euro spectra

SCIENTIFIC
AND
TECHNICAL REVIEW
OF THE
EUROPEAN
COMMUNITIES

SEPTEMBER 1969
VOL. VIII
NO. 3

Use of tyndalloscope and konimeter for dust-measurement (see p. 77).

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spectra

Scientific and Technical Review of the European Communities
(formerly Euratom Review)

1969-3

Quarterly publication

Five editions:

English, German, French, Italian and Dutch

Published and edited by:

Commission of the European Communities,
Directorate-General Dissemination of Information,
200, rue de la Loi,
Brussels 4, Tel. 350040

Subscriptions:

For details on how to subscribe please see order form facing last page.

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Let us hope that the setting-up of the Eurosat consortium recently by some fifty European firms may signify a new awareness of this problem.

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Sales office:

Agence et Messageries de la Presse (AMP)
1, rue de la petite île
Brussels 7
Belgium

Yearly subscription rates:

United Kingdom 21/-; United States $ 3.50

Basic rate:

Europe: 125 Belgian Francs

Other countries: 175 Belgian Francs

Single copies:

United Kingdom 7/-; United States $ 1.-

Printed in the Netherlands
by A. W. Sijthoff, Leiden

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Whither nuclear fission?

Will historians in the year 3000 devote just a few lines to nuclear energy, or will a whole chapter be needed to describe its contribution to progress?

JEAN LECLERCQ

The nuclear research effort

SINCE THE END OF the Second World War and even today the peaceful utilisation of nuclear energy has been the object of an immense research and development effort. At first confined to a few very big states, this effort, which has continually expanded, has been steadily taken on by a growing number of countries.

To begin with, nuclear research and development was exclusively in the hands of the national governments. Today, although these government offices, which have been joined by international institutions of regional or world magnitude, still retain a very substantial portion of the activities in question, another portion, which is constantly increasing and in recent years has probably become the major part, is carried out by private concerns.

One may wonder if it is worthwhile for the human race to devote to the development of the peaceful uses of nuclear energy a vast amount of capital and labour that could probably be directed to ends more immediately productive of prosperity and civilisation.

To the question as to why this effort is made, one might give the famous reply concerning the reason for climbing Everest: "Because it is there!"

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Or, in a less sportive vein, one could say that, in view of the gigantic efforts and sums expended to turn nuclear energy into a terrifying means of destruction, it would be wrong to spend much less on harnessing it for peaceful purposes.

However, the economy is hardly swayed by fine gestures, or by moral arguments either.

Development of the use of a new energy source can indeed be of great scientific interest and produce major repercussions in technology and industry. But it is only when, both in quality and in quantity, it fulfils the requirements of man that it finds its true calling.

Future estimates and prospects

The last fifteen or twenty years have hence seen numerous efforts to forecast the place that atomic energy may occupy in national or world energy contexts. Because of the long years that had, and according to some still have, to elapse before it reached its full industrial coming-of-age, the numerous predictions were always of a long-term nature.

To a public which, generally speaking, regarded any prediction, even only a few months ahead, as "crystal-gazing", assessments reaching forward twenty, thirty or even forty years could only add to the scepticism that surrounded the development of nuclear energy.

And yet a moment of thought as to whether this development is justified, or what broad lines it should follow shows the imperative necessity of going beyond even the long-term estimate and trying to situate nuclear energy in a prospective view.

There are, I think, two kinds of difference between the forward estimate and the prospect.

First, a difference of time: at present the boldest estimate does not go beyond the end of the century, whereas the term "prospect" is only used for the years 2000 onwards.

Secondly, a difference in the meaning of the assessments proposed. In estimates, a figure has a meaning as such, even if it is presented as an order of magnitude or a "range" or if it is bounded by margins of uncertainty which are themselves expressed in more or less precise figures. In the prospect, figures are only used as examples or illustrations of a general trend.

In fact, placing nuclear energy "in perspective" really means asking what part it will play in the "coming history" of mankind—or, again, wondering how the historians of the year 3000 will describe the emergence of this new form of energy and its effects on world civilisation. Will they simply accord it a few lines, or will a whole chapter be needed to describe the importance of this new energy source, displacing fossil fuels, in the evolution of all mankind towards a very high level of material prosperity and civilisation?

The reasons for nuclear development

It is recognised today that recourse to nuclear energy—and here we are referring very exclusively to nuclear fission energy—is necessary for two main reasons.

First, in spite of the fact that the energy now produced from the atom is still relatively expensive, there is every reason to believe that nuclear energy will soon have a constantly growing price advantage over the traditional sources. Other articles in this review have described and given the grounds for these development prospects[1] and I shall mere-

1. See the articles by HANS MICHAELIS, *Euratom Bulletin*, Vol. I (1962) No. 4 p. 10; Vol. III (1964) No. 1 p. 2; Vol. IV (1965) No. 3 p. 91; Vol. VI (1967) No. 2 p. 40.

First, in the domestic sector, the major desire for a higher standard of living and comfort and for labour-saving devices leads to a constant, inevitable rise in individual consumption.

In the industrial sector, the tendency towards an ever-increasing consumption of goods and services can only be reconciled with the call for shorter working hours and increased leisure by the gradual adoption of automation and of the machinery it entails. All this means greater consumption of energy.

Nor do the foregoing remarks apply only to the goods and services known and used at the present time. The introduction of new products, new activities and new services accelerates the trend, because innovations generally consume more energy than traditional activities. This effect is only very partially offset by the reductions in consumption afforded by improved efficiency in the production processes already in operation.

Another energy consumption factor which by its very nature will persist into the very long term is the fact that, as the basic industrial or energy materials are used up, we shall have to resort to poorer ores, and to mine deposits located at greater depths or in less hospitable regions or below the seabeds, or even, perhaps in a few decades from now, on other planets.

A fourth factor, partly linked to the previous ones, lies in the growth of transport as regards both the number of people or the volume of goods carried and also the distances travelled and the speeds attained. Here again there appears to be no inevitable limit[2]; once confined, for most people and goods, to the interior of a given region, transport only recently shifted to the intercontinental scale and may well be already on the threshold of the interplanetary age.

Alongside these very general factors which tend towards increased energy consumption, there are scarcely any working in the opposite direction. It is conceivable, of course, that spectacular discoveries will render certain operations or processes obsolete and bring about radical energy savings far greater than the

ly mention here its importance in regard to cheap fuel supplies and therefore to general economic expansion.

The second reason concerns quantity. Energy estimates are prepared by calculating the likely demand over the period envisaged and setting against it the existing availabilities from different sources, so as to show what additional production or import capacities will be called for.

It should be remarked, however, that in practice the factors of price and quantity are relatively inseparable in these forward estimates.

Apart from the fact that a shortage normally tends to put prices up, it is obvious that as the cheaper accessible energy sources, which are exploited first, begin to dry up it will be necessary to resort to ever more costly ones. In the long run, disregarding temporary or accidental fluctuations, it is the quantity curve that determines the course of costs and prices.

This view is even more pronounced if we move from the standpoint of estimates to that of prospects.

Admittedly prices continue to play a part insofar as, in times of plenty, they influence the consumers' choice. But in the very long term the contribution of a given energy source is essentially to be measured by the quantities used, even if they have been determined in part by production costs and the selling price.

The trend of demand

In the long-term prospect the importance for the future of nuclear energy development must be assessed first of all in the light of the evolving trend of requirements. I shall therefore try to point out some of the more important factors that govern this trend, before illustrating it with some hypothetical cases.

To begin with it is essential to recognise one basic factor, which is that, however far forward we look, there is no apparent reason why the overall demand for energy should shrink or even remain constant; on the contrary, there are a number of reasons why it should in crease.

A population increase can only be regarded as certain in the next fifty or a hundred years. Unquestionably, however, even if the world's population were to level off during that time, it would then be twice or three times the present figure and, furthermore, the average requirements per head would go on increasing thereafter, for various reasons.

2. Apart, of course, from the theoretical physical limit which is the speed of light *in vacuo*. But that is still a long way off!

economies normally achieved by improved efficiency to which I referred earlier.

For instance, it is sometimes suggested —outside the realm of science fiction— that we might achieve control over the force of gravity. Even with partial control, the energy needed for a multitude of operations would be substantially reduced . . . subject to one scarcely feasible condition, namely, that to master the gravitational forces it should not be necessary to use practically as much energy (if not more) as is needed to overcome them.

. . . what place will the historians allot to nuclear energy in the year 3000?. . .

of figures in prospective studies, it is possible to propose a simplified outline of the growth of annual consumption and of cumulative quantities that will be consumed in the world as a whole, starting from the present and covering, say, the next three centuries.

On the strength of various estimates, we can expect the following annual consumption figures (in 10^9 tons hce) up to the end of the century[3]:

1965 : 5.5	1980 : 11
1970 : 7	2000 : 20

Thereafter, for the three following centuries, we can sketch four hypothet-

Whatever happens, we cannot count on a reversal of the tendency towards increased energy consumption during the next few centuries. Here we must take care: the foregoing statement does not mean that such a reversal must be ruled out; it simply means that in organising today with a view to tomorrow, we cannot rely on any such radical change.

Examples of quantitative estimates

To illustrate the foregoing, and bearing in mind what was said about the meaning

ical developments based respectively on growth rates of

A: 3% per annum
B: 2% per annum
C: 3% per annum from 2000 to 2100
   2% per annum from 2100 to 2200
   1% per annum from 2200 to 2300
D: 2% per annum from 2000 to 2100
   1.5% per annum from 2100 to 2200
   1% per annum from 2200 to 2300.

On the basis of these assumptions we can draw up Table I.

3. tons hce = metric tons in hard-coal equivalent at 7,000 kcal/kg.

Even if we reject hypothesis A, which leads to truly astronomical figures, we arrive at annual consumption values which are, in order of magnitude, at least several hundred times as great as the present values. And in three centuries we should use up quantities of energy that at today's rate could have lasted some tens of thousands of years.

The question is, therefore, where are such quantities to come from?

Table I: Annual and cumulative energy consumption in the coming three centuries, according to four different hypotheses concerning the rate of increase in requirements.

Hypothesis	A (3%)	B (2%)	C (3-2-1%)	D (2-1.5-1%)
1) *Annual consumption* (10^9 hce)				
year 2000	20	20	20	20
2100	385	145	385	145
2200	7,430	1,050	2,800	640
2300	143,000	7,600	7,600	1,700
2) *Cumulative consumption* from 1965 (10^9 hce)				
year 2000	430	430	430	430
2100	12,800	6,700	12,800	6,700
2200	252,000	52,000	134,000	40,000
2300	4,800,000	380,000	610,000	150,000

The fossil fuel reserves

Before trying to answer this I must make one comment concerning the concept of reserves, the complexity of which is bound up simultaneously with:
—the very nature of our knowledge of deposits, which may be based on exact measurements, extrapolations, mere conjectures or general geological reasoning;
—the technical and economic feasibility of recovery;
—the economic conditions of exploitation, by comparison with other competing sources.

