, especially if no facilities have been provided for treatment at the time of filling each silo unit.

In some parts of the tropics, which have been or are associated with France, above-ground welded/steel sheet silos which are hermetic are used, particularly for the preservation of dry grain from insect attack. It is interesting that such silos have not been used more extensively in the tropics since the principle of hermetic storage is worthy of much more attention than it has received in the past. This may have been due to the high cost of the welded form of construction or lack of facilities for on-site welding in the storage areas.

The future

In July 1966, an advisory commission of the U.N. Food and Agricultural Organisation stated that "The world is on the threshold of the worst famine in its history" and Professor Myrdal, the Swedish economist has said that "a future historian may place the beginning of the hunger crisis at a point in time already past."

The United States through its AID scheme is assisting a number of tropical countries by supplying grain silos and these are commonly of bolted steel construction, produced by certain American firms. Thus in June 1966 an agreement was signed involving the supply of two steel grain silos to Dahomey.

In the design of large silos for use in the tropics, consideration should always be given to the practicability of having a storage unit in place of the more expensive silo handling unit. There has been a tendency to consider silos as necessarily consisting of storage bins plus a considerable amount of expensive handling equipment such as driers, and a multiplicity of conveyors. The need for famine or marketing reserve stocks in areas of likely shortage has not been given sufficient attention in tropical countries. Much should be done in providing low capital cost long term storage, thus avoiding handling costs (e.g. transport, machinery operation) of rotating seasonal stocks.

With steel silos of large, medium and small size, consideration could usefully be given to the development of a new method of effecting a gas tight seal between sheets at bolt holes and between the walls, floor and roof. Experience suggests that mastics or semi-liquid sealants are not sufficiently practical and a new system which can be readily erected under local conditions with a minimum of loose parts etc. is required. Ideally such a system should not only impart a sufficient degree of gastightness to the steel structure as to ensure successful fumigation but should hermetically seal the container to prevent sufficient oxygen entering to support insect life, during the storage of dry produce. For safe hermetic storage of damp grain, in which the development of moulds has to be suppressed, a welded metal construction seems to be essential, concrete or bolted metal bins being insufficiently airtight. Hermetic storage of damp grain is not recommended for use in the tropics by the Storage Department of the Pest Infestation Laboratory in England (Hyde, Personal communication), not only because of the difficulty of obtaining an adequately airtight bin, but also because of the extremely short "shelf-life" of the product on exposure to the air, under tropical conditions.

Although there are little factual data from a range of tropical conditions, it is clear that in certain parts of the tropics condensation problems can be important in connection with the use of metal in silo storage. Thus, in view of the range of types of finishes which can be considered for steel sheeting, perhaps for overseas conditions more extensive use in silo construction should be made of sheets incorporating a suitable insulant. Produce has to be protected from fluctuations in temperature.

Equally, the ubiquitous nature of insect pests of stored products makes it essential that each silo installation whether it be a single bin or multi-bin unit should be so designed as to enable produce to be treated with liquid or dust contact insecticides or with fumigants in the liquid, solid or gaseous form. Depending on the size of silo bin under consideration, the type of pesticidal equipment attachments required and their position in the silo will vary.

Produce which is to be stored in warehouses either in bulk or in bags has to be protected from the same factors which cause deterioration viz. fluctuations in temperature, absorption of moisture, attack by moulds, insects, rodents and birds and of course the unlawful attention of man through pilferage. The provision of warehouses of general design is quite inappropriate to modern needs and buildings designed for the storage of produce must be:

(i) gastight to enable the entire contents to be fumigated,
(ii) provided with controllable ventilation,
(iii) free from ledges on which dust and produce residues can lodge,
(iv) proofed against entry of rodents and birds,
(v) capable of having a few fans incorporated in the walls and ducting on the floor, for special bulk storage requirements,
(vi) free from light transmitting areas in the roof to avoid areas of high temperature on top of stacks.

Produce storage warehouses must be capable of being operated in such a way as to ensure that ventilation occurs only when the humidity of the air is low (in relation to the fluctuations typical for the area) and that there is minimal ventilation where or when the humidity is high. The entry of insects must be prevented during the times of peak flight activity (usually between 6.00 a.m. - 8.00 a.m. and 3.00 p.m. - 8.00 p.m.) and the warehouse must be of such design that fumigation of the entire contents is possible during which an adequate concentration of gas is held within the building for 24 - 48 hours. Temperature gradients, particularly at the top of stacks of produce must be kept to a minimum either by not stacking within some 2.4 m. of a metal roof or preferably by incorporating in the design a false ceiling with ventilated air space outside the warehouse between the roof and the ceiling. It is surprising and somewhat discouraging that (to my knowledge) the designers of warehouses have not considered such features essential.

Attention has been drawn (Biblio. 14) to the possibilities of the use of braced space structures and the various forms of double and triple-layer grids developed in Europe with which large areas can be spanned. It is perhaps at present speculative to consider the future use of such steel structures for storage buildings to provide an insulated structure with air as the insulant within the steel lattice with walls which are smooth and gastight.

In the tropics, the use of hermetic storage for dry grain and perhaps for a wider range of dry produce than cereals, has a future and one would expect a range of methods of this type of storage to be developed. At present there are three practical systems. One of these is storage in welded steel silo bins, another is storage in specially proofed concrete containers and the third is storage in specially sealed plastic containers, which for technical and economic reasons are usually constructed below ground level; of these three, the steel structure is probably at least three or four times more expensive than the other two, but is the only one of the three which could be considered for the storage of damp grain.

The rate of deterioration of produce varies with the temperature of the storage conditions and it has been shown that lowering the temperature of the stored produce can reduce the development of insects (moulds and other micro-organisms) to extremely low levels. Excluding the field of refrigeration which is a separate study, there are obvious indications of the practicability of storing produce under conditions of cool storage (e.g. 10°C - 15°C) in which the use of steel ducting and sheeting can play an important part. Although it is obvious that this approach to safe storage is particularly pertinent for the temperate parts of the world, the usefulness of adapting this method for storage in parts of the tropics, which have periods of cool or even cold conditions should be explored. While in the temperate countries adequate chilling is being used to store wet grain (say between 14 per cent and 20 per cent moisture for cereals), in the tropics the first attempts perhaps should be for the storage of dry produce (under 14 per cent moisture for cereals) to minimize the development of insect infestation.

The protection of steel work in the tropics has been given considerable attention and a number of modern processes are claimed to be advances in this field (*Table 4*). Commercial organizations concerned with such problems have developed their own specific series of treatments to which steelwork is subjected. With respect to the problems posed from overseas countries, the relevant experiences of those who are active overseas in the building and engineering field require to be carefully analyzed to provide a basis for current recommendations. Abrasive resistance may be important in desert climates and saline resistance is of particualr importance in coastal areas which are subject to combinations of high temperature and humidity. With the exception of areas adjacent to stretches of calm water this can be critical within 0.4 km. of the coast.

The importance of giving attention to the corrosion resistant properties of steel perhaps cannot be over emphasized, but the industry should give equal attention to improving the design of buildings and silos in order to meet the needs of organizations which are concerned with the handling and storing of produce.

Table 4 — Anti corrosion treatments relevant to storage buildings in overseas areas according to proximity to sea and sources of chemical constituents in the area (as recommended by the British Building Research Station)

Surface	Severe (Areas in salt spray from surf shore e.g. up to 2 km, or to engine sheds and "chemical environments")	Moderate (Areas near sheltered water, town or industrial sites where corrosion noticeable but not drastic)	Mild (Inland areas where no cases of corrosion)
Steel	Over 8 km., or over 8.5 g./sq. m. per year	3-8 kms, or 2.8-8.5 gm./sq. m. per year	Less than 3 km., or less than 2.8 gm./sq. m. per year
Zinc	Over 0.8 km. or over 0.8 g./sq. m. per year	0.3-0.8 km, or 0.3-0.8 gm./sq. m. per year	Less than 0.3 km., or less than 0.3 gm./sq. m. per year
Heavy structural steel (Stanchions, girders, frames etc.)	Aluminium sprayed + moderate etch. primer + micaceous iron oxide or aluminium paint. Heavy duty bitumen or coal-tar or coal-tar pitch/epoxy and wrapping	Aluminium sprayed, with or without paint. Zinc sprayed, with paint suitable for zinc. Heavy duty bitumen, coal-tar or coal-tar pitch/epoxy (less thickness needed). Zinc rich paint.	Red lead or metallic lead primer plus micaceous iron oxide or aluminium or gloss paint. Zinc rich paint
Light structural steel (trusses, purlins, braces etc.)	As above	As above Galvanized and painted with paint suitable for zinc. Wrapped with anti-corrosive paste and tape	As above. Galvanized with or without painting with paint suitable for zinc.
Sheet steel (cladding roofs, machinery covers etc.)	Replace by plastic sheet or asbestos P.V.C. coating butimen coatings (factory applied)	P.V.C. coatings Galvanized and painted, with paint suitable for zinc. Bitumen coated.	P.V.C. coated Galvanized, with or without paint suitable for zinc. Red lead or metallic lead or metallic lead primer, plus u/ct plus gloss. Zinc chromate primer (2 coats) + u/ct, + gloss.

This paper may do no more than create a stimulus or act as a catalyst for thought on these lines. Perhaps following the thought there will be action and we are approaching a new era in the design of buildings for the storage of produce in bulk and bags in the tropics.

What is harvested by man must be stored safely and from what has been said in this paper I trust it is clear that while steel is being used for storing produce in the tropics the use of steel can and must play a more purposeful role.

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Delegates' Papers and Comments

Michel DUBOIS

Ingénieur Conseil
Paris

The Storage of Cocoa Beans

(Translated from French)

Previously it was generally agreed that cocoa was impossible to store for more than very brief periods in tropical countries, where high humidity encourages mould and multiplication of insects. The arrangement of storing it in bags or in sheds and relying on the generous use of insecticides is not adequate to keep the product properly and moreover these methods require too much space and handling. Under certain conditions airtight metal silos might be the answer. They preserve the beans from all contact with the surrounding atmosphere, whereas concrete silos are porous so that calcium acetate develops easily from the action of the acetic acid in the beans.

It will be necessary:

(1) to run the beans down into the silos by an auger, so that they would not break;

(2) to re-dry the beans before storage in order to reduce their moisture content to 8%;

(3) to have the silo adjacent to a carbon-dioxide or air-gas plant so as

  (a) to kill the insects, since the graded bean during fermentation did not naturally exude CO_2,

  (b) to keep the moisture content at 8% by injecting dry gas,

  (c) to inject the gas at a low temperature (less than 10°C), in order to prevent the growth of cryptogams by eliminating the whole matter of relative humidity and the dew point,

  (d) to blend and inject suitable preservative gases, such as ethylene oxide, which could serve instead of methyl bromide for getting rid of insects,

(4) to give the silo a heat-proof lining in the event of its not being possible to use cool enough gas.

Only airtight, i.e. steel silos would meet all these requirements. Moreover they were the only kind that could be supplied ready prefabricated—an important point in countries which often did not possess the necessary assembly or manufacturing equipment. They had the further advantage of being light in weight, so that they could well be installed in harbour areas where the soil tended to be spongy.

Alphonse ALS

Directeur de la Société A. Als & Cie
Bruxelles

(Translated from French)

Grab-dredgers for well-digging

If one reads the pages in the "Official Gazette of the European Communities" on the work of the Directorate-General for Overseas Development, it soon becomes apparent that a high priority is attached to well-digging for drinking water and irrigation supplies.

In developing countries, such operations are often difficult, slow and dangerous if modern drilling equipment is not available. But to suggest to developing countries that they should use modern drilling equipment is asking them to take on a financial burden often beyond their means. But there exists a piece of machinery with revolutionary characteristics from the point of view of cost, efficiency, durability and adaptability. A Belgian company holds the exclusive manufacturing licence for countries covered by Working Party No. 4 for a reasonably priced impact grab-dredger. This works by using a system of levers similar to lazy tongs and there are no springs and cables to go wrong, so often the weak points in former grabs. The new type of grab can therefore be considered foolproof. As the grab works by impact it has the great advantage of being adaptable to most existing drilling equipment now on the market, and it can also be used by wheeled or tracked cranes found on building sites throughout the world. The grab has other useful advantages in that it can be used for digging foundations for buildings, bridges and harbour walls in many types of difficult geological formations. It can easily bore wells in stony ground, through gravel, clay, schistes, fissured rock and marl. In rocky soil it will cover 1.5 m. an hour whilst in clay it can excavate between 18 to 20 m. in the same time.

The control mechanism can easily be locked so as to leave the grabs open, so that, when the working conditions are awkward, the grab can be used as a boring-bit. But if the ground or rock is very hard, the grab is used solely to remove broken rock and a true boring bit carries out the drilling. The grab can be worked efficiently in moving sands and water-filled gravel pits since when it is raised out of the water or mud, the matter contained in it does not escape. Emptying takes place by the use of a circular ring hanging from the crane or the drilling frame.

The same Belgian firm makes advanced rotary grabs for use when the well-excavator has suitable machinery available (in the wide range of machinery using Kelly bars). What strikes experienced well-diggers most is the reasonable price of these grabs (a few thousand dollars) when compared with the cost of drilling equipment (several hundreds of thousands of dollars) which are often immobilized by the use of badly designed or overcomplicated grabs.

Water towers, irrigation

It is surprising to note that amongst the subjects put forward for discussion by those taking part, Working Party IV decided that questions relating to water-towers and irrigation should be dealt with by Working Party I although these questions are of primary importance to developing countries.

During journeys through countries belonging to the British Commonwealth—whatever their latitude—one is struck by the widespread use (especially in India and Africa) of equipment ingeniously conceived and extremely well-suited to the need of new nations: sectional reservoirs made from dished plates and water-towers made from standardized components and assembled by bolting together. As the heaviest components weigh less than 100 kg. no transport problems arise whatever type of communications have to be used before the assembly point is reached.

It is odd that this type of easy to assemble and competitively priced water-tower is hardly found in French-speaking African republics, with the exception of Congo-Kinshasa where they are very numerous. This geographically unbalanced distribution of the water-towers is due partly to the fact that they were invented by a British firm, which has sold them for decades. They can be assembled, taken down, enlarged or subdivided by using a very simple tool, a spanner. The purchaser has therefore no need for the skilled labour-force and special assembly equipment required for welded, riveted or reinforced concrete water towers. One would think that such attractive water-towers would be found throughout our countrysides and that local authorities would encourage their use for rural drinking water supplies where there are still many gaps to be filled, especially as this would keep down capital investment costs at a time of budgetary restrictions. But a human element seems to prevent their introduction: the whole idea is so easy to assemble and so cheap that the experts would be put out of business by its use.

Jean-Charles PONCHON

Directeur à CEFILAC, division "Matériels spéciaux"
Paris

The Permanent Magnet as a Means of Improving Tropical Agricultural Produce by Removing Metal Waste

(Translated from French)

Some fifteen years ago, the term "permanent magnet" was considered more or less synonymous with "dressmaker's magnet." Today we all instal magnetic door catches, attach magnetic cigarette cases to our car dashboards, or use a telephone or office note pad with a magnetic pen.

But still the same adjective! It recently gushed from the traditional smashed bottle of champagne; "France, the magnetic liner," we read in the press when this transatlantic liner was launched. The expression is picturesque but accurate, for there are some 53,000 permanent magnets on board the liner "France."

Magnetism is in the news, and it is a great temptation for the technician to harness this invisible force. What could be easier, indeed, than to buy a magnet whenever scrap metal has to be removed from a sack of maize or groundnuts, or a lump of sheet metal retrieved. But what disappointments lie in store when the magnet is put into use! The engineer will soon conclude that industry is not the place for the permanent magnet and that it is essentially a household article. However, this is not so. Magnetism in industry is a technique in which improvisation has no part. That is why the user would be well advised to consult specialists on the subject. These specialists supply industry—every industry—with magnetic equipment able to deal with all types of problem relating to magnetic separation and handling.

Before examining in more detail certain applications of magnetism in industry, let us first briefly consider the two traditional methods of obtaining powerful magnetic fields:

(a) The principle of electromagnetism involves the passing of an electric current through a conductor wound around a soft iron core. Apart from a very few specialized applications, direct current is used, and little progress has been made for many years.

(b) The use of permanent magnetic materials, in which field technological progress has been great. The most commonly used alloys are Ticonal and the Ferrites. The magnetization so obtained is really permanent particularly if the alloy is incorporated in a well-designed magnetic circuit.

Two separate ranges of equipment apply to these two possible techniques, but we shall here consider only that using permanent magnets. This technique has numerous advantages, the greatest of which is undoubtedly the elimination of the need for an electric current. There are countless possible industrial applications and it is beyond the scope of this paper to list them all. A book would barely be sufficient.

(a) Purification of any crushed, powdered, liquid or paste product (foundry sand, blast cleaning abrasives, warf, glassworks cullet, granulated sugar, grain before and after milling, fertilizers, slip for china and porcelain, pigments, inks, machine tool coolants, etc.). It may appear surprising that iron is such an industrial parasite, but this is an apt description for the stray metal and scrap (bolts, elevator screws, scraps of wire, etc.) which finds its way into bulk goods during transport and which causes accidents or stoppages of work on the processing machinery. Any form of crushing is in itself a source of fine particles which must at all costs be removed in, for example, the food or animal feedstuff industries.
(b) Handling, at any angle up to 90°, of tin cans and blanks of various kinds (the discharge side of presses for example), easy lifting of sheet metal, sections and tubes conveyed automatically by magnetic rollers or rolls.
You have probably noticed that for industrial applications we do not speak of magnets, but of magnetic equipment using permanent magnets. This is not merely a subtlety of expression, but indicates a technical fact, as is shown below.

From the magnet to magnetic equipment

There are many disappointed users of open magnets. They buy a number of large magnets and mount them on a shaft or some other support. This sounds a simple operation, but it generally results in a power loss of about 30 per cent, with high leakage due to incorrect installation. This is regrettable, but we should not be too critical. Everyone to his own trade, as the old saying goes. After some time, this collection of magnets appears to lose its power. What is actually happening can be explained very briefly: cleaning an open magnet of the impurities adhering to it is sufficient to reduce its power. It is true that the loss is very small at each cleaning or handling operation, but the effect is cumulative and gradually makes itself felt. The result is a wasted investment.
In contrast to this outdated and unsatisfactory assembly of open magnets, what are the properties of efficient magnetic equipment designed for a specific purpose, with due allowance for technical exigencies? Firstly, magnetic equipment is constructed with non-magnetized magnets. They are not magnetized until mechanical assembly is complete, i. e. after the magnetic circuit has been established by the assembly of the magnets and pole pieces. This technique allows the magnets to operate at the optimum point of their hysteresis loop, and maximum efficiency is thereby obtained. In magnetic equipment, the magnets never operate by direct contact, and accordingly most of the factors which reduce the power and permanent life of a magnetic field are eliminated.

Some examples of applications

A consequence of the increasing mechanization of agricultural techniques (methods of cultivation, spreading of fertilizers and soil nutrients, sowing, harvesting and various handling operations) is the occurence of pieces of metal which cause wear and tear on implements or impair the quality of the produce sold. I propose to show how sifting and screening equipment provided with permanent magnets can eliminate this stray metal.
Pieces of metal (bolts, screws, etc.) which find their way into tropical agricultural produce such as coffee, cacao or groundnuts are traditionally removed at some stage during handling operations, generally before the produce enters the crushers. If there is only an occasional piece of metal to be removed, protection will be provided by a magnetic plate which may be fitted to the crusher feed table or placed below one of the feeders. This is a unit containing permanent magnets which have been carefully designed for sifting purposes. Pole pieces distribute the magnetic fields evenly along the magnetic plate. The produce to be sifted flows over the magnetic surface, the metal adheres to it and merely has to be cleaned off from time to time.
If large quantities of metal are present, or if the throughput is high, a single magnetic plate is not sufficient, since the frequency with which it would have to be cleaned would render continuous industrial operation impossible. This generally arises with belt, chain or bucket conveyors. So let us now examine the equipment to be used in such cases. A magnetic pulley mounted at the head of a conveyor belt is excellent for removing stray metal from produce handled in bulk, such as unshelled ground-nuts. Installation apart, this is un-

doubtedly the method we would recommend. Experience has shown—and satisfied users have confirmed—that magnetic pulleys with permanent magnets provide the perfect answer (used alone) for this type of magnetic purification.

Even with bulk produce of medium size such as coffee or cacao beans, it is often desirable to eliminate the maximum possible amount of metal impurities, however small (for example, broken pieces of wire). That is why we draw attention to the magnetic drum with rotating casing consisting of a half-round fixed magnetic element about which rotates a stainless steel casing.

When mounted below the discharge point of a conveyor belt or any other distributing equipment (screens, shaking tables, vibrating feeders) a magnetic drum acts on an "aerated" product, and this facilitates the removal of small ferromagnetic particles. The impact of the product on the drum casing is also a factor which undoubtedly helps to secure optimum separation.

It is also possible to use overbands, *i.e.* separators mounted above the moving product, to eliminate stray metal. These operate under far from optimum conditions. Because of the vibration of the conveyor, the metal scrap tends to collect in the lower half of the stream of material. Therefore, if it is to adhere to the overband, it must pass through all or part of the stream and also defy gravity. For this reason very powerful equipment is used, but it is still unable to eliminate small pieces of metal. You are, I am sure, familiar with the basic law of magnetism which may be summarized as follows: the efficiency of a magnetic material is inversely proportional to the square of the distance between the magnetic surface and the respective piece of metal. In any case it is not sufficient to evaluate the absolute power of magnetic equipment, but its relative power as a function of the scrap metal to be removed must be determined. Each piece of metal, depending on its mass, absorbs a given quantity of flux. In other words, it is often easier to remove a large piece of metal than fine filings. These facts alone indicate that the pulley and magnetic drum are to be preferred to the overband.