This complexity gives rise to uncertainty which is only partly removed by the explanation that we are speaking of measured, proven or calculated reserves, probable or estimated reserves, or potential reserves, especially as these various concepts mean little unless accompanied by prices or costs.

Clearly, then, there is a great difference between the total physical volume of reserves and the amount that will ultimately be utilised.

Leaving this question aside for the moment, let us look at the size of the estimated reserves of fossil fuel. Unfortunately, it is very difficult to choose between the many different estimates advanced. To give an idea of their variety, we shall here consider two which avoid the extremes of optimism and pessimism and which cover all fossil fuels.

One is taken from a report prepared in 1962 by King Hubbert, entitled "Energy Resources"[4]. The other was prepared for the 1968 World Power Conference on energy resources and concerns total reserves, i.e. the measured or proven reserves plus the presumed or estimated reserves (see Table II).

One conclusion emerges: by comparison with the cumulative requirements mentioned above, the fossil fuel reserves as estimated at present would hardly carry us to the end of the next century.

To this initial conclusion we can apply two contradictory correction factors.

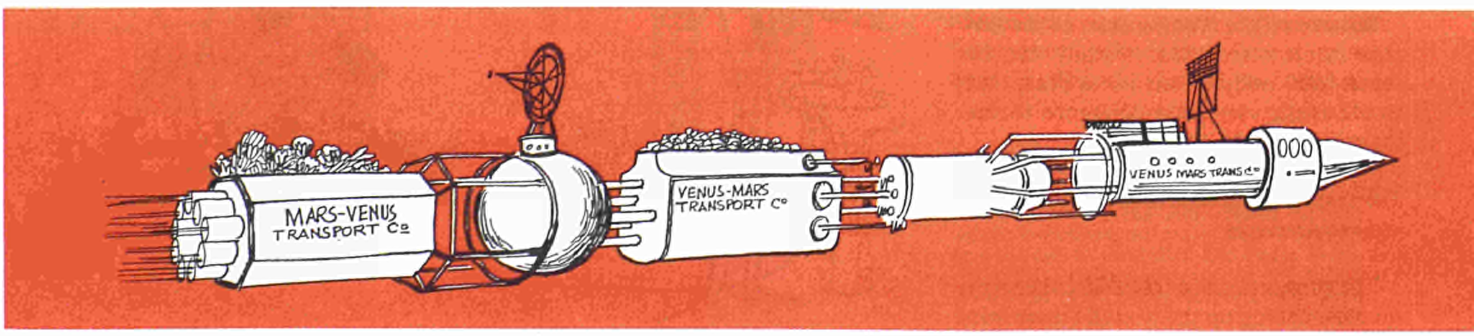
Self-renewing energy sources

The Hubbert survey also assessed the contribution available from the "renewable" energies, i.e. those drawn from more or less regularly replenished sources rather than from reserves built up over the geological ages.

These sources are mainly solar, wind, geothermal, hydraulic and tidal energies.

Except for special, small-scale purposes, wind power is little used and is likely to remain so, because of its irregularity and the low unit capacities achievable. Solar power is in much the same position, in spite of the enormous stream of energy

4. Energy Resources. A report to the Committee on National Resources of the National Academy of Sciences—National Research Council — by King Hubbert, Chairman of the Energy Resources Study, Washington DC, 1962.



delivered to the world in this form. The attempts to convert solar heat into electricity have proved very expensive and, moreover, demand plant of very extensive area if any considerable capacity is desired.

Geothermal and tidal power, like hydraulic power, depend on the installing of plant at specific sites. The latest list of potential sites for tide-powered or geothermal power plants indicated that capacities of several thousand MWe could be installed for each of these sources. Since then, however, the French experiment with the Rance plant does not seem to have justified the hopes that its sponsors placed in tidal power.

Hydraulic energy, on the other hand, could provide a world-wide electrical capacity of about three million MWe, of which only about 5% is already installed. Such a capacity would supply not more than 10 million million kWh a year, which, at the conversion rate of 300 g hce per kWh soon to be achieved, gives 3,000 million tons hce a year.

Thus it can be estimated that the renewable sources are altogether capable of providing, probably in a rather remote future, a maximum regular contribution of between 3,000 and 4,000 million tons hce as against the approximate 200 millions of today.

But even if the requirements of the distant future were thus virtually cut by some 4,000 million tons hce a year, that would make very little difference to the magnitude of the problem.

The respective structures of reserves and requirements

The proportions of the different energy sources making up the overall reserves in no way correspond to the present distribution of consumption. Coal, which forms over 70% of the reserves according to Hubbert and over 90% according to the World Power Conference, now represents less than half of world consumption, whilst oil, which makes up more than 40% of world consumption, forms —even taking liquid fuels of every origin into account—only something less than 20% of the reserves according to Hubbert and less than 5% according to the World Power Conference.

This mismatching of resources and requirements shows that there would be difficulties long before the world resources are exhausted.

The potential nuclear contribution

This being so, we must now determine what contribution nuclear energy can make. In order to assess it properly, one must bear in mind that the exploitation of fission energy and the exploration of uranium resources are both really only just starting.

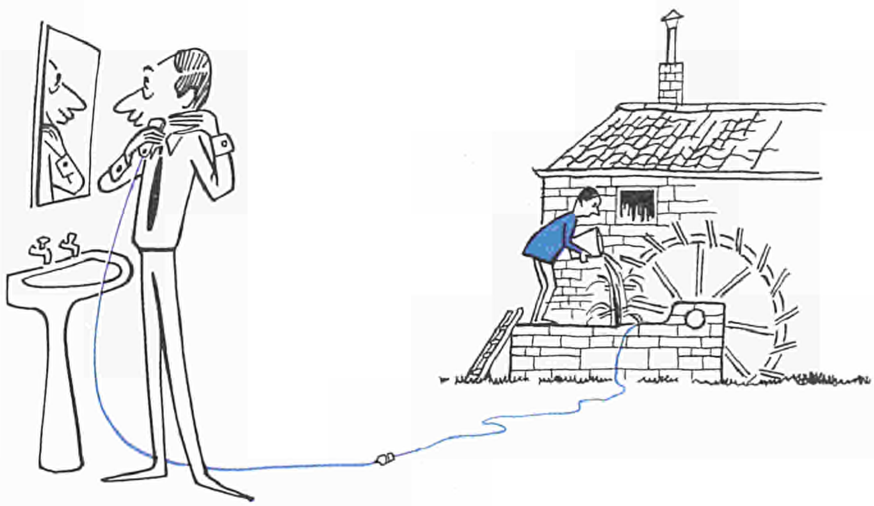
It will therefore be necessary, as regards both reserves and efficiency ratings, to adopt both cautious hypotheses which have already been established and the more optimistic hypotheses which may reasonably be entertained given suitable developments.

According to the World Power Conference, total uranium reserves may at the present time be estimated at 3,300,000 tons of oxide (U_3O_8), or 2,800,000 tons of metal.

If we take as our basis the efficiency factors now being achieved in industrially proven reactors (leaving aside the energy which can be produced from the plutonium bred), namely 1 g U^{235} = 1 MW d(th) = app. 3 hce, we may estimate these reserves as being approximately equivalent to 60,000 million hce, which will not go very far towards covering future needs.

If, on the other hand, we consider the efficiencies which would appear to be attainable in fast breeders, we arrive, on the basis of the same reserves, at a figure of about 2,500,000 million hce, which is quite close to the total fossil fuel reserves estimated by Mr. Hubbert.

In actual fact, however, as we have already pointed out, uranium exploration is only in its infancy. It has only recently been resumed as a result of the increase in demand, after having been suspended for many years—a factor which is bound to have had its effect on the World Power Conference's estimate of the level of reserves. The pressure of future requirements, coupled with the definite improvement in processes for locating and working deposits, will undoubtedly neces-



sitate a continuous adjustment of estimates of exploitable reserves.

A study by Mr. J. Brinck[5] published in this review assessed uranium resources in the earth's crust to a depth of 2.5 km at 30 million million tons. If we assume that 1% of this mass is exploitable, we arrive at about 300,000 million metric tons, which, with present efficiencies, would give more than 6,000 million million hce. Whatever the growth hypothesis adopted, requirements in the forthcoming centuries would be covered to a very large extent.

With the efficiency factors obtainable with fast reactors, there would be over 250,000 million million hce, i.e. 50 times the cumulative needs for the next three centuries according to the highest hypothesis entertained above (growth in energy requirements a steady 3% per year).

It will also be noted from these estimates that:

— No account has been taken of the costs which would be involved in the working of the reserves under consideration. In the first place, it is a fact that improvements in ore working methods offset the decrease in ore content and the need to tap deeper and deeper deposits. It is also a fact that the influence of the fuel cost on the price of the energy produced is relatively small in the nuclear field and in the case of fast reactors very small indeed.

— No account has been taken of the uranium in the sea, which there are already prospects of recovering.

— Nor has account been taken of the contribution — probably substantial — which will be made by thorium. Although this metal occurs in larger quantities than uranium in the earth's crust, even less is known about the relevant reserves at the present time.

— Finally, nuclear energy will probably never oust all other sources, for users will clearly not wait until some, or *a fortiori* all, of the reserves of fossil fuels have been exhausted before having massive recourse to nuclear energy. On the other hand, they will thus be able to continue for a very long time ahead to employ fossil fuels for certain specific purposes. But in this connection it may be that more attention will have to be devoted to the chemical uses than to their employment for the production of energy.

5. Johan Brinck: Calculating the world's uranium resources, *Euratom Bulletin*, Vol. VI (1967) No. 4 p. 109.

How much nuclear energy will be used?

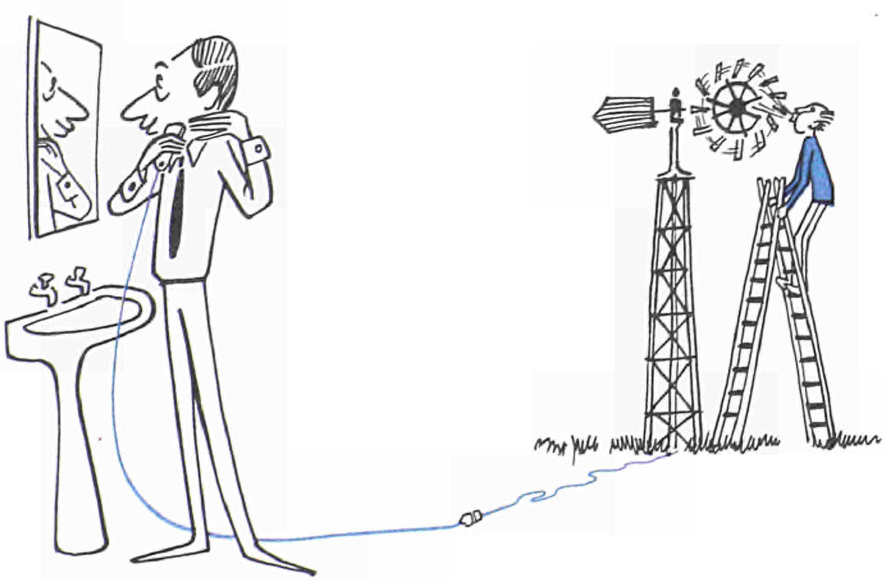
A final question arises. Can we be certain that the potentially tremendous quantities of energy made available to man by nuclear fission will in fact be used?

Experience shows that the technical availability of a source of energy is not in itself a guarantee that it will be utilised. Today, it is virtually certain that a large proportion of the enormous coal reserves will never be worked. This is borne out, moreover, by the trend of estimates of reserves, the highest of which are at the moment appreciably lower than the most optimistic assessments made in the past[6].

To judge from past experience, there is an optimum period for the use of each source of energy. This pattern would appear to be immutable and means that the exploitation of a given source of energy will probably never—in relation to other sources, at all events—exceed the scale which it reached when economic conditions were most propitious.

This does not apply only in the case of coal. It is highly probable that hydroelectric power plant sites on the Congo or the Amazon, which appeared so attractive no more than ten or fifteen years ago, will not be fully exploited. A similar evolution will no doubt occur with regard to oil, even if the peak of the curve of relative importance, already passed for coal, is not yet in sight as regards hydrocarbons in general.

In the case of nuclear energy, too, it is quite on the cards that, through the operation of market forces and competition from another source offering a greater economic attraction, energy derived from nuclear fission will never reach the potential capacities outlined above. The situation differs somewhat, however, from that of traditional sources. While we are already well aware which energy is preparing to take over from fossil fuels, we cannot yet obtain a clear idea of the next stage. This may quite conceivably be energy from nuclear fusion, but at the present time it has not been sufficiently tamed to permit a



6. A striking example is provided by Canada, whose coal reserves were estimated at 1,216,770 $\times 10^6$ t in 1913 and 61,000 $\times 10^6$ t in 1966; the low level of the more recent estimate—which represents no more than 5% of the first—is due to the better knowledge available concerning the deposits and to the fact that allowances were made for the new market conditions.

Table II: World fossil fuel reserves (total reserves in 10^9 hce).

	Hubbert	WPC
Coal	2,320[a]	6,712
Lignite	—	2,100
Peat	—	180
Total solid fuels	**2,320**	**8,992**
Oil	220	150
Natural gas condensate	40	—
Shale oil and bituminous sand	345	285
Total liquid fuels	**605**	**435**
Natural gas	**275**	**185**
Grand total	**3,200**	**9,612**

a. Recoverable reserve, i.e. including coal still present in seams of 35 cm and over in 1961, down to a depth of 900 m and on the basis of a 50% recovery factor.

qualitative and quantitative assessment of its future prospects.

It would therefore appear that for fission energy a field of development is opening up which is vast enough to enable it to fulfil many of the possibilities known to exist, provided, however, that it is available in forms and in sectors characterised by substantial and growing consumption.

Uses of fission energy

Heat production for urban heating, for industrial (possibly metallurgical) applications or for the desalting of sea-water, propulsion for ships, spacecraft and perhaps, at some later date, aircraft or land vehicles—all these applications are possible but, however important they may ultimately become, it would appear that they must be secondary to electricity output. It is a well-known fact that this form of energy, ever since it was first made available to users, has been steadily increasing its share in the end-uses of energy.

There is no need to enlarge on the reasons underlying this expansion, which reflects the operation of a law which is empirical but of fairly general application in time and space and which states that electricity comsumption doubles every ten years. It will suffice to point out that electricity is a very versatile source of energy and lends itself not only to thermal but also to mechanical or chemical applications; that it can be obtained on tap right where it is required by simply flicking over a switch; that it has an efficiency of near unity and produces no waste; and lastly, that it can be employed economically for mass production and for transport within a radius of several hundred miles.

If there is sometimes found to be a saturation in certain uses, new ones invariably arise, and many of the leading prospective growth sectors are electricity consumers.

Here, too, increasing importance is being attached in many countries to pollution of the atmosphere. In this connection, electricity production only offers the necessary assurances if it does not involve the discharge to the atmosphere of the combustion residues of huge quantities of fossil fuel. Hydroelectric, geothermal and nuclear power generation alone satisfy the requirements in this respect.

Conclusions

It is therefore clear that, to the extent that it contributes, as a "preferential" source, to the production of a form of energy consumption which is increasing and will continue to do so for a long time to come at a faster rate than overall power consumption, nuclear energy will meet the conditions outlined above for the coverage of needs over the very long term.

Barring, therefore, the aforementioned possibility of its being timely ousted by another source during the next few decades, it will not prove a mere flash in the pan as regards the satisfaction of man's energy requirements. Without claiming infallibility, we can say that nuclear energy's historical importance is likely to be at least as great as, and possibly even far greater than, that of the hydrocarbons.

Over and above this conclusion, we should like to emphasise that the foregoing does not entirely constitute a piece of mental exercise. If the present is a result of the past, the future, even the distant future, must inevitably help to determine our activities and behaviour today.

In this connection, we should like to make one or two points which certainly have not the merit of originality but which are so important that they have to be brought up when the occasion arises to demonstrate their validity from a slightly different angle.

Firstly, future requirements will be so vast that the various sources of energy will be complementary rather than competitive, and they will have to be allowed to find their relative positions in accordance with their specific characteristics.

Secondly, in the development of nuclear energy the greatest possible attention must be paid to the fuel cycles, every effort being made to widen their range and improve their efficiency. The fast reactor development work, the use of thorium and studies on reprocessing techniques must be in the forefront of research.

Thirdly and lastly, no effort must be spared in the exploration of nuclear fuels and the improvement of techniques for extracting them.

When all is said and done, it is comforting to note that use of the crystal ball—which we believe to be reasonable—serves not only to justify the extent of the research and development efforts which are being and are due to be made for the promotion of nuclear energy but also to bear out the major trends the importance of which is now generally recognised.

It would appear that, like Molière's bourgeois gentilhomme with his prose, we are planning ahead without knowing it.

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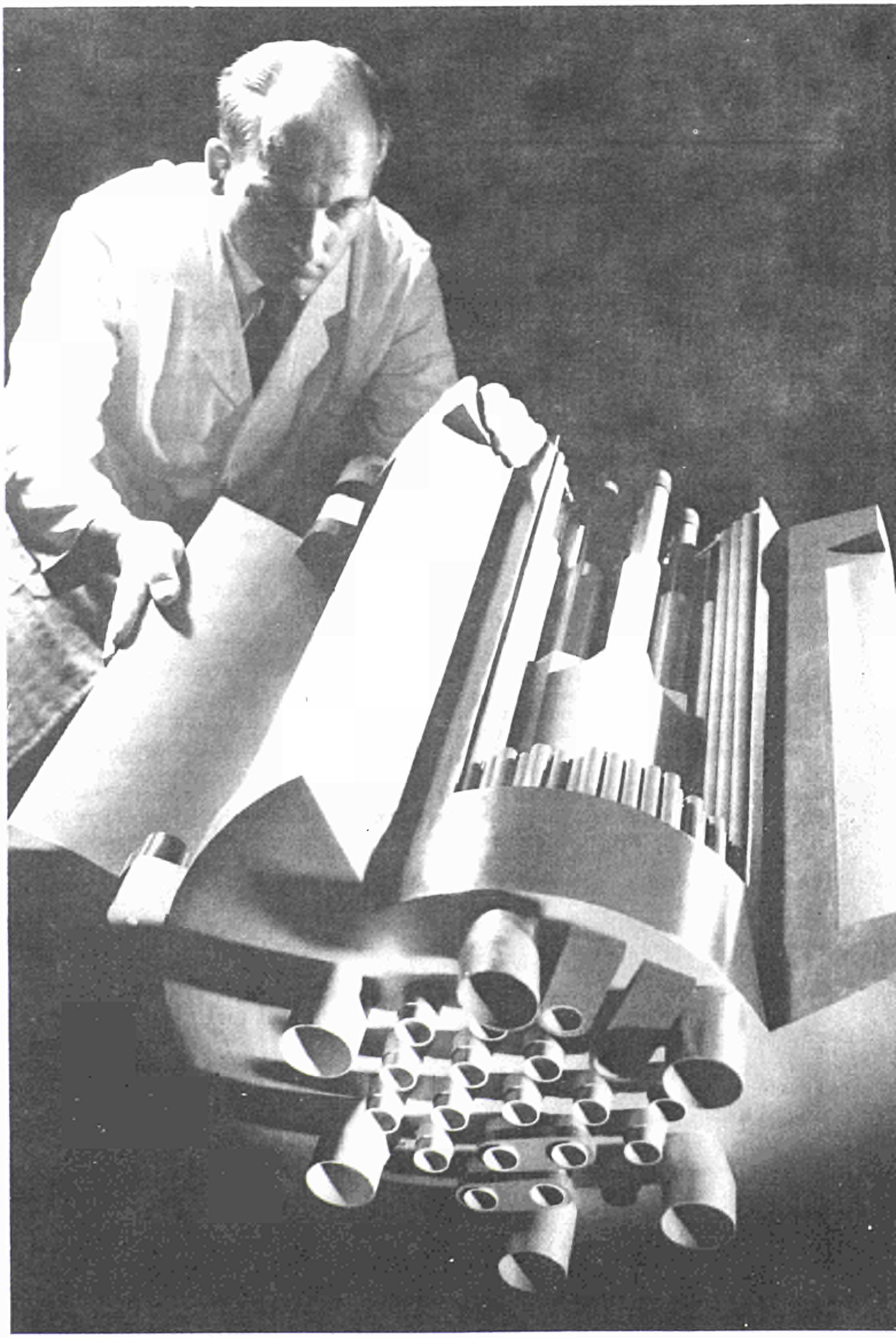
A future application of nuclear energy? – Model of an in-pile thermionic reactor for use as a power source in spacecraft (Siemens – see also Euratom Bulletin, *Vol. V (1966) No. 1 p. 24).*



ECSC sponsorship of coal research

One of the responsibilities of the European Coal and Steel Community is the promotion of research in the coal sector. This article gives a survey of the nature of this task and of the methods used to fulfil it.