At the start of this paper, it has been said that stray metal was a real industrial parasite. Perhaps you thought that this expression was merely chosen to back up my argument, but it is in fact an apt description, as the following anecdote will show:

About two years ago the Paris offices of a large ground-nut oil mill in Senegal informed us that its plant was about to be shut down: stray metal had increased fantastically following a rise in sisal prices! One result of this rise in price was the substitution of wire for sisal binder twine on the ground-nut sacks. When the sacks arrived, most of this wire fell into the ground-nuts, and the result was serious damage to the oil-extraction presses. Moreover, as you know, the residue from the presses (*i.e.* the ground-nuts after the oil has been extracted) is made into cattle cake. Broken pieces of wire found their way into the cake, and the company concerned had received claims for compensation following the death of several cows fed on this cake. You can imagine the disaster this represented for a company with a very well-known trade mark.

The end of the story is that magnetic drums mounted on the ground-nut circuits solved the problem most efficiently after a visit from an engineer who was able to decide on the most appropriate sites for them. This is a very oversimplified example, but the daily problems of magnetic sifting are just as important, although fortunately they are generally a matter of less urgency.

Another advantageous application for permanent magnet separators is found in the textile industry and, incidentally in connection with cotton, a fact that allows us to keep to tropical agricultural products. After being picked, cotton is baled and sent to textile factories. In it is found the normal stray metal picked up during bulk transport, in this case generally prior to baling, not to mention the scrap metal which may contaminate the cotton after it arrives in the factory. For example, it is quite common to find beer-bottle and other caps. Breaking and carding are early stages in cotton processing. If the cotton contains stray metal, the result may well be a shower of sparks in a beater or breaker. The cotton dust floating in the air in the breaker is particularly inflammable. Further, metal card clothing is fragile and frequently damaged by stray metal. Cotton is often carried in pneumatic conveyors where scrap metal can easily cause a fire. Magnetic plates mounted as baffles on bent steel plates retain the metal on the conveyor. Such metal plates do not cause a significant pressure loss.

From screening to magnetic purification

You may have noticed that the equipment described so far has primarily been designed to eliminate fairly large pieces of metal, and, as I mentioned, it is easier to retain a bolt than metal filings. Yet fine metal particles still have to be removed. This is no longer called magnetic sifting, screening or separation, but magnetic purification. How can it be done?

Theoretically, the force exerted on a homogeneous particle of small size in a non-uniform field depends on four factors:

(a) the field existing at the level of the particle;

(b) the field gradient, which characterizes the non-uniformity of the field, and determines the direction in which the particle moves. It helps to provide as turbulent a field as possible either by the appropriate arrangement of the fields used or by the movement of the product;

(c) the magnetic susceptibility of the particles. Only rarely do particles to be removed consist of the pure iron so highly susceptible to the magnet. More frequently are they salts or oxides of varying permeability, all coming under the general heading of "rust";

(d) the mass of the particles: under identical conditions a large particle will be subjected to a greater force of attraction than a small one.

Apart from these theoretical factors, there are others which are of significance in practice. Let us examine them briefly

Firstly, the physical state of the product: liquid or powder. If the latter, grain size is of primary importance. The force counteracting the movement of a particle surrounded by powder results from friction with the grains of the product, and this friction in turn depends on the number of grains with which it comes into contact. Sizing by screening is therefore useful but rarely possible for users. The tendency for the product to agglomerate or coalesce obviously increases these frictional forces and impedes separation. The particles may also have grains of the product adhering to or surrounding them, particularly in the case of soft crushed products and liquids.

Secondly, the throughput required by the production cycle. This is never proportional to the degree of contamination. Throughputs of 300 kg./hour with 10% contamination are as likely as throughputs of 10 tons/hour with 1% contamination. Different equipment would be required in each case.

Thirdly, the user's objective. He often tends to demand 100% purification when this degree is not really justified. The price of the equipment, its size and the financial aspect of the purification process must also be considered. As one might suppose, the final percentages of purification are extremely costly. The problem is worse than the proverbial needle in a haystack, since magnetic purification involves chips, filings and similar particles! Any crushing operation involves the detachment of numerous fine metal particles. Since you will agree that it is not very pleasant to eat chocolate or drink coffee "flavoured" with iron, we shall examine equipment to overcome this drawback. We are thinking here primarily of food products, but the same problems are encountered in all industries (chemicals, plastics, pigments, enamels, ceramics, etc.).

Powdered products

The simplest equipment consists of a magnetic grid. This is a collection of magnetic bars assembled parallel to one another. Each of the stainless steel magnetic tubes holds a group of Ticonal permanent magnets and suitable pole faces. The magnetic tubes in such a grid are mounted so that their magnetic fields are interlaced to form a network of lines of force. Some magnetic grids have a second tier of magnetic tubes staggered in relation to the first tier. This provides an additional magnetic network overlapping the first.

These magnetic grids function reliably and permanently, unaffected by damp atmospheres or high temperatures. No electrical connections are required. The only maintenance needed is very simple periodical cleaning (with rags or compressed air). For products which tend to pile up, similar equipment is available which may be briefly described as a rotating magnetic grid.

To reduce periodical cleaning operations to a minimum, magnetic purification installations are sometimes designed as follows:

(a) Material is discharged into a magnetic drum with a rotating casing (as described previously and which, as you will remember, has a fixed magnetic element around which rotates a stainless steel casing) by means of a vibrating feeder, for example, in such a way that a stream of the substance flows over the drum. This equipment removes ferrous impurities automatically and continuously. Nothing needs to be done by hand.

(b) One or more magnetic grids are mounted below the magnetic drum to provide optimum purification. In this case, cleaning is only required at infrequent intervals, which is quite compatible with normal industrial operation.

Liquid or paste products

The magnetic vessel is commonly used in food industries (melted chocolate for example). It is a stainless steel container inside which are mounted magnetic bars. What is its operating principle?
Magnetic tubes integral with the cover are arranged in an arc. The shape of the magnetic fields in any one tube and the arrangement of the magnetic fields of two adjacent tubes are such that the unit forms a very dense magnetic network through which the fluid to be treated must flow. The magnetized particles are thus attracted and held against the magnetic tubes. The fields are arranged so that the particles can move freely round the magnetic tubes to shelter from the flow of liquid or paste which might otherwise carry them with it. The sealing system (a star supported on a neck in the vessel and fixed to the cover by a locking screw) allows the magnetic element to be dismantled easily and rapidly for cleaning. If the degree of contamination of the product makes frequent cleaning necessary, two magnetic vessels can easily be installed in parallel with a by-pass arrangement.
There are also automatic separators such as magnetic rollers equipped with scrapers or sealed magnetic drums. I mention them in passing only, as I wish to give examples of applications rather than a catalogue of equipment. Engineers specializing in magnetic separation and purification are available either to select the correct equipment for the particular problem, or to design new types.

Conclusions

At the start of this paper we mentioned the two traditional methods of obtaining powerful magnetic fields: firstly, by means of an electric current passing through a conductor wound round a soft iron core, known as electromagnetism, and secondly, by using special steel alloys (Ticonal or Ferrite) which are permanent magnets.
Comparisons are sometimes drawn between installations designed on the basis of these techniques. What objective conclusions can be drawn from such comparison?
(a) Although the ancillary installation costs (mountings, drive, etc.) are about the same in both cases, there are other costs incurred only with electromagnetic equipment: direct-current supply (special cables, rectifier); power consumption which, although not very high, has to be taken into account; maintenance costs (rewinding coils, renewing carbon brushes) which are high in themselves and are increased by the stoppage of work involved.
(b) With equipment based on permanent magnets, no maintenance or inspection costs are incurred. The permanence of their magnetic properties can be reliably guaranteed almost indefinitely. In view of what has been said above, it is clear that this guarantee only applies to efficiently designed permanent magnet equipment and not to open magnets with the same metallurgical components as those of the magnets used in magnetic circuits.
The comparison undoubtedly works out in favour of permanent magnet equipment with the exception of very large plants such as those used in mines (particularly for the beneficiation of ores) or for moving salvage scrap in bulk.
For ordinary industrial purposes, what conclusions would the financier and the engineer reach in view of the investment costs involved in purchasing permanent magnet equipment? They would agree that
(a) such equipment makes a direct contribution towards hourly production capacity while not requiring a special file to be opened in the maintenance department;
(b) it has a clear effect on the quality of the products sold;
(c) no skilled labour is required to operate it.
Capital investment? It is rather a kind of insurance policy to guarantee very long-term productivity and quality, the "premium" only being paid once.

Robert B. BANGS

Senior Industrial Economist U-S. Department of Commerce
Washington

Export Expansion by the Emerging Countries

Our purpose in this meeting, as I understand it, is to discuss, in a realistic and constructive spirit, the prospects for expanding trade among the less and the more industrialized nations of the world, with particular reference to steel products and products of agricultural origin. My purpose in this paper is merely to suggest a few starting points and a possible frame of reference for this discussion.

In their search for critical paths toward accelerated development, the emerging countries face many individual and peculiarly difficult problems; but one they all share is the need to expand export earnings as rapidly as possible. Successful implementation of a development programm calls for a gross expansion in imports of capital equipment, and often some rise in imports of foodstuffs and other consumer goods as well, unless aggressive fiscal and other measures are taken to limit consumer spending.

The bulk of capital requirements for development, which are enormous, must be mobilized internally. Major expansions in foreign aid flows are unlikely for the foreseeable future and private capital is limited by the good investment opportunities now available within the well developed countries. Thus an emerging country must raise very large amounts of capital in local currency by either voluntary or induced saving and smaller but still large amounts of capital in foreign currency by expanded exports of goods and services.

The emerging countries, except those few that are blessed with abundant minerals and fuels, are exporters primarily of products of agricultural origin, often tropical products. Demand for these products is normally only moderately elastic, so that shipping larger quantities at lower prices earns only a little more than shipping smaller quantities at higher prices. One escape from the dilemma has been sought in international commodity control schemes—which seek to limit shipments and to stabilize prices; but these agreements are difficult to reach and to maintain and are sometimes opposed by the consuming countries. If effective in maintaining prices consistently at a profitable level, these agreements also accelerate the search for substitutes, synthetic or otherwise.

Diversification of exports

The long-run solution for the emerging countries is clearly diversification of exports; but this is inevitably a slow process. It is often considered an easier development strategy to start new industries to replace imports, even at much higher cost, than to invest in better export performance. I have repeatedly been impressed, when studying the development plans of many emerging countries, with how little investment is contemplated by many of these countries in the already established exporting industries.

I submit that this neglect of already established exporting trades is often a mistake, or a misjudgment of proper investment priorities, and that emerging countries would usually be well advised to give greater priority to improving those industries which have already demonstrated comparative advantage in the world economy.

The kinds of investments likely to have high ratios of benefit to cost in these established trades are in quality improvement, in assembly, storage, and marketing methods, and in more extended processing of commodities now exported in relatively crude form. Because these investments build on an existing base, they often require only modest amounts of capital for fairly impressive results, which can also be realized quickly.