GUSTAV WONNERTH

THE AIM OF the Treaty establishing the European Coal and Steel Community *(ECSC)*, which came into force on 25 July 1952, was the creation of a common market for the coal and steel industries.

Promotion of research is not a focal aim of the *ECSC* Treaty; it is only one of the means of exercising a long-term influence on technical development and of improving efficiency.

Under Article 55, the High Authority (whose duties were taken over by the Commission of the European Communities in 1967) is required to foster technical and economic research directed at improved production methods and the expansion of coal and steel consumption, and also at greater safety in these industries.

Dr. GUSTAV WONNERTH is Adviser to the Directorate for Coal at the Directorate-General for Energy of the Commission of the European Communities and specialises in coal research problems.

For this purpose, the High Authority has first of all "... to organise appropriate cooperation between the existing research organisations".

The High Authority may itself initiate research projects or help them off the ground by such means as getting the enterprises concerned to adopt joint financing or appropriating for research purposes funds derived from the *ECSC* levies.

Before releasing funds for research of any kind, the High Authority must consult the Consultative Committee, on which are represented not only producers and workers in the coal and steel industries but also the major consumer groups; before appropriating funds derived from *ECSC* levies, it must in addition obtain the consent of the Council of Ministers.

It may be worth drawing attention, without going into details on the subject, to the extent to which the responsibility for research promotion laid down in Article 55 of the *ECSC* Treaty differs in respect of its aim, subject matter and scope from the central nature of the corresponding provisions of the Euratom Treaty. Consequently, research promotion has a wider compass in the one Community than in the other, the lines along which it is run being totally different also.

Organisation of technical research in the coal industry

As a key industry in the economies of the various coal-producing countries in the Community (Germany, France, Belgium and the Netherlands), the coal sector, whose business it is to exploit one of the most important minerals, formerly occupied what in many respects was a privileged position.

Its leaders were quick to recognise that technical progress in their branch

Stone-drift in a mine of the Campine area, Belgium, with circular lining of reinforced concrete. The development of this new technique was financed by the European Community.

Coalface with a mechanised advancing support. This technique was developed in Belgium with financial backing from the European Community.

could be given an appreciable fillip if the different firms would cooperate and pool their efforts in the field of research and development. Thus in the course of time special mining research organisations were set up by the national industrial associations in all the Community coal-producing countries.

These central research bodies—in Germany the *Steinkohlenbergbauverein*, Essen *(STBV)*; in France the *Centre d'études et de recherches des Charbonnages de France*, Paris *(CERCHAR)*; in Belgium the *Institut national de l'industrie charbonnière*, Liège *(INICHAR)*; and in the Netherlands the *Proefstation* and the *Centraal Laboratorium voor de Nederlandse Staatsmijnen*, Heerlen—had as one of their main tasks the solution of the member firms' technical, economic and scientific problems where this could not be done by the firms themselves.

Their second main task was to secure a large-scale exchange of experience among the member firms and to disseminate information on general technical progress. Furthermore they notify the research laboratories of the preoccupations, wishes and needs of producers, thus ensuring the permanent contact and cross-fertilisation which are so vital between research and industry.

For various problems and tasks peculiar to the mining industry, such as those relating to mine safety or mine hygiene, carbon chemistry, geology or coal utilisation technology, the joint research organisations set up specialised research centres, both with and without government backing. A notable contribution to mining research and development—particularly in the early days of scientific and technical development—was made by the mining school institutes and also by the colleges of advanced technology. Work in the fields of machinery and process technology has however for the most part remained the province of the suppliers concerned.

Shortly after the establishment of the European Coal and Steel Community, the national mining associations formed an "umbrella" association for Europe, the *Western European Coal Producers' Association (CEPCEO)*, to safeguard the common interests of the various mining industries at supranational level, particularly with relation to the *ECSC* Executive; the technical interests are dealt with by its Technical Research Committee.

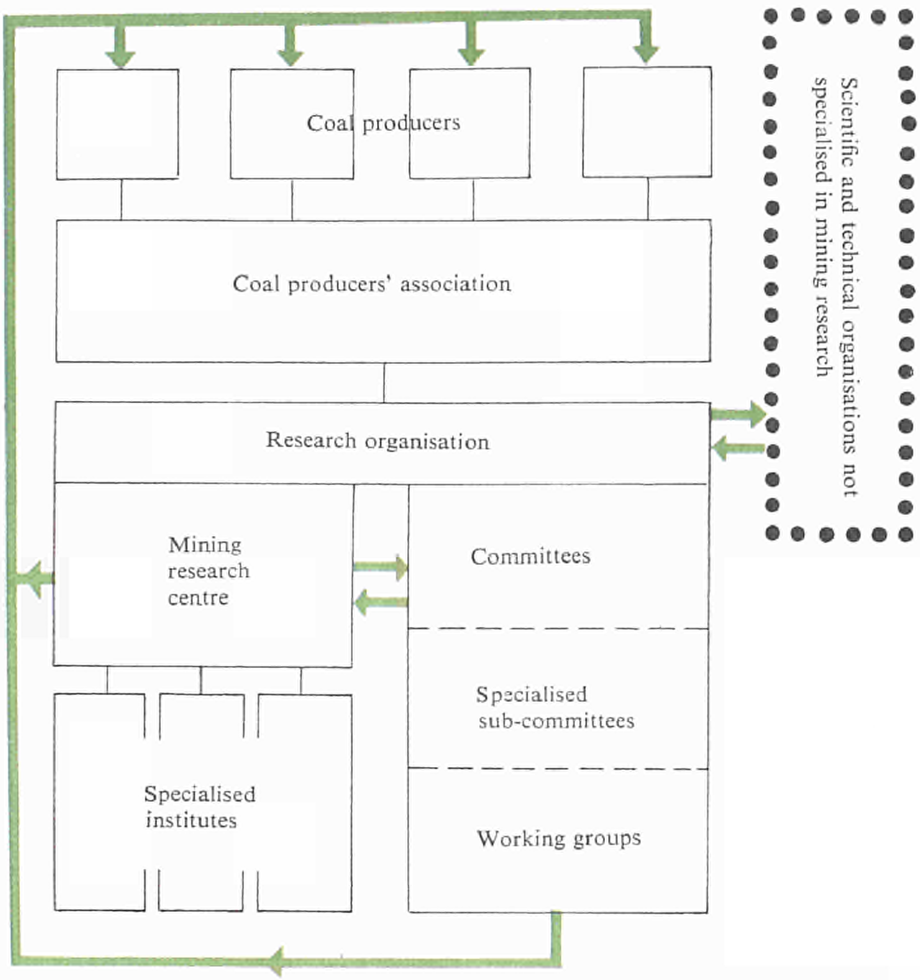


Figure 1: Typical organisation of coal research at the national level (the coloured arrows represent flow of information).

The structure of technical research and development in the Community coal industry as outlined above, together with inherited traditions and attitudes, formed the backdrop against which the High Authority had to set about its mission of promoting research.

Promotion of cooperation among the various research organisations

The first step to be taken towards the improvement of cooperation between the mining research organisations was to acquaint those responsible for research and development in the coal industry with the state of technology and research in the various coal-producing countries in the Community, the problems on hand, the available resources in equipment and manpower and the research activities in progress.

To this end, the High Authority set up two international technical committees, one for mining technology and the other for coal valorisation. These committees consist of leading experts from the mining companies and of the responsible heads of the central research organisations. They meet once a year to study particular sets of problems, each time in a different

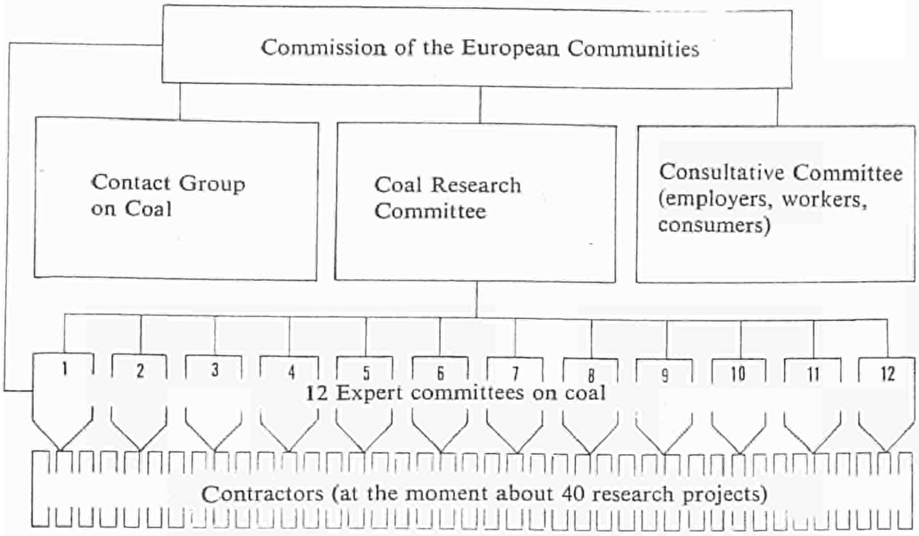


Figure: 2 Organisation of promotion of research on coal by the European Community

Expert committees:
1. *Heading techniques*
2. *Winning techniques*
3. *Remote control and automation*
4. *Explosives and explosions*
5. *Rock pressure and supports*
6. *Firedamp and ventilation*
7. *Thermal treatment of coal*
8. *Coal preparation*
9. *Clean air*
10. *Fundamental research in chemistry*
11. *Technical documentation*
12. *Coal utilisation.*

coalfield. The results of these meetings are conveyed to the national mining associations and organisations in the form of publications and abstracts for further distribution to the mining companies and collieries. In this way, the research results and development work achieved at a given establishment are made available as promptly as possible to the entire Community mining industry, thus making a substantial contribution to technological advancement on a broad front and to the avoidance of duplication of effort.

The second step towards the improvement of cooperation between research organisations and the coordination of their activity was the creation of a central committee on coal research for the Community, on which the heads of the mining research institutes as well as experts from the collieries in the three major sectors of coal research (mining techniques, coal valorisation and coal utilisation) are represented. This committee is responsible for advising the Commission on all important research matters, appraising the merits of proposed research projects and lending the Commission technical assistance in the implementation of programmes.