Many emerging countries that ship raw materials such as rice, rubber, coffee, furs, and jute abroad have excessive costs and product losses throughout the assembly, warehousing, grading and shipping processes attending these commodities. Quality control is often deficient so that premium prices are lost. Packing for export is frequently poor so that losses in transit and on arrival are higher than they should be.

Both the capital and the technical assistance necessary to correct these problems can be secured fairly easily, sometimes with the assistance of the consuming countries. I suggest to you that emerging countries in virtually all cases would be well repaid if they gave closer consideration to the high potential yield from relatively small investments in improving the quality of their exports.

Improved value to weight ratio of exports

A good beginning on export diversification can often be made by adding one or more processing steps to the materials before they are shipped internationally. This improves the value to weight ratio, saves some shipping costs, and creates some employment at better than average productivity and good wage rates within the exporting country. The processing I have in mind would include such operations as spinning cotton into yarn, fabricating jute into bags, converting tea and coffee into instant products, and the like. Concentrating mineral ores, and processing logs into finished lumber and plywood, are other examples applicable to non-agricultural exports.

My point is simply that manufacturing operations based on known local materials and already partially established export markets, which operations strive primarily to add value to traditional export products, are apt to be both more quickly and more spectacularly productive than the building of entire new industries. I believe careful study of the feasibility of investments in upgrading exports will demonstrate this fact and I urge development planners in emerging countries to consider these possbilities closely.

To invest in improving quality and in adding value to established export products does not mean that other efforts to diversify productive activity within an emerging country should not also receive attention. Development planners always face a dilemma about whether to concentrate investment in a few industries and areas, thus maximizing the near term gain, or to disperse it more widely, thus bringing the entire nation ahead but at a slower pace. A program properly balanced between industry and agriculture, with investment in the former highly concentrated and in the latter widely dispersed, can help to resolve this dilemma.

Traditional patterns of agriculture must be modified from the very beginning of the development sequence by the introduction of new crops, new methods of seeding, cultivating, and harvesting, and new channels of trade. This process of restructuring agriculture is slow and tedious, limited as it is both by the conservatism of those who live close to subsistence on the land and by the need to build agricultural extension organizations that can reach farmers in small groups in their own localities.

Nevertheless, a marked gain in agricultural productivity is a necessary preliminary to and concomitant of any successful program of industrialization, as the experience of any country that has passed the take off into self-sustaining growth will testify.

Expansion of industrial base

To improve agriculture and to raise the quality and degree of processing of agricultural exports does not mean that an emerging country is destined to remain indefinitely agricultural, or that it cannot simultaneously expand its industrial base. The export processing operations I have mentioned are a type of manufacturing activity, while the transporting, storing,grading and packing operations are industrial services which are vital to any other expansion of manufacturing for the home market.

Improving the productive process at any point spreads both forward and backward in the chain from primary producer to ultimate consumer, as well as laterally to related or complementary activities. Raising farm yields helps get better roads, which in turn aids in the distribution of manufactured goods and the improvement in services. Development, as we all know, is an intricately interconnected process in which an improvement anywhere creates opportunities and incentives for productivity gains elsewhere.

Since this conference is devoted primarily to the use of steel in agriculture, you are naturally concerned with what improvements in agricultural productivity within the emerging countries can mean in terms of these countries' imports of steel products. In my opinion, use of steel in agriculture will increase only a little, but use of steel in infrastructure may expand greatly if the efforts to raise agricultural productivity are successful. It is this gain which frees the resources for the major expansion in investment that is necessary.

The needed agricultural improvements in the emerging countries are primarily changes in organization and methods, and in inputs of fertilizer and other materials, rather than the application of mechanization which would use steel in larger quantities.

Despite land reform in a few countries, there is no observable trend in the developing countries toward larger farm units except in the communist countries where collective methods are being forcibly imposed by the State. Improvement in agricultural methods will mean such obvious things as replacement of wooden plows with steel ones and more steel tubing for wells and irrigation systems; but no dramatic burgeoning of demand for steel within the agricultural sectors in emerging countries. Products made from steel and used in agriculture such as pumps, small tractors and simple implements will experience a steady but basically unspectacular growth in demand. The big increase in demand for steel products is a result of investment in economic overhead such as a better transport net, power and water supply projects, and the eventual building of factories; but these investments cannot be financed and manned without the improvement of agriculture.

If I appear to stress growth of agricultural productivity unduly, it is because virtually all students of the development process agree that this is vital to successful industrialization. It is only by the accumulation of capital out of agriculture and the transfer of labor away from agriculture that an industrial base can be built. In building this base a most vital factor is adapting advanced technology to the peculiar combination of scarce and abundant resources which an emerging country possesses. This is a job primarily for local entrepreneurs, aided by both capital and intellectual assistance from the state and from friendly foreign sources.

As a foreign advisor I have participated in the development planning and financing processes in five emerging countries. Each country had to face a different constellation of problems and individual limitations on the rate of progress it could achieve. Yet in every case had earlier and more sustained attention been given to export expansion, I believe the short-range results would have been better and the longer range financial problems less stubbornly intractable.

Investment plans

Because export earnings from agricultural products do fluctuate considerably, there is a need to adapt investment schedules in an emerging country to the average experience and not to speed them up and slow them down as export earnings rise and fall. Plans must be ambitions to accommodate national aspirations and to generate enthusiasm for change; but they should not be contingent on financial resources that may evaporate. To vary investment with every change in export accomplishment means to strain resources unnecessarily and to waste capital because forecasts are not realized. It is usually better to accept fairly broad swings in foreign exchange reserves and to offset these swings when necessary by compensating financial measures.

State marketing board arrangements for principal export products and progressive export taxes are sometimes used to divert profits from a rise in export demand to the state and away from the producers. In my opinion both these techniques, although temporarily useful, are in the long run almost invariably deleterious to export performance. Stiff profits or gross receipts taxes, with incentives to reinvest in future export improvement, would, I think, ordinarily be much better.

The use of steel

In upgrading the quality and presentation of traditional agricultural exports, minor quantities of steel products may be employed with good effect. I refer to such products as strapping, standardized containers, and the like as well as to weather and pest proof storage facilities. These activities as they grow serve to expand demand for light steel products somewhat but not by large amounts.

If one or more processing steps can be added to exports prior to shipment, usage of steel will rise materially. Such processing requires machinery, new construction, and often better transport facilities in order to be effective. Its expansion creates new demands for power, for repair and maintenance services, and for industrial materials such as chemicals and fuels. Demand for steel in these affiliated activities will rise moderately.

Practically all the machinery and equipment necessary for a pre-export processing step on some agricultural food or fiber must be imported in the first instance into an emerging country. This may include the packages or containers for the partially fabricated product to be shipped. Rarely is it economic for an emerging country to consider supplying its own packages and containers until industrialization has gone much farther than it has in most countries that are just getting started.

In suggesting as I do that initial steps toward building a manufacturing sector might be oriented more toward export processing than toward replacing simple imported consumer goods in the home market, I am aware that the latter course often is easier in the short run. It is simple to wall off the home market by tariff barriers and other import restrictions, and thus to guarantee a market for manufactured goods of local origin even if they are of poor quality and high cost. Many countries have done this to their ultimate regret.

When exports are processed, the competitive test of world market acceptance must be faced from the beginning. Therefore, careful market surveys and cost calculations should precede any substantial investment in this type of processing; but where these studies do show an opportunity for profitable investment, this opportunity is likely to become both broader and deeper as world trade expands and as growth in customer countries continues.

There are some financial concessions a government can employ to assist the establishment of processing operations in a predominantly agricultural country. Temporary tax exemption or partial tax remission is one of these. Properly differentiated export duties on fabricated and unfabricated material is another.

This latter technique is dangerous, however, since export duties can seldom be shifted forward to the purchaser except temporarily during periods of buoyant demand. For the most part analysts agree these duties rest mainly on the producers of the commodities taxed. Too often excessive reliance on export taxation has weakened to an undesirable degree business incentives to produce and has promoted the adoption of substitute materials.

Regional specialization

Emerging countries are coming to see that much more regional specialization will be necessary if all these countries' aspirations to industrialize are to be accommodated. As a representative of the U.S. Government in the U.N. Committee on Industrial Development, whose membership comprises primarily emerging nations, I have seen to what an unfortunate extent the development plans of different countries overlap, in the sense of looking to the same industries to be fostered and the same markets to be tapped. This can only mean a growing competition for trade among the emerging countries themselves in which some countries are bound to be disappointed. There is a clear need for more regional international consultation among the development planners of various countries and for regional agreements, informal or otherwise, that will insure that new industries in countries within a natural trade area will be complementary rather than competitive.

Regional consultation in development planning may be only a first step toward negotiation of trade preference areas within which much freer exchange than at present will become possible. This market broadening is a necessary preliminary to the adoption of mass production methods.

The U.N., I believe, offers the proper forum for this type of consultation, and the emerging countries would do well to avail themselves of U.N. facilities for this purpose. The expanded semi-autonomous Organization for Industrial Development which is soon to come into being, should move aggressively to provide facilities for this regional specialization. The Regional Commissions of the U.N. can perhaps be even more effective. In Europe, the OECD has done much to focus on the problems of the emerging countries and to draw the attention of the aid providing nations to the need to coordinate their efforts in extending assistance to the less-developed world. The Development Assistance Committee of this group has made good progress in defining problems and in outlining possible solutions and in seeking to enhance the assistance efforts of its member states. Its activities will continue to be pushed even more vigorously.

Similarly, the European Development Fund of the EEC has not only provided much-needed development capital to its Associated African States but also has shown how international cooperation on specific investment projects can improve both the technical appraisal of these projects and the terms of financing.
Co-operative efforts such as these should be considered as portents of an even broader framework of international consultation which cannot but help the development process in most of the world to move forward.

General trade and commercial policies

The well developed countries can assist the emerging nations to develop more rapidly than in the past by paying closer attention to the impacts their trade and commercial policies have on these countries.
It is shortsighted at best for the US, for example, to provide extensive economic aid to a particular country that is trying to develop and simultaneously to block that country's exports from the US or from third country's markets; but this has happened all too frequently. Other aid supplying countries have done the same thing.
At best this is baffling to the emerging country thus treated. It also weakens the political and strategic effectiveness of economic aid and postpones the time when it can properly be diminished.
We should look to the emerging countries not so much in terms of what they will buy from us as what we can additionally buy from them, and how this can assist their ascent into higher levels of specialization and exchange. Trade instead of aid is an old slogan but one which still contains a kernel of truth that is applicable and significant to our economic policies toward the developing world.

Export of licenses and know-how

Advanced countries can also do much to help the emerging nations by concentrating more on the export of usable technology and less heavily on sales of goods. I refer to such activities as licensing patents and know-how to countries that are striving to establish processing operations. While there is a substantial volume of these exports of technology from the advanced countries, it goes primarily to other countries already established industrially rather than to those just getting started. For example US business licensing agreements of this nature with Japan outweigh by far those with all the emerging countries.
This export of technology depends primarily on the initiative of private business and can only be assisted in a limited way by government programs. These programs serve chiefly an intermediary role of bringing licensor and licensee together in mutually beneficial arrangements.
Studies of licensing operations have shown these to be fundamentally an intermediate step between simple export of goods and the establishment of branch plants to do limited manufacturing in the consuming country.
If emerging countries are sincere in their wish to attract private foreigh capital, and in many cases they are not except on terms too restrictive to be acceptable, they should for their part consider commercial import of technology as a necessary step to this end and should encourage it more actively.
The emerging countries have by now learned that private capital is scarce and hard to attract; in most cases it is no longer looked to as a major source of capital for development purposes. Domestic savings mobilized through government must of necessity be the main source, supplemented in a minor way in most cases by bilateral government to government aid, and in a still more minor way by funds from international agency sources.
Capital supplying agencies are fond of noting that their resources often exceed the volume of bankable, well worked out investment projects originating in the emerging countries. To the extent this is true, and I do not doubt it, it indicates a gap between lending standards and the average state of investment feasibility studies.
This gap must be closed from both ends; i.e., by better studies and by more flexible standards.

Multilateral trade patterns

Let us come back now from the broader problems of economic development to the narrower focus of this meeting. I think this particular international agency, as a steel exporter, would do well to look not only to the emerging countries as a potential growing market for steel products, but also as a trade area, in the broad sense, with which gradually ascending and ramifying trade patterns, hopefully of a multilateral nature, will slowly emerge. It should seek to speed this process in every practical way.

This developing world must attain, and soon, a sufficiently high rate of economic growth to give reasonable prospects of an eventual rise in living standards. Barring this critical achievement, which is still far from being attained in most of the world, political unrest and revolutionary changes in political philosophy are inevitable.

Looking narrowly at the developing world as a market for steel, which I have just suggested is not the most constructive light in which to view it, one can foresee a slowly rising demand. I believe that in both quantity and value terms this demand expansion will be far smaller than that which will emerge from the already industrially established countries, whose growth is much larger than that likely to be realized in the emerging world. Trade grows more than proportionately to industrial progress, as the statistics of any country that has experienced a sustained period of substantial growth will testify. Trade with the emerging countries will accelerate, but more slowly than trade among the advanced countries. This is my forecast for the next decade, much as I might wish the prospect were otherwise.

As one who is neither an expert on steel nor on agriculture, but as a general economist who has studied the progress of economic development both generally and in particular emerging countries that were trying to organize a sustainable development sequence, I suggest to you that removing impediments to development one by one and especially by a more enlightened trade policy toward the emerging countries, is the path that will expand your markets most effectively in the long run. We cannot reasonably expect all national aspirations for development to be met on schedule, but we must be equally chary of allowing them to lag too much.

Conclusions

In summary we, in the advanced countries, must think less narrowly of what we can export to the emerging countries and more creatively of how we can expand our imports from them. We must also devise new techniques to speed the transfer of technology to emerging countries, so that good methods can help offset the diseconomies of scale these nations must overcome in their early efforts to industrialize. We should also welcome their efforts to process their exports a little more and should not regard these efforts as a threat to our established manufacturing arrangements. The developing world for its part should realize that continued economic growth in the advanced countries is the best guarantee of expanding markets for their products, both agricultural and industrial, and of continued capital inflow which is vital.

If these viewpoints can be appreciated and these policy accommodations can be made promptly and in good spirit by both the well and the less well developed countries, we can look to the developing world as a group of trading partners of great promise, with whom exchanges of growing value and increasing sophistication can be worked out to mutual advantage.

3 *Summaries*

of the Congress Proceedings and Closing Speeches

Helmut ODENHAUSEN

Rapporteur to Working Party I

Steel in Farm Buildings and Installations

In the mechanized, intensive agriculture of today, farm buildings and their installations are playing a more and more important part: indeed, rationalization of farmyard operations cannot proceed without them. While in some extreme cases nowadays farming can well enough be carried on without farmland, it cannot possibly be carried on without buildings. There are three purposes for which steel can be used in this connection: for the load-bearing structures, for roofing and walling, and for indoor installations and equipment.

1. *Load-bearing structures*

Quite substantial changes are in prospect with regard to the use of steel for load-bearing structures. Those at present manufactured are often unduly expensive, functionally unsatisfactory, and occasionally, inadequately corrosion-proofed. Attention will be increasingly concentrated in future on enabling thoroughly corrosion-resistant structures of maximum simplicity and uniformity of design, usable for both industrial and agricultural purposes, to be mass-produced and so marketed at reasonable prices. I shall be adding a recommendation on this point at the end of my summing-up.

2. *Roofing and walling*

For buildings not requiring thermal insulation surface-protected steel plate and sheet are widely used, mainly in the form of large-surface sections galvanized by the hot-dip process.
Cheap heat-insulated roof and wall components for the type of sturdy building needed out in the country are still not being manufactured in sufficient quantities. This is another market to which the industry would be well advised to devote attention.

3. *Indoor installations and equipment*

Steel, mostly corrosion-proofed by hot-dip galvanization, is proving very popular for indoor installations and equipment of all kinds, especially in livestock housing (*e.g.* gates, stanchions, boxes, bays and stalls, partitions and slatted floors). Steel installations of this kind are strong and light, of open-work construction allowing the beasts plenty of air and making it easy to keep an eye on them; they can be altered and extended as required, and they are thoroughly corrosion-resistant. The facts thats steel does not absorb moisture and is eminently hygienic (its smooth, compact, easy-to-clean surfaces offering little or no lodgment for germs) make it a good selling proposition.
Container storage at the farm has got off to a good start, and there is already a promising market for steel containers for the drying, storage and preservation of feedstuffs of all kinds. Self-supporting silos of hot-dip

galvanized or enamelled steel sheet are durable, clean, air-, gas- and watertight, and quick and easy to assemble, move and service, and facilitate mechanical charging and discharging, and such subsequent operations as automatic cattle feeding.

Unfortunately steel silos are all too often rendered uneconomic to build by absurd and antiquated regulations which not only impede technological progress but also stultify the farmers' efforts to reduce their production costs. In the agricultural sector too it is being found an intolerable nuisance that there has still been no harmonization of building regulations among the six Community countries.

Growing under glass being the most intensive method of plant cultivation, glasshouses can be expected to come in more and more with the general increase in affluance. These offer good openings for lightweight surface-protected steel structures. "Vertical" glasshouse design, with its great labour-saving advantages, may perhaps afford a new field of applications for steel.

Various other types of building, rating broadly as agricultural, which were not discussed by the Working Party, are nevertheless also of considerable importance from the point of view of steel utilization, namely all those connected with the marketing of produce, such as fruit, potato and plant stores, cold-storage plants, poultry slaughterhouses, dairies, distilleries, premises for wine, cider and fruit-juice making, and so on. Farm-house construction was another aspect not discussed, since nowadays the farm-house is nearly always located away from the farm-yard installations and differs little from the ordinary urban dwelling.

There is every reason to take an optimistic view of the prospects for steel in agriculture, especially now that the problem of surface protection has been overcome. Hot-dip galvanizing is the main basic method, affording exceptionally effective and lasting protection, and there are the further possibilities of galvanizing plus painting and hot-dip galvanizing plus plastic coating, these extra treatments serving not only to give substantially increased corrosion-protection but also to improve the appearance of the metal. With a suitable coat of paint the buildings can be made to tone very pleasantly with their surroundings and the landscape generally; there are plenty of excellent examples to show that steel need not be an alien intruder in the countryside, but can blend harmoniously into the rural scene. Conservationists unfortunately still often have a rooted prejudice against it, but a series of good practical examples should help in course of time to dispose of these outdated ideas.

Both the papers and the debates revealed the lively interest taken in the Working Party's theme. On this occasion leading agriculturists and steel experts were able to compare notes, an outline was given of some coming developments and suggestions made for expanding the use of steel in agriculture. On the basis of the Working Party's conclusions, the following recommendations are submitted for the High Authority's attention:

1. The High Authority is urged to finance research on the optimum cross-sectional dimensions for a multi-purpose farm building (recommendation by Dr. Odenhausen).
2. The High Authority is urged to establish Euronorms for farm buildings, building components and installations, which will at the same time ensure lining-up of the building regulations in the six Community countries.
3. The High Authority is urged to set up model farms at which extensive use will be made of steel and experiments conducted with new departures in this connection, and which will in addition provide training for young people intending to go in for farming (see paper by Mr. Thiry).
4. The High Authority is urged to prepare a comparative study on the practical and economic values of modern milking parlours, with special reference to the layout and equipment of the milking stalls (see paper by Mr. Corcelle).
5. The High Authority is urged to set up an Agriculture/Steel Industry Liaison Committee to help promote the increased use of steel in agriculture (suggestion by the Chairman of the Working Party, Prof. Ramadoro).

Jacques LECLERC

Rapporteur to Working Party II

Steel in Agricultural Machinery

What we should have wished to do, in dealing with the subject of steel in agricultural machinery, was to arrive on the basis of the Working Party's proceedings at a general approach to the promotion of the use of steel in this connection.

Actually, the papers and debates related mainly to general aspects of agricultural improvement, the need for standardization, and the specific characteristics of certain types of equipment Mr. De Forest of United States Steel did, however, suggest an approach for the future, and I feel that, although he based himself primarily on special instances, some of them of an *avant-garde* character, we can draw a number of very pertinent conclusions from his remarks.

The link between steelmaking and agricultural machinery is the manufacturer's design office. By thinking himself into the concerns of the designer, and of the agricultural equipment manufacturer generally, the steelmaker is enabled to suggest the right *qualities*, the right *shapes*, the right practical measures—processing, assembly, treatment—for overcoming the problems involved by employing *steel*.

United Steel's Research and Development Department, which I had the opportunity to visit last year, does not have a particularly large staff, but it is organized to go thoroughly into the problems of expanding the use of steel under three main heads:

(a) form (convenience, appearance, design);
(b) structure (construction, assembly, ease of operation);
(c) purpose, suitability and choice of materials (comparative testing of alternatives).

To my mind, this approach—form, structure, purpose—is the right one in the promotion of any product. Market conditions and market studies will not of themselves ensure a future for new products where the products are not yet forthcoming or not yet tailored to potential practical requirements. Successful promotion of steel utilization will come when steel is offered in forms and structures fully in line with the users' needs.

In seeking to ensure more and wider uses of steel, then, the aim should be to see that the equipment manufacturers and steel producers are kept well informed concerning users' requirements. In agriculture, these requirements are focused on three things, specialization, mechanization and modernization.

However, these are wide general concepts. To come down to more simple concrete terms, why should wood be used in such and such an instance, rather than steel? Why this or that steel casting and not a welded assemblage? Where could folded sheet, or galvanized plate or sections, be used in appliances etc...? Where is there a tendency to wear, or fatigue, or corrosion?