In order to improve cooperation and the exchange of experience in some special sectors a fairly large number of technical committees were set up at Community level in each of which are represented the experts in the sector concerned from the various Community coalfields and research centres. These committees are responsible for supervising the execution of Community sponsored research in their special field.

Over the years the projects undertaken have tended more and more to involve the participation of research institutes in two or more countries. Some programmes developed into truly Community research projects, bringing together the mining research centres of all the member countries and also all leading scientists and researchers in the field concerned from various institutes in the Community.

The apportionment of the work between countries, coalfields and institutes is done in accordance with common objective principles, the determining factors being the technical competence, specialisation and research potential of the institutes or researchers.

Guidance and coordination of coal research

In its "General targets for coal", published in 1955, the High Authority had already indicated its main guidelines and priorities for technical research. In a document brought out in 1963, "The High Authority's research policy in the technical field", the most important research projects to be sponsored by the Community in the coal sector are set out in concrete terms.

These were supplemented, at the suggestion of the High Authority, by a programme for research and development in the field of mining techniques, drawn up in 1965 by the *CEPCEO* Technical Research Committee, already mentioned above, which at the end of 1967 issued a new version covering in addition the fields of coal valorisation and utilisation.

The malaise in the Community collieries in the sixties, the need to improve their technical efficiency and pressure to make the most rational use of dwindling research funds pointed to the advisability of concentrating research efforts. With this aim in view, a medium-term coal research programme was worked out for the Community and published in the summer of 1968. It contains the research activities and projects to be undertaken by the Community in the immediate future.

Financial backing for research

Among the various methods of promoting research open to the *ECSC* under Article 55 of the Treaty the appropriation of sums from the Community levies has proved the most efficacious. Coal research, apart from work carried out in colleges of advanced technology, is financed mainly by the collieries themselves. The principal beneficiaries of backing from the public authorities are institutes dealing with problems of workers' safety or industrial hygiene.

For the accomplishment of its mission, the High Authority—now superseded by the Commission of the European Communities—is empowered by the *ECSC* Treaty to impose a levy on coal and steel output. From this source the *ECSC* Executive covers not only its administrative expenses but also its outlay for the retraining of workers made redundant by rationalisation measures and for the sponsoring of research projects by the Community.

Up to the end of 1968, a total of about 100.3 million u.a. had been made available by the *ECSC* for the promotion of research, breaking down as follows:

—coal: approx. 29.7 million u.a.;

—iron ore and steel: approx. 39.0 million u.a.

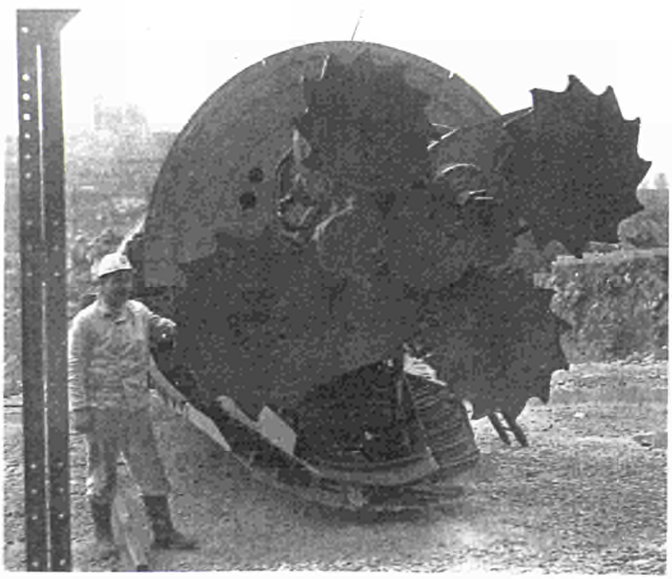
—workers' safety and industrial hygiene: 31.6 million u.a.

As a rule, such aid covers only part of the research costs; the proportion defrayed by the Commission depends on the nature of the research (basic or oriented), the significance of the project for the Community from the technical, economic and safety standpoints, and the type of body undertaking the research (mining research centres, institutes attached to technical colleges or industrial firms). This proportion varies widely, ranging from 30 to 100% of the actual research costs, and may be said to average about 60%. The research aid is in principle granted on a non-repayable basis.

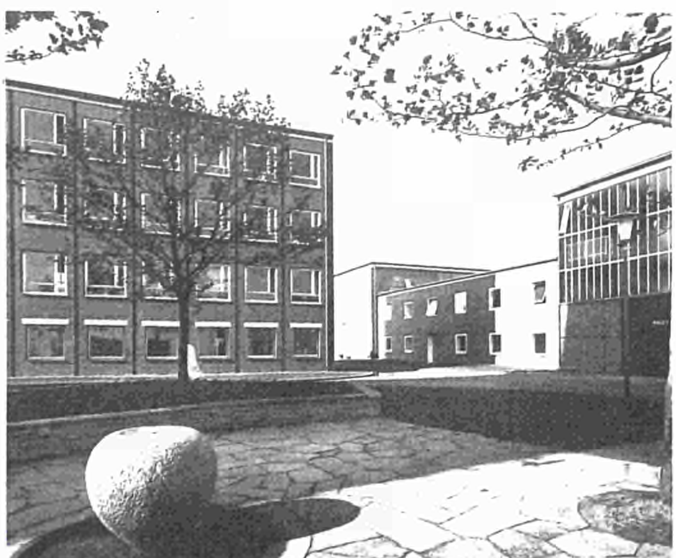
The extent of the Community's contribution to total expenditure on mining research is very difficult to pinpoint, as the definition of the term "research" differs from country to country. It is estimated at 10-15% and varies considerably according to which coalfield or research sector is considered.

Use of tyndalloscope and konimeter for underground dust-measurement.

Milling head of Krupp *drifting machine for 3.6 m dia roadway.*



View of the main courtyard of the Bergbauforschung GmbH *at Essen-Kray, Germany.*



equipment or materials developed or for the acquisition of licences), the *ECSC* also encourages publication of such results. This is done through the medium of the Annual General Report, the half-yearly reports of the various establishments performing the research, which are sent to the technical committees and experts, articles in the technical press, the final reports on major research projects, which are circulated as "Coal research booklets", and also the holding or financing of technical symposia.

After this overall survey of coal research promotion by the *ECSC* it may be said that the efforts of the High Authority and the European Commission have given technology a certain impetus in this field. These endeavours have been backed by goodwill and understanding on the part of all concerned—researchers, producers, workers and consumers.

A further article, to be published in the near future, will present the main coal research projects sponsored by the Community and high-light their results.
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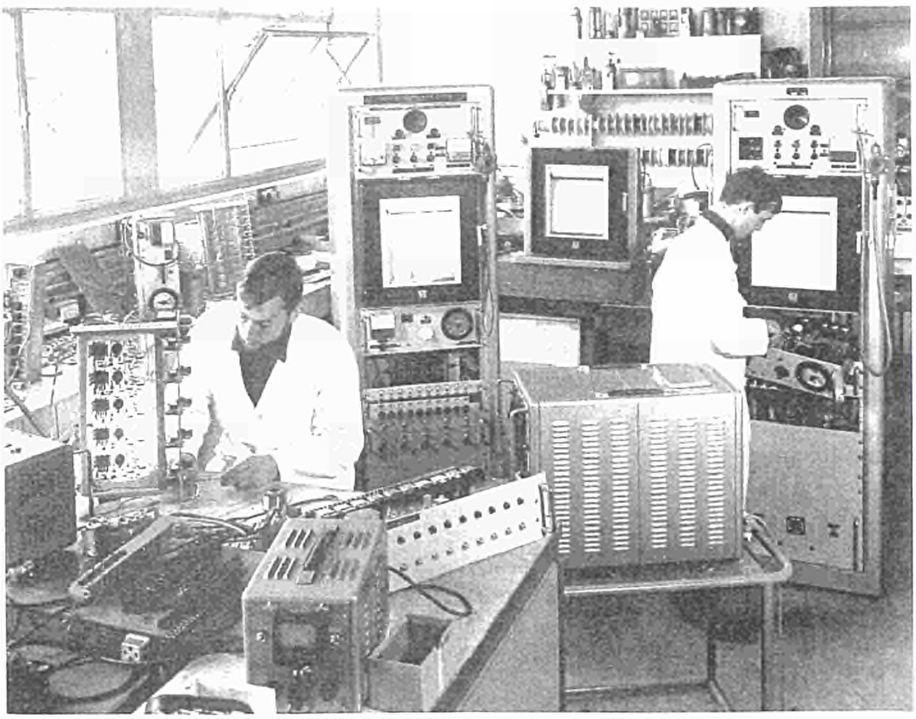
Firedamp detection laboratory (Verneuil-en-Halatte, France).



Dissemination of research results

The Executive is expressly required by the *ECSC* Treaty to disseminate and guarantee access to research results, when these have been achieved with Community resources. For this purpose the High Authority relies to a great extent on the assistance of the national mining associations and research organisations.

Apart from ensuring direct access to research results (through definition of the conditions governing the purchase of

Irradiation technology and the European economy

The industry of the European Community should not only make full use of this advanced technology but take an active part in its development.

GEORG PRÖPSTL

THE ECONOMIC aspects of irradiation technology in the European Community form a complex topic which can only be dealt with in part. It would therefore be wrong to expect an economic analysis containing observations backed by statistics, as would be suitable for an established branch of industry. Any discussion of the economic aspects of irradiation involves entering the front-line area of the technological battle, where there are retreats as well as advances. Ground is won when new processes developed as a result of scientific research are recognised as economically attractive, but a step back has to be taken when a supposedly viable new method cannot stand up to the harsh realities of industrial practice.

Since the use of irradiation is still at the frontier between research and development and industrial production, the statistical and other data which are usually characteristic of a branch of industry are still scarce. Consideration should also be given to the fact that there is a considerable gap between the technology and use of irradiation in the highly industrialised countries and the European Community, although efforts are being made to make up the leeway. It is therefore understandable that a quantity of data is in existence but cannot be included in a report presented to the public.

Dr. GEORG PRÖPSTL is the Head of the Eurisotop Office which forms part of the Directorate-General for Industry of the Commission of the European Communities.
The article is an extract from a paper read at the Conference on the irradiation of foodstuffs, chemicals and plastics held in the "Haus der Technik", Essen, on 11 June 1968.

Irradiation technology

It seems appropriate, before examining economic aspects, to define what is meant by irradiation technology here. Basically it involves irradiation with high-energy rays, thus causing specific chemical, biological or physical changes in the material through collision or ionisation. Changes in the atomic nucleus are not within its scope, these coming under the heading of nuclear reactions or nuclear chemistry.