In discussing agricultural machinery we often think too much of the purely mechanical side—transmission gear, special steels, heat treatment of particular parts. With motor cars it is the bodywork, not the engine, that boosts the firms' reputation and appeals to the user.

I make the point in order to emphasize that to expand steel consumption we must concentrate not only on the amounts of special steels needed for the internal parts, but also on the large tonnages of ordinary steels required to house these and to administer to the user's convenience.

We must concentrate on ancillary equipment quite as much as on tractors.

We must concentrate, too, on quick, smooth distribution of the steel appliances required for at-farm repairs, servicing, and assembly and erection work. Steel consumption on farms will expand if arrangements are made to supply not only spare parts but also necessary components for immediate use, by simple assembly operations either in the farm's own workshop or at a co-operative centre. Steel can be sure of acceptance if it is made available on the spot by efficiently phased arrangements in forms and qualities tailored to the structures intended.

Now to turn to points specifically urged or suggested by speakers during the Working Party's proceedings. Among the desiderata mentioned in a number of papers was the standardization of equipment. As a matter of fact, speaking personally, I feel caution is called for here, since after all standardization is only possible for very carefully thought-out equipment designed to fulfil already standardized functions: efforts to standardize can actually be a handicap where mechanization is not sufficiently advanced to meet the various requirements that come up in specialized connections. Speakers referred, *inter alia*, to:

- studies on specialized equipment from the point of view of the purpose to be served;
- studies by manufacturers on the openings for mass production, since short production runs result in unduly costly equipment;
- study and introduction of standards for farm equipment;
- co-ordination of the activities of standards organizations.

Over and above this investigation of spezialized requirements, needed to enable mass production to be undertaken and particulars obtained from farmers of what they are trying to produce as well as what they want to produce it with, it will be necessary to work on the co-ordination of specialized equipment in sets corresponding to given production chains.

Speakers pressed for:

- analytical studies to arrive at a clear definition of production chain machines;
- studies to establish series of co-ordinated items of equipment (more especially harvesting chains);
- co-operation between manufacturers and farmers to study production chains;
- manufacturers to accept and act on their responsabilities as educators and advisers in the matter of machinery;
- production chains to be organized in line with size of farm.

In a word, as I mentioned earlier, the need is for full-scale, organized engineering in the field of agriculture.

A number of points were made concerning improved convenience and safety in tractor design. Mention should also be made of suggestions put forward for reviving agricultural craftmanship, by means of:

- efficient after-sales service;
- instruction of farmers in mechanical skills;
- well-equipped repair shops and spare-part and component depots;
- provision for farm workshops of plans for ancillary installations and small buildings for erection by farm labour.

With regard to the properties of the steels supplied to agricultural-equipment manufacturers, it may be noted that structural steels, heat-treatment alloy and non-alloy steels and tool steels are nowadays all standardized, so that selection is a simple enough matter.

Not much was said about the hardness or fatigue strength of steel parts: speakers were concerned more with resistance to abrasion and corrosion. However, the choice of steel for a particular item of equipment, whether of ordinary or of special steel, is no great problem once it is clear how the item is to be used.

Clarity as to use, purpose construction, special attention to delicate mechanisms, simple design, ease of servicing and the place of the machine in fabrication chains—such are the main considerations to be borne in mind in production for agriculture, whether in designing new and possibly somewhat *avant-garde* prototypes or in adapting items to the size of the farms concerned, with due regard to the cost saving ensured by mass production. But the great point above all is the saving in money and effort for the user.

I have been asked to conclude by listing the measures the Working Party would like to see adopted to follow up ECSC's initiative on a broad front.

The Working Party considers it essential to the expansion of steel utilization that efficient manufacture of agricultural equipment should be encouraged in all Community countries.

In such manufacture, particular attention should be devoted:

- to selecting the specialized equipment most appropriate to the purpose envisaged;
- to establishing co-ordinated sets of machines and appliances in order to offer farmers a more straightforward choice among a smaller number of alternatives.

The steelmakers should consult more closely with the manufacturers and the manufacturers with the farmers, agricultural colleges and engineers.

The High Authority should encourage systematic, co-ordinated studies of equipment needs in the Community countries. It is especially urged to promote research with the aim of securing the adoption of scientific calculation in place of the present empirical approach with regard to:

the behaviour of materials at points of assembly;

the reactions of working parts to abrasion or wear under ultra-hard use.

In addition, it is urged to encourage steelmakers as a body to provide the research associations and manufacturers with technical information and advice in the form of recommendations as to selection and use.

Prof. Corrado RICCI

Rapporteur to Working Party III

Steel in the Storage and Marketing of Agricultural Produce

Introduction

The contents of the two introductory papers and the number and standard of the other papers contributed on points connected with the subject of Working Party III are conclusive evidence of the importance attached in all countries to the preservation of agricultural produce. The productivity drive which has been in progress for a number of years in the more advanced countries has led to the, at first glance, somewhat paradoxical result that it can be actually uneconomic to expand agricultural production beyond a certain point unless arrangements are made at the same time to eliminate the losses occurring between the harvesting of the produce and its distribution to the consumers.

To do so, the experts are agreed that thoroughgoing modernization will be needed of the present facilities, at farm, co-operative and commercial level, for preserving and processing agricultural produce. At the same time, with markets steadily growing in size and extending further and further away from the production areas, greater streamlining of the distribution channels is becoming necessary.

The need for these measures is further enhanced by the very considerable changes in eating habits and preferences: consumers are developing more and more of a predilection for foodstuffs that will not normally keep for long, which they are at the same time demanding shall be supplied in a condition as close as possible to the fresh product.

It has been clearly brought out in the Working Party's discussions that steel can play an extremely important part in the three main fields of utilization offered by the preservation of foodstuffs:

(1) the manufacture of containers enabling the produce to be kept in sound condition for long periods and making for convenience of handling;
(2) the provision of machinery for the transport, packaging and processing of the produce;
(3) the construction of storage premises designed in line with the biological considerations involved, and of processing plants.

So far, steel is not being used to the same extent in these three fields.

It is undoubtedly predominant on the transport and handling side, and there is a close correlation between the growth rate for such machinery and the growth rate for steel utilization. With regard to the packaging of foodstuffs, and of certain products used in agriculture—pesticides, fertilizers, chemical compounds and so on—there is a similar correlation, though here the development of alternative materials constitutes a potential threat to steel's position.

As regards storage premises, steel is not at present employed to the extent it might be, principally because not many prefabricated structures suitable for farm use are available. This is one of the fields in which the lag between industry and agriculture is most apparent, since although progress in agriculture is making it more and more important that farm buildings and installations should be "industrial" in character, they still tend to remain on the old traditional lines.

In order to deal more fully with the problems of storing and preserving the main types of produce, taking account of the points of similarity among the steel products used for the purpose, it is proposed to consider

produce under four heads:
- cereals and forage;
- potatoes, vegetables and fruit stored fresh;
- dairy produce, wine and other liquid produce;
- canned foodstuffs.

Storage of cereals and forage

The storage of cereals presents no particular problem where the moisture content on harvesting is below 14%. For on-farm storage the steel industry already offers a wide range of galvanized-sheet silos suitable for both indoor and outdoor use. Batteries of similar silos with mechanical transport devices can also be employed at co-operative collecting centres and at the auxiliary centres run by the big storage networks. For the construction of large-capacity silos prefabricated steel components have the advantage of making the structure substantially lighter in weight and quicker and easier to erect. Steel silos have therefore every chance of becoming competitive *vis-à-vis* the traditional reinforced-concrete type inasmuch as reduction of the load-stresses on the ground beneath is a most important consideration; in addition, silos specially made from high-tensile steels can well be used for storage at ports despite the highly corrosive sea air. At present, the use of the combine harvester very commonly makes it necessary to effect some extra drying of the grain, either at the farm or at centralized plants. The preference is mainly for on-farm installations, as with these the drying can be done more promptly and the farmer is able to sell on better terms.

Similar installations are also coming increasingly into use for forage, the traditional method of haymaking, which is both costly and uncertain, being gradually discarded in favour of indoor drying. The latter method and the fact that it is then necessary to have somewhere to keep the hay dry make it particularly suitable to use steel sheds and barns for the purpose and consequently these are far and away the most widely-used steel structures in farming.

Gas-tight cylindrical steel containers with mechanical charging and discharging devices are also proving fairly popular for storing forage in countries where the climate allows of partial pre-drying in the hayfield.

Storage of potatoes, vegetables and fruit stored fresh

Potatoes account for 20% of human consumption of agricultural produce, and the question of proper storage for them, especially on the farm, is a very considerable problem in northern Europe. The requirements storehouses should fulfil as regards design and atmosphere are now well known, thanks to the systematic research which has been carried out in this connection and the many excellent examples in service in various countries. The basic prerequisites thus already exist for their standardization and construction from suitably protected prefabricated steel components: the successful experiments effected in a number of countries are highly instructive in this regard.

The advantages of storehouse standardization and prefabrication are still more apparent in the case of fruit and vegetable refrigeration, a field in which there are good and practical reasons for trying to secure the standardization without delay throughout the Community countries of all refrigeration equipment. Prefabricated steel refrigeration units are not as yet in extensive use in Europe, owing partly to the technological difficulties involved in their manufacture and partly to the greater concentration, so far, on large centralized plants than on smaller-scale installations. However, improvements in the properties of the steels and insulating materials used, the standardization of small-size gas refrigeration units and the general introduction of automatic temperature-control devices have enabled progress to be made in overcoming these problems, as can be seen from some recent successful examples.

Dairy produce, wine and other liquid produce

Milk is particularly tricky to store owing to the special importance of keeping it pure and the speed with which bacteria multiply in it at normal ambient temperatures. Milk containers must therefore

(a) be totally non-reactive to their contents;

(b) allow of absolute cleanliness, to be obtained by means of powerful chemical detergents, sterilizing and so on;
(c) cool rapidly to around about 4° C.

These requirements are satisfied by the stainless-steel refrigerating tanks which first came on to the European market in the 1960s and are gaining in popularity despite the problems arising from the small size of the herds in many European countries; farmers like them for storing the milk temporarily at the farm, because they will keep the output from four successive milkings in good condition, so that it retains its full market value and is less expensive to transport to the central depot.

Stainless steel is particularly suitable for use in connection with milk and its derivates, as can be seen from the fact that the dairy industry is employing it more and more in preference to any other material. In the wine trade also it is being increasingly used for fermenting and storage vats, which have in the past ordinarily been made of wood or reinforced concrete. This is because stainless-steel containers do not react with the wine, can be mass-produced, require practically no maintenance, remain gas-tight, are good conductors of heat (an important point in the blending of wines to the required standard), and can be employed in a variety of ways.

The same is true with regard to beer, for which stainless-steel containers are being used more and more for purposes of both storage and transport.

Still more, stainless steel is an eminently suitable material for the carriage of liquids by road tanker, since in this case it is necessary, apart from the properties just listed, that the tank should be usable for transporting quite a number of different types of fluid. Recent technological improvements in road tankers, and more particularly the designing of lighter-weight tanks, clearly indicate that this field of steel utilization has quite a future.

The qualities of stainless steel used for these purposes are, in the case of the dairy industry, 18-8 and 18-10 chrome-nickel steels; in the wine industry 18-10 or 18-12 molybdenum steels can be used instead for wines with a high sulphur-dioxide content.

Canned foodstuffs

For the past hundred years tinplate has been *the* material for the preserving of foodstuffs, despite efforts from time to time to introduce various rival products. World tinplate production per annum stands today at something like 10 million tons, of which 7,500,000 go to the canning of foodstuffs, producing round about 100,000 million cans, or 25 per head of the entire world population.

The canning industry's faithfulness to tinplate is mainly due to the constant technological improvements which have been and are being made both in the quality of the actual tinplate and in the can-manufacturing processes. The two most important recent developments in this connection have been the substitution of cold-rolled for hot-rolled sheet and of electrolytic for hot-dip tinning.

The present trend is towards the use of thinner and thinner sheet, the reduction and possibly the supersession of the tin coating, and the continuous production of cans with larger and larger capacity plant, the result being to lower the cost of the container and hence its incidence on the selling price of the produce.

A number of problems, however, still remain, notably the devising of easier ways of opening the can and of more effective protection of the cuter surfaces, in order to prevent local corrosion liable to put the consumer off.

The use of tinplate in agriculture is not confined to the canning of produce; it also includes the making of containers for chemical and para-chemical products. Here too, with new products and methods appearing all the time, it is necessary to develop appropriate types of packaging.

In the tinplate sector also, therefore, there are extremely important technological choices to be made, which can only be satisfactorily settled on the basis of ongoing detailed consultations between the steelmakers, the farmers and the marketing experts. The need for such consultations, to be held not merely at regular intervals but all the time and at several different levels, was repeatedly emphasized in the course of the Working Party's discussions.

Conclusions

Viewed objectively, there is still a certain cleavage between the steelmaking and manufacturing industry and agriculture.

This is not due purely to traditional factors, but also the result of natural differences in past development with regard to production processes and techniques, enterprise structure and psychological considerations.

So far as steel is concerned, therefore, the future expansion of production and consumption requires not only improvements in the quality of the various products, but also an efficiently-organized system of technical information at institutional level.

Accordingly, it is considered desirable that the High Authority of ECSC should set up a Study and Co-ordination Centre dealing with the uses of steel in agriculture, to be responsible for

(a) assembling and disseminating information on the uses of steel in agriculture;

(b) pinpointing the fields in which the use of steel could resolve problems of special importance to progress in agriculture;

(c) promoting the establishment of Study and Co-ordination Committees drawn from the steelmaking and manufacturing industries and from agriculture, with the aim of instituting closer co-operation;

(d) working for the European-level unification of standards relating to stainless steel and other steel products relevant to the purposes of agriculture.

Charles GOUZÉE

Rapporteur to Working Party IV

Steel in the Agriculture of Developing Countries, Especially Tropical Countries

Working Party IV discussed, firstly, the general features of agriculture in the developing countries, secondly, the various factors helping and hindering agricultural production, and thirdly, in this context, the role of steel and the action which might be taken by the steel-producing and marketing organizations.

Speakers recalled

(a) that in the developing countries anything up to 80% of the working population were employed on the land;

(b) that amid the traditionalist, "artisan" agriculture practised up to now—sometimes by primitive sometimes by very elaborate methods—there were already quite sizeable nuclei of more "industrialized" cultivation based on the use of either animal-drawn or motor-powered equipment;

(c) that owing to the predominance of the agricultural sector in the economics of the developing countries any fluctuation in foreign exchange rates or deterioration in terms of trade was liable to produce especially damaging effects.

Reference was made to the part which agriculture had played in the transition from a subsistence to a trading economy. It was through increased productivity in agriculture that development in other sectors would become possible: thus it was for agriculture

1. to feed more people with less manpower;
2. to raise export crops that would earn foreign currency for capital investment;
3. to supply the raw material for the country's own agricultrual industries;
4. to increase farmer's earnings in order to initiate internal money flows;
5. by means of the movements started and taxes paid by it to aid the establishment of basic communications and social infrastructures.

Development programmes should, it is considered, be designed to help agriculture perform these various functions.

The Working Party discussed at some length the optimum degree of concentration and point of impact of such programmes, both as regards practical implementation and as regards basic aims and organization.

For agricultural equipment steel is of course essential: steel consumption per head of population is an index of development generally, in agriculture, as elsewhere. Steel and machinery will be needed right from the start in improving the manual implements available, and subsequently in going over to harness cropping. They will be needed still more, and in larger quantities, where it is felt necessary or desirable to introduce powered traction, whether for cultivation proper or for land reclamation and improvement, which require heavier machinery still. The figure the Working Party was given concerning India, which was stated to need 15 million tractors, the number at present in service in the entire world, are illustrative of the scale on which production must be envisaged in one of these fields; equally astronomical estimates can be made with respect to traditional implements, to earth-moving machines and to irrigation and drainage installations.

But while the overall requirements are known to exist and can be roughly calculated, it is difficult to obtain an accurate idea of the specific requirements, let alone meet them. The type of equipment that should be used, the type of measure that should be advised cannot be the same in densely and in sparsely populated countries, in dry and in wet ones, in fertile and in barren ones, in ones with plenty of foreign currency to spare and in ones without, in ones with an industrial infrastructure and in ones tied to the soil, in ones that welcome scientific progress and in ones that reject it.

In the course of the discussion various aspects of the problem were touched upon and a number of points urged. With regard to agricultural machinery, several speakers were in favour of the development of models specially designed for use in the tropics: this would involve, in addition to co-operation by the research departments of the producer firms in the industrial countries, experimentation in tropical conditions.

The hope was also expressed that private firms would make a push to work up their after-sales service arrangements. The Governments of the developing countries could assist them in this and enable the arrangements to operate mor effectively by reapportioning the equipment used and having large concentrations of equipment of similar type built up in individual areas.

With regard to storage, detailed recommendations were put forward concerning improvements to steel silos. Attention, it was considered, should be focused on the construction of airtight welded silos and on the production of steel walls coated or clad inside with an insulating material to eliminate condensation. Here too it was urged that a careful study should be made of the specific requirements of tropical countries, covering optimum-size selection, the provision of simple and effective ventilation devices, and the production of specially corrosion-resistant steels.

Attention was drawn by individual speakers to the advantages of permanent magnet steel and of certain drills particularly suited for use in the tropics.

It was pointed out, however, that real progress would not be achieved in tropical agriculture simply by supplying equipment: the equipment would not do its job properly unless proper arrangements were instituted to ensure its rational utilization.

Accordingly, the Working Party would emphasize the importance of:

(i) conducting preliminary studies to determine the optimum degree of mechanization appropriate to each particular set of circumstances;

(ii) organizing agricultural schemes as part of broader programmes designed to ensure parallel progress in establishing a social and educational infrastructure, training local technicians and developing economic channels which will make it possible to market the produce, amortize the investment and pay for the equipment;

(iii) giving priority to schemes which can be expanded from the initial pilot projects into more comprehensive programmes.

These recommendations relate to schemes launched within the developing countries. There will of course also have to be international agreements for the marketing of these countries' produce. Governments are urged to support all endeavours to stabilize the prices of tropical produce. It is also hoped that industrial countries wishing to increase their exports to the developing countries will recognize the corresponding need to step up their imports from them.

One speaker referred to the likelihood of world famine—a contingency which we cannot but take as the background to the Working Party's general conclusions.

With this in prospect, it is becoming more and more urgent that industry should do its part in aiding the development of tropical agriculture. The fact that a working party on the developing countries has been organized at this Congress is evidence that ECSC is willing to help in this. We feel it could do so by arranging the establishment of a standing liaison body linking planners of technical assistance projects, recipients of that assistance, and industry.

There are precedents. The aid given by makers of fertilizers towards FAO's experiments is one example. Co-operation between silo manufacturers and the American organizations which are helping the developing countries to grapple with the storage problem could be another.

Such a procedure could be generally introduced, every technical assistance project on any considerable scale being jointly studied by the sponsoring organization, representatives, of the developing country concerned and the suppliers, who would provide equipment, advice and information, whether as a gift or against payment. By instituting such a system ECSC, would be helping to tackle one of the great problems of our time. Moreover, it seems clear enough that notable advances in the agriculture of the developing countries would be automatically followed by a rise in steel consumption in other sectors.

Comte MOENS de FERNIG

Former Minister, Chairman of the Congress

Address

On the completion of these three days of debate on what the steel producers and manufacturers are in a position to do for agriculture, I should like, before putting to you a few points as to the lessons the iron and steel industries can learn from the Congress proceedings, to say a few words of thanks, in which I am sure that I shall be speaking on behalf of us all.

First of all, our thanks go to Their Royal Highnesses the Grand Duke and Grand Duchess of Luxembourg, who so graciously showed their interest in the Congress by consenting to be present. This was a much-appreciated encouragement to all of us from the outset.

Our sincerest thanks also to the Luxembourg Government. The Grand Duchy has given us its hospitality, a venue for our discussions and every facility for the organization of this Third Steel Congress, and I should like the authorities to know that we appreciate this also.

I said in my opening address that I should now be summing up the Congress proceedings, but I feel that in view of what we have just heard from the rapporteurs of the four Working Parties I need not do so in any detail. There seems little object in my summing up their summings-up, so I propose simply to offer a few comments.

The iron and steel industries can, I think, draw some very pertinent conclusions from the tremendous strides agriculture has made, technologically and economically, in the industrialized countries of the world during the last twenty years.

It was up against some very difficult problems with regard to farming techniques, to profitability and to marketing alike, arising out of the small size of many holdings, the comparative slackness of the market and the difficulty of reorganizing and of recruiting the necessary labour. These problems are now being overcome in Europe by a drive on three fronts: organization, research and mechanization.

The headway which has been made in this direction is of course due in part to the support agriculture is receiving from the official quarters responsible. But at the same time it is due in large part to the work of the farmers' own associations, and to the vigour and the go-ahead spirit with which the individual farmer, big or small, despite his well-known sense of independence has taken up and put in hand the changes and new techniques devised for him. There is a moral there for everyone, and more particularly for the equipment manufacturers, who are in many cases also pretty limited in their range of action at present.

Actually, the manufacturers have some exceedingly competent research establishments working for them. But whereas the steel firms proper, with their highly-trained executives, have very quickly absorbed and applied the findings of research, the constructional steelwork and mechanical-engineering companies seem to be taking much longer about it—quite apart from the fact that their research may possibly have been rather less intensive.

The problem is, then, twofold: to step up research on steel utilization and to disseminate the findings more efficiently.