Radiation therapy, radiation-induced mutations and the stimulation of biological processes by radiation are not discussed. The topics dealt with are, rather, radiation chemistry in the narrower sense, i.e. the induction of chemical reactions, such as the use of radiation for polymerisation, cross-linking and grafting, radiolysis and radiobiological effects such as the inhibition of fruit ripening, the preservation of foodstuffs, disinfection, sterilisation, etc.

Purely nuclear work such as testing the strength and behaviour of reactor materials under radiation is not touched on here either although such research can be of considerable economic importance.

Production of irradiation devices

In the irradiation industry three different types of irradiation devices are used, (Table I) namely, radioactive sources, nuclear reactors and electrical irradiation devices.

In the *first group*, beta- and alpha-sources have so far been employed only in the form of small irradiation devices for ionisation of the air. Large beta or alpha radiation sources are at present unknown. There is a possibility, however, that in the future large surface-type radiation sources will be used alongside the electrical electron-beam generators mentioned further on. The technological know-how necessary for building such radioactive sources is lacking today.

Spent fuel-elements have hitherto found no industrial use as radiation sources, although the reactor industry would welcome such possibilities. The varying spectrum, the need for cooling and the handling difficulties are all obstacles to further utilisation. It is possible, however, that with the increasing number of nuclear power plants special uses for spent nuclear fuels will be found. It is not likely that they will be used for irradiating foodstuffs, because radiation from nuclear fuels is capable of inducing a slight amount of radioactivity in the irradiated substances.

At present, therefore, only cobalt-60 and caesium-137 are available for large irradiation devices. As regards cobalt-60, the European Community has an adequate production capacity in its experimental, power and materials-testing

Table I: Irradiation devices.

(Industrial application: X = desired, XX = anticipated, XXX = existing.)

Radioactive sources	
Beta and alpha sources	XXX
Spent fuel elements	X
Co^{60}, Cs^{137}	XXX
Nuclear reactors	
In the reactor	X
Near the reactor	XX
Electrical irradiation devices	
Electrons	XXX
X-ray bremsstrahlung	XX
Ions	XXX

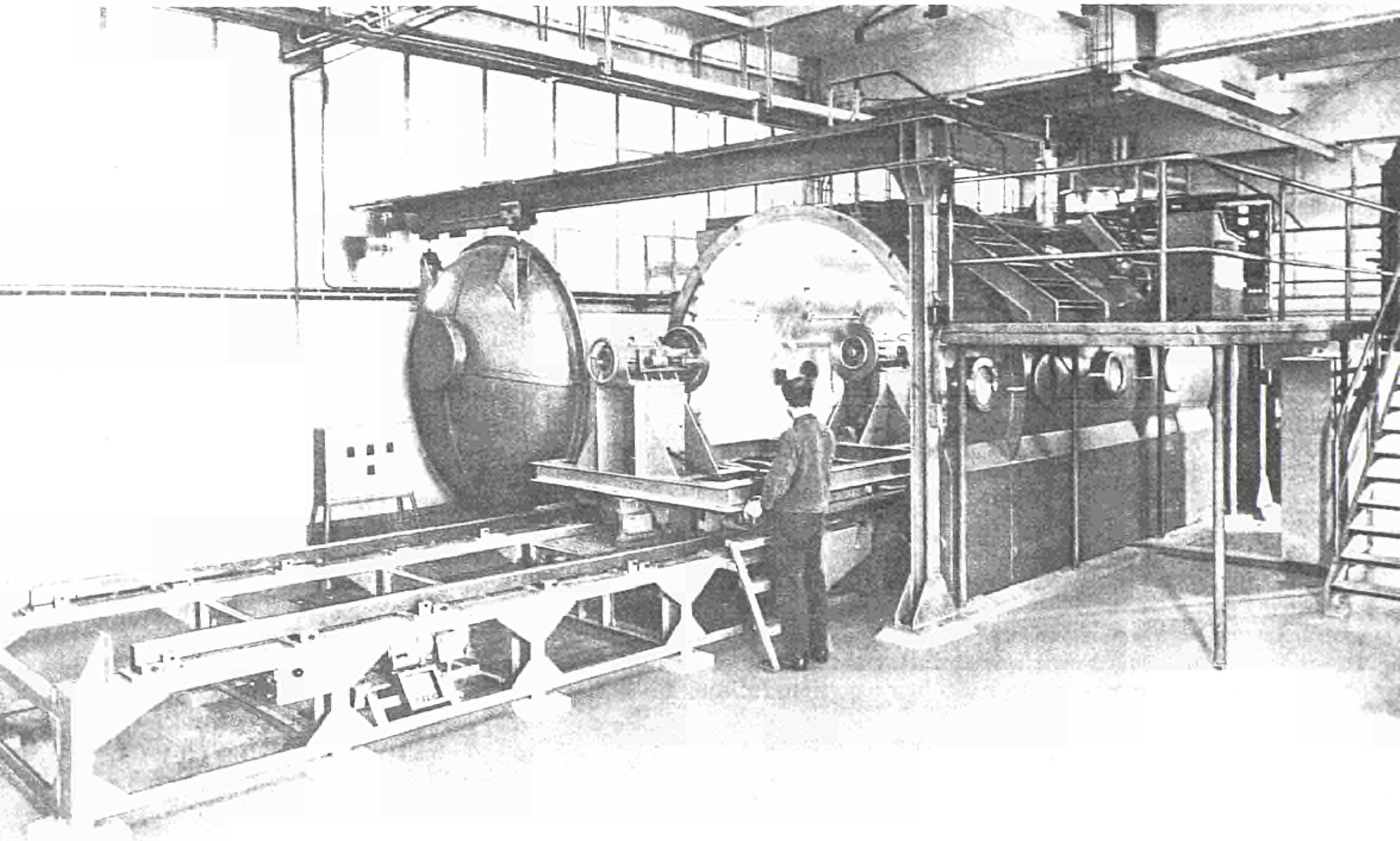
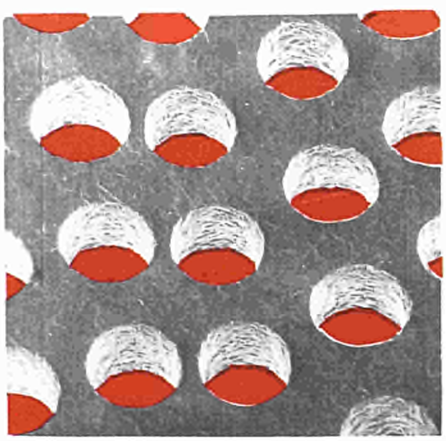


Figure 1b: *Nickel plate perforated by electron beam (plate thickness and hole diameter 0.1 mm).*



reactors. The *BR*-2 reactor, operated jointly by Euratom and Belgium, is able by itself to cover the Community's present-day demand, notwithstanding which, this isotope is imported on relatively favourable terms from Britain, the United States and Canada. The supply situation is considerably more difficult in regard to caesium-137, which is obtained from spent nuclear fuel by chemical separation. The European Community is dependent on deliveries from the United States until France brings its big separation facility at La Hague into operation. The heavy cost of this dependence is shown, for instance, by the fact that in mid-1968 the *USAEC* raised the price for caesium-137 by a factor of six. As a result of this major increase, European firms' projects for Cs^{137} irradiation plants have had to be abandoned for some years.

Nuclear reactors are still being contemplated as radiation sources, e.g. for radiation chemistry processes, but as yet there is no industrial project within reach. Further reactor development (honeycomb and fibre fuels) and radiation chemistry research are necessary before such a project can see the light of day. Out-of-reactor irradiations, e.g. by using the radioactivity of the coolant, the moderator or the extracted fission gases, are performed in research centres but not in industry. Industrial utilisation is conceivable provided uses are found that justify the reactor modifications thus entailed.

Electrical irradiation plants are not actually nuclear in character, but cannot be excluded from the discussion on that account. Electrically generated low-energy ion and electron beams of up to 100,000 eV have long been used for the vapour-deposition of metals and for several other industrial purposes. The

Figure 1a: Large electron beam welding machine. Supplier: Steigerwald Strahltechnik. *Length of chamber 6000 mm, diameter 2700 mm; in front: support for working piece; at rear: electron ray gun and control platform.*

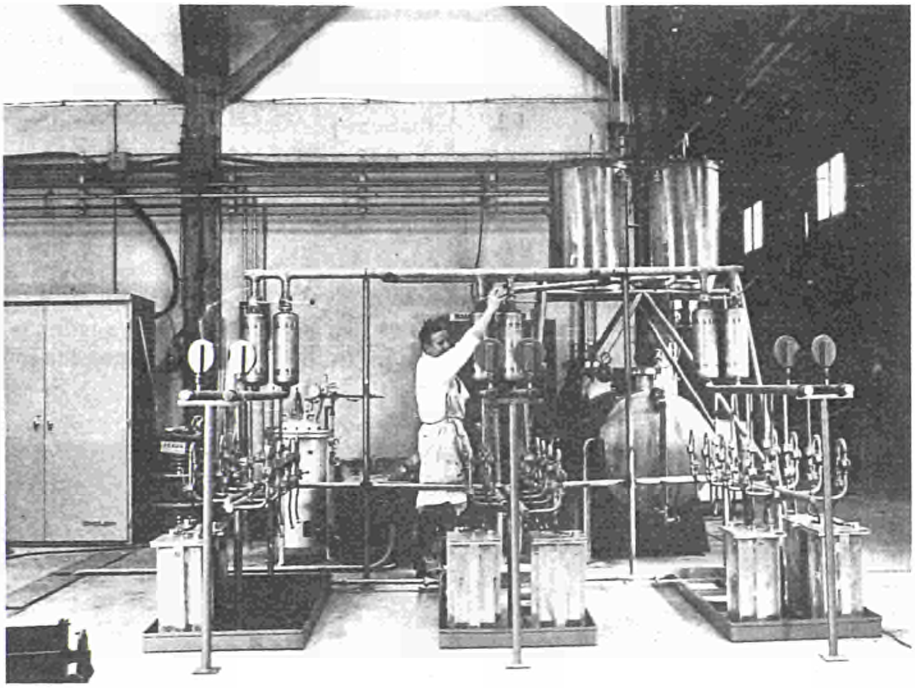


Figure 2: Pilot device for saturating wood wiht monomers for the fabrication of polymer wood (property of Conservatome-Industrie *Paris).*

only high-energy electrical devices used in industry as yet are the electron accelerators (e.g. linear accelerators, van de Graaff generators). These and the cobalt-60 and caesium-137 devices at present supply industry's irradiation requirements as to high-energy and high-intensity radiation.