In this connection, I should like to pay tribute to the High Authority of the ECSC, and very specially to its eminent President, Professor Del Bo. The High Authority has taken it upon itself to make substantial grants for steel research, particularly on ways of improving the quality of the metal, and it is now asking the manufacturing firms to submit detailed, carefully-thought-out research programmes. It is up to the manufacturers to respond—but it is up to them also to organize themselves, as the farmers have done, so that the small firms too can have the benefit of the research that is being done: there must be regular dissemination of research results among all manufacturers on whatever scale, to create the same urge to progress via technology as we now see in agriculture. Meantime ECSC, by promoting contact between the manufacturers and their customers as it has done at this Congress, is also giving proof of its keen and continuing interest in the market expansion of the iron and steel industries and the consequent need to develop new products. The Working Parties' rapporteurs have made it clear to us what a receptive market agriculture is for the new equipment and techniques, and that is a very valuable encouragement to research. But I want just to make some general points which seem to me to emerge from these interesting discussions.

(a) One is that, to meet the needs of such a distinctive and difficult sector as agriculture, the manufacturers will have to undertake major adjustments in their production and marketing arrangements which, while doubtless rewarding in the long term, will cost them a great deal at the start. Consultation between the manufacturers' and farmers' federations would certainly help to give the two sides a better idea of one another's problems and enable the resources available to be disposed more in line with market requirements. The present Congress was a start in this direction: I hope very much that the talks begun here will be followed up in the different countries.

(b) Then again, it would appear that particularly extensive and growing use is being made in agricultural buildings and equipment of the new materials in competition with steel. This competition should act as a stimulus to technological progress for the steel producers and manufacturers; moreover, the new insights they gain in this field will be applicable in many others as well, to the benefit of society generally. Which will be one more demonstration that healthy bodies thrive on a good tussle.

(c) The push being made to increase the technological efficiency of agriculture and of agricultural buildings and equipment may not be such an eye-catching business as space exploration or nuclear research. Nevertheless, it involves a number of forward-looking people getting together to deal with a mass of problems presented by traditional technology. The work that is being done to improve our knowledge of the materials in use and of the best ways to use them, and the results already achieved, are clear witness of the economic benefit to be drawn from consistent, persevering studies in fields admittedly obscure, yet all-important to humanity, since they directly concern the population as a whole.

These are a few of the general considerations I though it well to bring out in referring to the excellent job which the four Working Parties have done.

What with the breadth of the subjects handled and the many new aspects involved, the Working Party chairmen and rapporteurs had no easy task. To them, and to all those who took part in the discussions, I extend most cordial thanks for their contributions to the success of the occasion. And we are all greatly indebted to Director-General Peco, who was the linchpin of the whole Congress and who was responsible in the first place for giving us this challenging subject to debate.

In the industrial civilization of today, all sectors of the economy are interlinked, and progress often derives its impetus from contact between men of widely-differing backgrounds. To focus the minds of such men on a common objective and enable them to make the acts of choice that are entailed by a policy of technological progress necessarily limited as to the means of action for implementing it, there need to be organizations like our present host, the High Authority. And one of the things this Congress has accomplished is that it has given men, working in different fields, the opportunity to get to know one another and to view their own concerns in a wider context.

It is greatly to be hoped that this man-to-man contact, a counterpart to the co-operation between producers, manufacturers and users to which I referred just now, will lead on to fresh advances for the good of society as a whole—the ultimate objective of international organizations in general and of ECSC in particular.

And now, before I ask President Del Bo to speak to us, I should like once again to thank him and his fellow-Members of the High Authority, both personally and on behalf of all present, for inviting us to this Congress and for the most efficient way it has been organized. I feel confident that good results will follow the work that has been done here.

That this will be so, is my fervent wish at the end of this Congress.

Dino DEL BO

President of the High Authority

Address

On behalf of the High Authority, may I first of all offer our sincerest thanks to the Sovereigns of the Grand Duchy and to the authorities of the city of Luxembourg, which has once again housed our Congress.

At the same time, with respect more specifically to the Congress proceedings as such, we would offer some further tributes of special gratitude.

First, to the Congress Chairman who has so admirably ensured that these three days of study and debate went so smoothly and successfully. Then again, to those who have attended our third Congress—both the "old hands" who have regularly taken part on the previous occasions and the newcomers here present for the very first time, including more especially the representatives of the agricultural sector. These last, true to their cast of thought, initially regarded the new departure with their usual caution, indeed if I may say so with a touch of healthy pessimism. But once they had taken the plunge they became, as has been noted on all sides, even keener and harder workers for the success of the Congress than the delegates of the past. And lastly, our thanks to the representatives of the Press—the big general dailies and weeklies, the economic and business papers, and, still more, the specialized farmers' periodicals of our various countries. Press coverage has done much to aid our Congress by reporting it, by offering the necessary comment and evaluation, and by drawing attention to the further exertions that still lie ahead.

Concerning future action, we have heard from our rapporteurs detailed and thoughtful, yet at the same time thoroughly clear and straightforward summaries of what the Congress has felt and said during these three days and what it would now wish the High Authority to do. For our part, I have to remind you that we are strictly bound by a Treaty, which makes it entirely out of the question for us to take on the functions of a board of building contractors, as the findings of the first Congress suggested, or, as was urged from some quarters at the second, to own and operate a processing enterprise. Similarly, we cannot possibly run a model farm however attractive the idea may appear to some of us personally. Nevertheless, so far as our terms of reference permit, we shall certainly, as is our responsibility, bear most carefully in mind the points that have been made both in the past and at the present Congress.

Generally speaking, I would say that these confirm what was brought out following the first and second.

Steel has got to be launched in an increasing number of new economic sectors. And for that purpose there has got to be a sustained publicity campaign to prepare those sectors to make due use of steel when the time comes.

What we have sought to do in convening this Congress of steel men and farmers is to draw a wide arc from a basic heavy industry to a primary producing activity, in order partly, of course, to help resolve the specific problems arising between steel and agriculture, but also to demonstrate, practically as well as symbolically how such contact between two at first sight widely different and sometimes indeed conflicting sectors can always be achieved provided both sides bring to the encounter the fullest mutual understanding, a willingness to think things out together, and a real social and political solidarity in the best sense of the term.

To the Directorate-General for Steel, then, must go the credit for suggesting to the High Authority as the theme for the Congress this field of immense, though long-term, potentialities. By choosing this theme it has once again been demonstrated that the so-called "Eurocrats" have very often a common touch on daily affairs that merits fuller appreciation from public opinion in the different countries.

I feel, too, that there is something else this Congress has shown us. It has confirmed that, to get results, the High Authority should press ahead with its work of establishing contact between the steel producers and all those who can broadly be ranked as steel consumers. And, in this particular instance, it has brought out the further point that the industrial planners too should be included in that contact—the people (nowadays primarily technologists) who have the tricky job first of selecting the materials to be used and then of working out the optimum size of the installations from the economic and operational standpoint, and are thus responsible for ensuring that both producers and consumers are able to forge ahead simultaneously to the benefit of all.

This is the case, needless to say, in modern industrialized countries. It is the case still more in the countries which have recently attained independence. We have duly noted the findings of Working Party IV. We fully recognize that the developing countries, located mostly as they are in tropical climates, have in the matter of agricultural installations and equipment special needs requiring to be further studied and taken most carefully into consideration. And we recognize, too, another more important fact—that, just as their movement to full independence is irreversible, so too is their movement to industrialization. No industrialized country, let alone a Community such as ours, can suppose that the developing countries' march towards industrialization can be halted. The first step is to industrialize agriculture, since only by judicious industrialization in this sector can the new countries introduce crop diversification and so build up sufficient capital reserves to go ahead by swift stages to the establishment first of the necessary infrastructure and secondly of industry proper.

At the same time, there is another basic fact we have been shown. It is this: the main thing which the developing countries are anxious that we should do is to buy their products. And we have to remember—a point very specifically for the attention of the farmers—that those products are still today in overwhelmingly large measure agricultural.

So may I be permitted to put in the further plea that the statesmen and the farmers of the industrialized countries, while of course seeking by political and restrictive measures to safeguard their lawful interests and indefeasible rights, should also bear in mind that for so long as our countries maintain subsidized prices for home-grown produce, and quota restrictions on the importation of produce from the developing countries, our aid and goodwill will remain merely the outward form and not the real thing. The problem is one we cannot sidestep, even though, to avoid awkwardness, it is too often preferred not to talk about it.

Lastly, I feel there is another task we should tackle together—the promotion of research and study without which certain problems of economics, technology and general policy will never be overcome. And unless they are overcome we shall never progress as we should, not only in industrializing agriculture, but in enabling our industries to draw abreast of those in the major developed countries outside the Community. Never before has there been such constant reference to the growing competition growing up in world markets. We must trust that such competion as this, economic in character, will be the only one.

In that competition it is absolutely vital that Europe should not be worsted. It is absolutely vital that Europe's brains should prove to be of as high a standard as they were in times long and not so long past, that it should continue to play its part in the betterment of the human lot. From being ourselves the prime movers we must not allow ourselves to become nothing but passive accepters of great decisions and great advances which have sprung from the intellect of others.

It is partly to this end that we are planning to continue with our series of Steel Congresses. This year we organized an encounter between steelmaking and the world's very oldest activity, agriculture; next year's Congress, in all probability, will deal with one of the world's newest, a sector already of tremendous importance for our own time and with a future so immeasurably vast that it is hard indeed for us today to form any idea of it. I refer to petrochemistry, the subject the High Authority is envisaging adopting in 1967.

I should like now to end with an observation of wider scope. We have all of us registered the note of warning struck by the Luxembourg Prime Minister at the opening of the Congress. Mr. Werner's emphasis that the Common Market in so basic as ector as steel must be safeguarded, and not allowed to become eroded and vanish away, came as no new or unfamiliar thought to the High Authority, which has for months been devoting careful study to the incipient crisis that looks like coming upon the Common Market for steel.

I am now in a position to tell you that, pending the forthcoming session of the Council of Ministers, the High Authority is preparing, in order to meet this contingency, to take the action it is empowered to take, to request that the six Governments assume their due responsibility, and to put to the Council those measures

it now feels should be adopted to ensure that, parallel with the further consolidation of the integration of steel production, integration will also be maintained in the steel-manufacturing and steel-consuming sectors, and beyond, in the economies of the six countries generally.
This is a matter of very great moment indeed, affecting, as we are aware, the whole standing of the High Authority. We, Members, care keenly about that standing, not just as people, but with a consuming, all-absorbing intensity. For to us the Community movement is something that has sprung from the agonies of our six countries' young men and women in two World Wars, from the hope that blossomed in and after 1945, and from the heart and soul and mind that intellectuals and thinking producers, technologists and workers have put, despite recurrent and still persisting obstacles, into the building of Europe.
On this, I think, we can wish one another good luck, and it is fitting too, that we should do so in the watchful presence of those from other parts of the world, who resolved of their own accord to associate themselves with our great venture, and who rightly expect not to be betrayed and disappointed.
And so I felt it to be permissible, indeed most fitting and proper, at the conclusion of this Congress to look for an instant to wider horizons, and, while continuing to concentrate on our daily labours, to be mindful, all of us, of the things we are striving for and the ultimate ends towards which Europe is to move.

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