The Community's own production of high-energy irradiation equipment is very modest. Of the industrial radioactive devices installed in the Community, only two are home-grown products, and only one of the accelerators. No equipment is exported. In contrast the United States have an industry eighteen firms strong for isotope irradiation devices and an eight-firm industry for electrical devices. British firms have eleven industrial installations with an irradiation capacity of 6.8 million curies, six of which have been exported.

In Germany (under the impetus of *AEG*) efforts are being made to let industry adopt X-ray machines for radiation chemistry. Conveyor-type and batch-processing equipment has been designed and in some cases constructed for testing purposes.

To sum up, it must be admitted that the European Community is at present still dependent on other countries for irradiation equipment and that great efforts will be needed for it to secure its rightful place. If, up to now, almost all the equipment necessary to this new technology has been designed, tested and manufactured abroad, then this means that whatever new ideas as to the utilisation of that technology are developed in the Community will principally benefit the country that has supplied the production plant.

Existing irradiation devices

A list published in 1967 of the *particle accelerators* in existence in the European Community mentions 337 such devices. Ten of them, i.e. 3%, are employed for industrial production. They include six for radiography and one for activation analysis, the remaining three being used for production purposes. The list is not exhaustive. It can be assumed that in the Community eight accelerators, with a total capacity of about 60 kW, are in use for production and commercial services. In contrast, an American survey dated 1967 shows that electrical devices of at least 400 kW capacity are in use there for industrial purposes. Of these, 30% are used for applied research, 10% for commercial services, 15% for pilot installations and 30% for pure production.

In the Community there are about nine *industrial cobalt-60 devices* with a total installed activity of 500,000 curies. About half this activity is accounted for by Germany, while France has a mobile caesium-137 unit of 180,000 curies. The activity used for industrial purposes in irradiation devices in the United States is several times greater.

Balance sheet

It is thus apparent that the European Community is lagging far behind other industrial nations in the *production and design of irradiation installations*. Almost all the devices used in the Community for production and research in the radiation chemistry field are of foreign origin. There is an evident danger that the present dependence upon foreign sources as regards the key devices required for a new and rapidly advancing technology will hamper our own development while helping that of the supplier countries. Owing to the lamentable situation of the Community in this field no irradiation equipment has been exported to other countries. As an underdeveloped area in this respect, the Community is restricted to the role of buyer.

Reasons of self-preservation should compel us to further the development of an industry for the manufacture of irradiation plant of independent and advanced design. The necessary basis has already been created, since highly experienced technicians and firms have for years been trying to promote irradiation technology, albeit with only limited success as yet. It would require more intensive cooperation among the industries of the European Community and the

Figure 3: Cross-sectional view of the Dynacote experimental installation for varnish hardening through irradiation belonging to Dürr, *Stuttgart.*

1 Transport system (fully automatic)
2 Radiation funnel
3 Electron accelerator
4 Vacuum device
5 Electrical monitoring, regulating and control system
6 TV set
7 Exhaust system
8 Power supply (transformer and rectifier)
9 Varnish flow machine
10 Shielding bunker
Not visible in diagram: photospectrometer for dosimetry and TV camera.

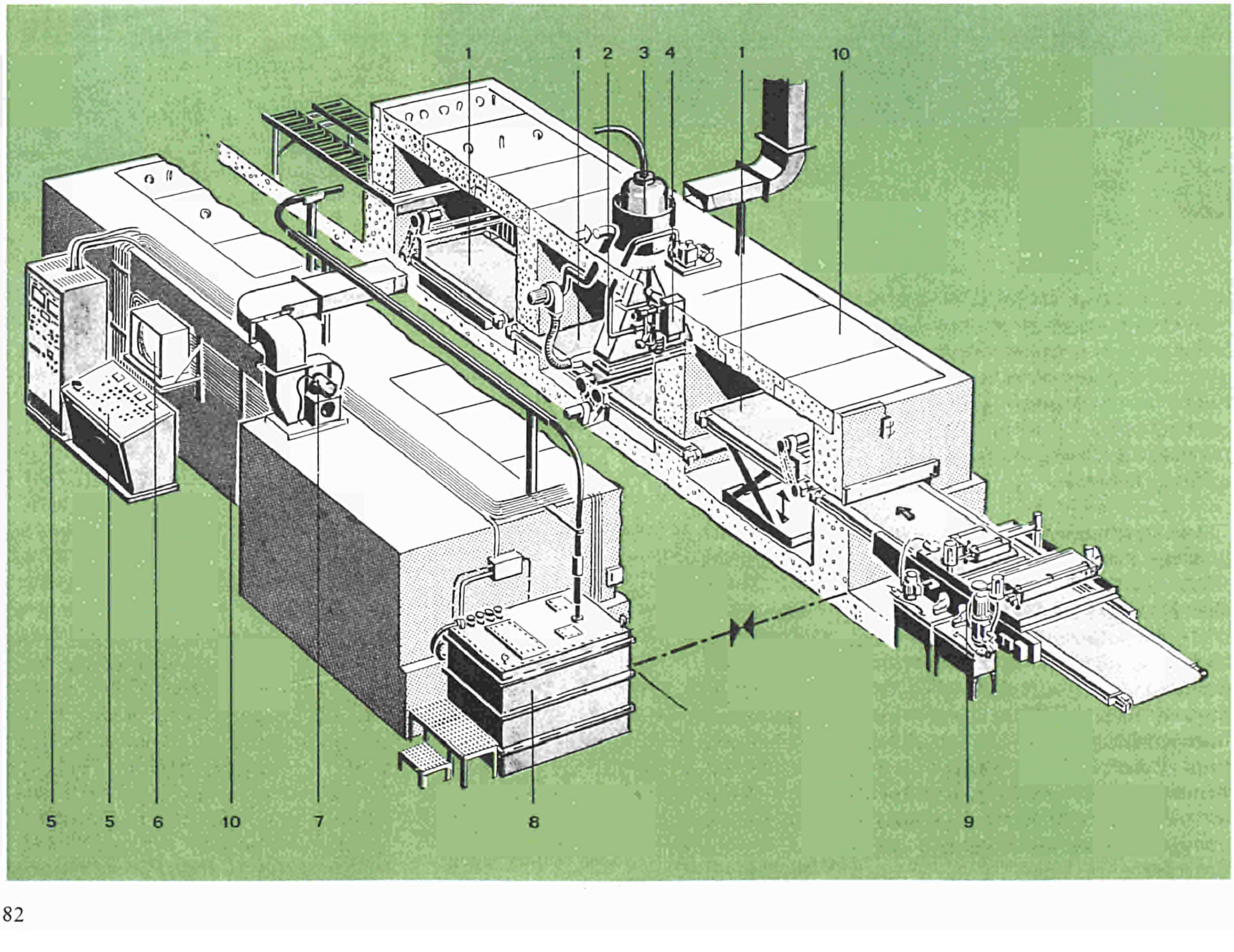


Figure 4: Co^{60} irradiation device for sterilisation of medical and surgical articles belonging to Ethicon, *Hamburg (activity 60,000 Ci).*

provision of financial means for sponsoring of new and existing ideas.

The irradiation equipment should be designed with a view not to the present technical level of the advanced countries, but to that which they will probably have attained in five years' time.

The number of *installed irradiation devices* in the Community in use for industrial purposes is very small. Moreover, their field of application is narrow. They are employed almost exclusively for radiosterilisation and contract irradiation.

Since irradiation devices are an important element in the development and application of this technology, and their advantages manifest themselves only when they are incorporated in the appropriate industrial and technical setting, it would be desirable for all branches of industry which offer potential fields of application to be equipped with radiation sources.

Operation of the devices at the present stage of development should lead to the elaboration of methods for applying irradiation techniques and to the determination of the basic technical and commercial production data required for the practical introduction of these methods.

The equipment of industry with devices would have to begin with research institutes (textiles, civil engineering, chemical engineering, wood finishing, electrical engineering, foodstuffs, etc.) and gradually lead to the use of industrial pilot installations in factories. Bearing in mind the capital investments involved, coordination at Community level would be desirable.

It would be possible to improve the availability of irradiation devices for industrial purposes during a transitional period if some devices at present used exclusively for pure research, but not fully exploited, could also be employed for industrial or similar purposes. The extension of the scope of such research equipment, however, is hindered by the existence of traditions and regulations whose validity would have to be reviewed in this instance.

Since industrial irradiation devices are economic only above a certain size, the setting up of joint installations should be promoted (e.g. in ports, cities, industrial centres, warehouses). The devices could be operated by municipal or port authorities or on a cooperative basis. It would also be worthwhile to consider the use of transportable devices, or devices mounted on vehicles, boats and ships.

The *use of irradiation technology* is much less widespread in the Community than in the United States and the Soviet Union. A total of 8 million dollars have been spent by the Atomic Energy Commission and 50-75 million dollars by industry on research and development in the United States during the last twenty years in the following seven fields alone:

— hardening of varnish through irradiation *(Ford Motor Co., Radiation Dynamics Inc.)*

— use of radiation in the production of plastic wood *(Lockheed-Georgia Co., American Novawood Corp., Nuclear Materials and Equipment Corp. NUMEC)*

— radiation polymerisation of polyethylene *(Raychem, Grace-Cryovac, Electronized Chemical)*

— radiation grafting on battery separa-

Table II: Radiation-generation installations in the European Community.

Operator	Installation				Application
	Type	kW/kCi	keV	Origin	
Grace, Hamburg	ICT	10 kW	500	US	Shrink films
Leybolds Nachf., Cologne	vdG	3 kW	3,000	US	Contract irradiation
Dürr, Stuttgart	Dyn	7.5 kW	300	US	Varnish hardening
Ethicon, Hamburg	Co^{60}	60 kCi	1,330	UK	Sterilisation
Braun, Melsungen	Co^{60}	90 kCi	1,330	Switzerland/ US	Sterilisation
Rüsch, Stuttgart	Co^{60}	90 kCi	1,330	Canada	Sterilisation
Imhausen, Lahr	Co^{60}	12.5 kCi	1,330	US/ Switzerland	Plastic wood
SRTI, CARIC, Paris	Lin	9.8 kW	7,000	France	Contract irradiation
Grace, Epernon	ICT	10 kW	500	US	Shrink films
CLAA, Lyons	Co^{60}	100 kCi	1,330	France	Contract irradiation
Cons. Ind., Paris	Cs^{137}	180 kCi	660	France/US	Contract irradiation
High Volt. Europe, Amersfoort	ICT	10 kW	500	US	Service
Stichting Proefbedrijf Voedselbestraling, Wageningen	Co^{60}	80 kCi	1,330	UK	Contract irradiation
	vdG	3 kW	3,000	US	Contract irradiation
Pirelli, Milan	vdG	3 kW	3,000	US	Cable insulation
ICO, Bologna	Co^{60}	22 kCi	1,330	UK	Sterilisation
Ethicon, Rome	Co^{60}	60 kCi	1,330	Canada	Sterilisation

ICT = Insulated Core Transformer, vdG = van de Graaff accelerator, Dyn = Dynacote Accelerator, Lin = Linear accelerator, Co^{60} and Cs^{137} (irradiation sources above 10,000 Ci only taken into consideration), kW = radiation power in kilowatts, kCi = activity of the radiation source in kilocuries, keV = maximum energy of the radiation in kiloelectron-volts.

tors (*Radiation Application Inc., High Energy Processing Corp.)*

— radiation finishing of textile fibres *(Deering-Millikan Corp.)*

— radiation synthesis of ethyl bromide *(Dow Chemical Corp.)*

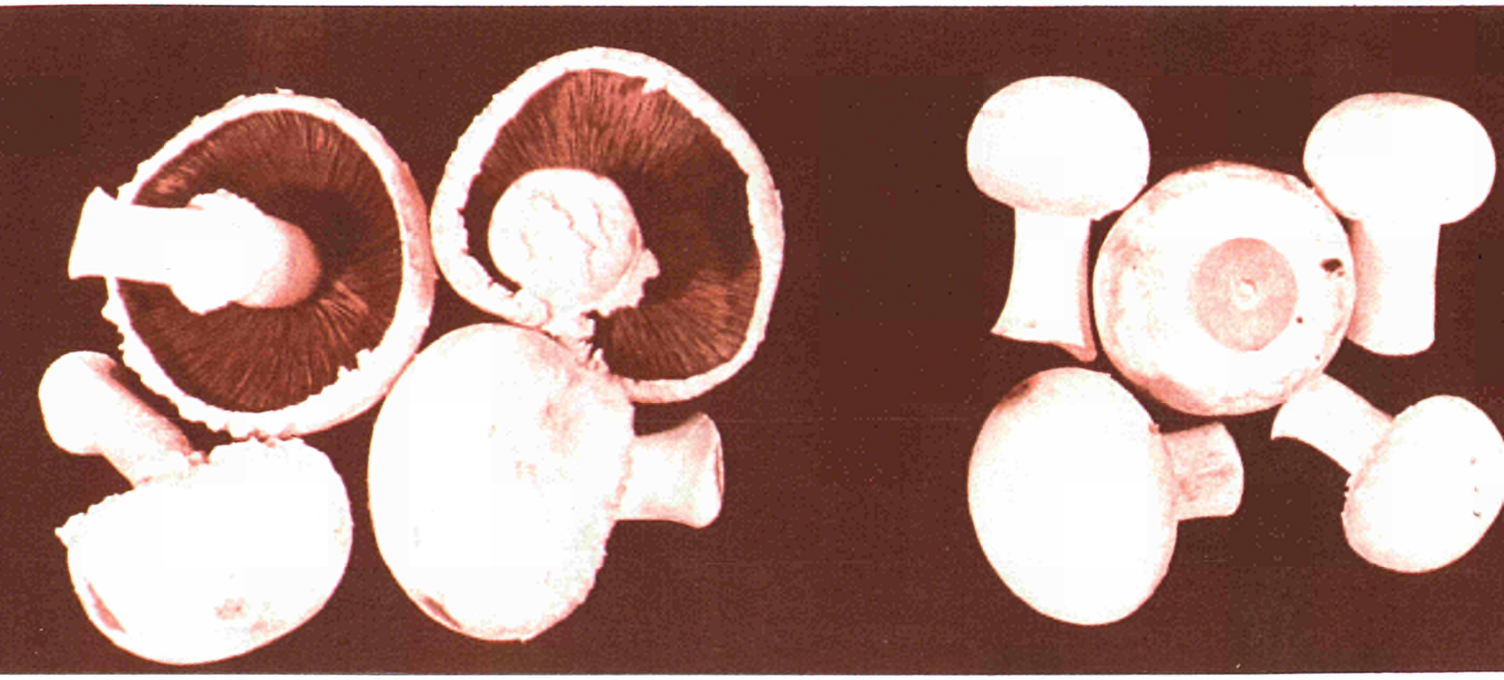
— radiation degradation of polyox *(Union Carbide)*.

If it is borne in mind that the above is not the total expenditure on the seven projects and that other projects, such as sterilisation and preservation of foodstuffs, work on polymerisation of monomers, etc., are being intensively backed by the nuclear authorities, the armed forces, other public bodies and industry it can be assumed that at least 25 million dollars are spent annually on the development of radiation chemistry, a sum far transcending European notions. The result of this intensive promotion work is that the turnover of radiation-treated industrial products (not including foodstuffs) for the year 1967 is estimated at 250 million dollars. In the Community output is probably not 10% of this figure; besides it is made up principally of radio-sterilised medical articles *(Ethicon Hamburg, Braun Melsungen, Rüsch Stuttgart, ICO Bologna)* and shrink films *(Grace Hamburg, Grace Epernon)*. And even this turnover would not have been reached had not the European branches of American firms pioneered the use of irradiation techniques—partly in the face of resistance from European quarters. In this way American ideas have played an important part in the development of the European Community in this field. The stimulating influence of foreign firms is also to be noted in the advertising of the manufacturers of irradiation devices.

However agreeable and efficacious this stimulating influence from abroad may be, the situation is extremely dangerous. Admittedly a probable ten-year lag as compared with the United States is not overwhelming in the infancy of a complex and highly scientific technology. The production deficit of about 250 million dollars of radiation-treated material can be made good commercially, either by abandoning the materials or their improvement, or by using other and possibly more expensive methods. But precisely because the technology in question is scientifically orientated, a large amount of experience is gained in this initial stage which becomes embodied in patents. There are at present 5,500 patents on irradiation technology. This network of patent rights makes it more difficult every year to enter the field of radiation technology on the basis of one's own achievements.

In order to improve this situation, it is not enough merely to undertake research work; it is also essential to quicken the receptivity of the potential user of these techniques at the beginning of the technological chain by showing him how to apply them and bringing him into contact with experts in radiation technology. These contacts are necessary for the radiation expert, too, so that he may direct his work into pragmatically sound channels. It is to be hoped that through this basic work hitherto unstudied possible applications will be found, and in this way a technical lead will be won in previously neglected fields over other countries which are on the whole more advanced. It is obvious that work of this kind on a wide front, particularly if carried on at Community level, can also have a politically formative effect.

For such reasons an "*IRAD*" action was carried out by the Eurisotop Office of the European Community, its main purpose being not so much research and technical development as demonstration and publicity.



IRAD action of the Eurisotop Office

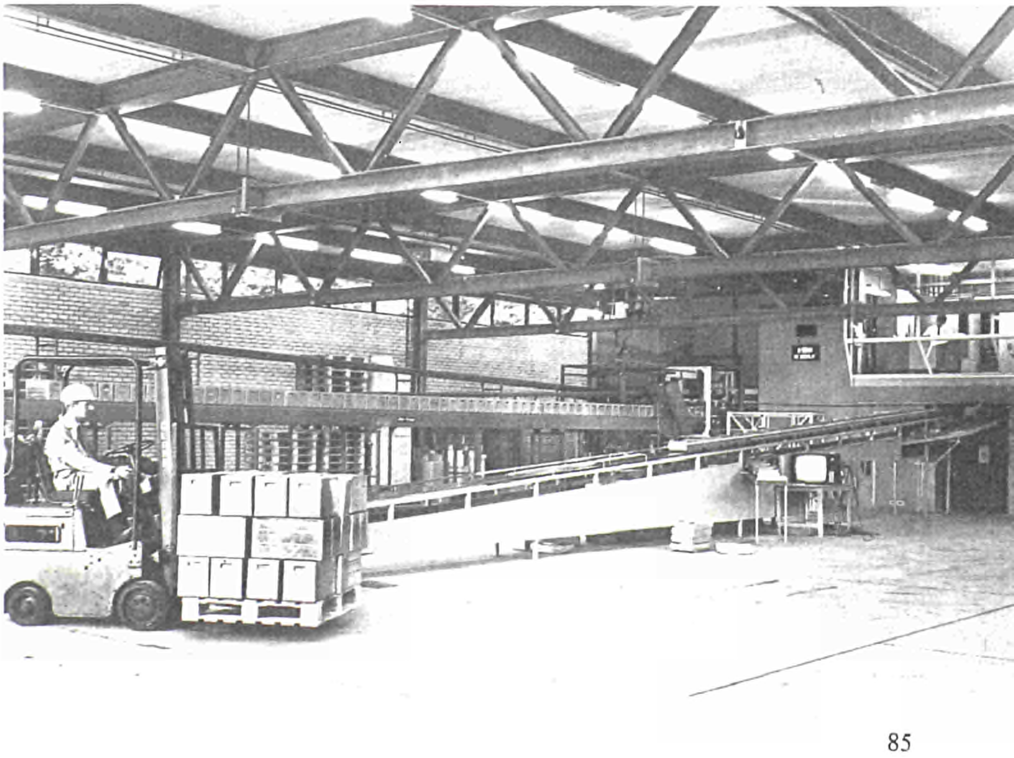
This *IRAD* action, which is a promotion campaign for irradiation technology, was begun in 1967. In the first place working groups of experts in the field were formed, e.g. for textile finishing, the preservation of foodstuffs, the disinfection of animal fodder, or synthetic wood compounds. In these working groups the current problems were discussed at a high level and an exchange of experience was initiated; in some instances joint programmes were laid down, which are now being carried out.

After a certain basis for European cooperation had been agreed in this way with leading circles, we proceeded to try and interest the wide industrial and commercial public in irradiation technology, mainly by means of a travelling unit with a powerful transportable radiation source having an activity of 180,000 curies of caesium-137. This unit has hitherto operated in ten cities of the European Community (Wageningen, Bremerhaven, Kiel, Düsseldorf, Courtrai, Charleroi, Rome, Milan, Lyons, Munich) for periods of one or two months in each case.

The programme consisted of the following points:

Figure 5: Retardation of the opening of mushroom caps through irradiation (stored for 3 days at 20°C and 95% relative humidity; left non-irradiated, right radiation dose 200 krad).

Figure 6: Experimental irradiation plant Stichting Proefbedrijf Voedselbestraling, *Wageningen, Holland (80,000 curies Co^{60}, van de Graaff generator 3 MeV—1mA).*



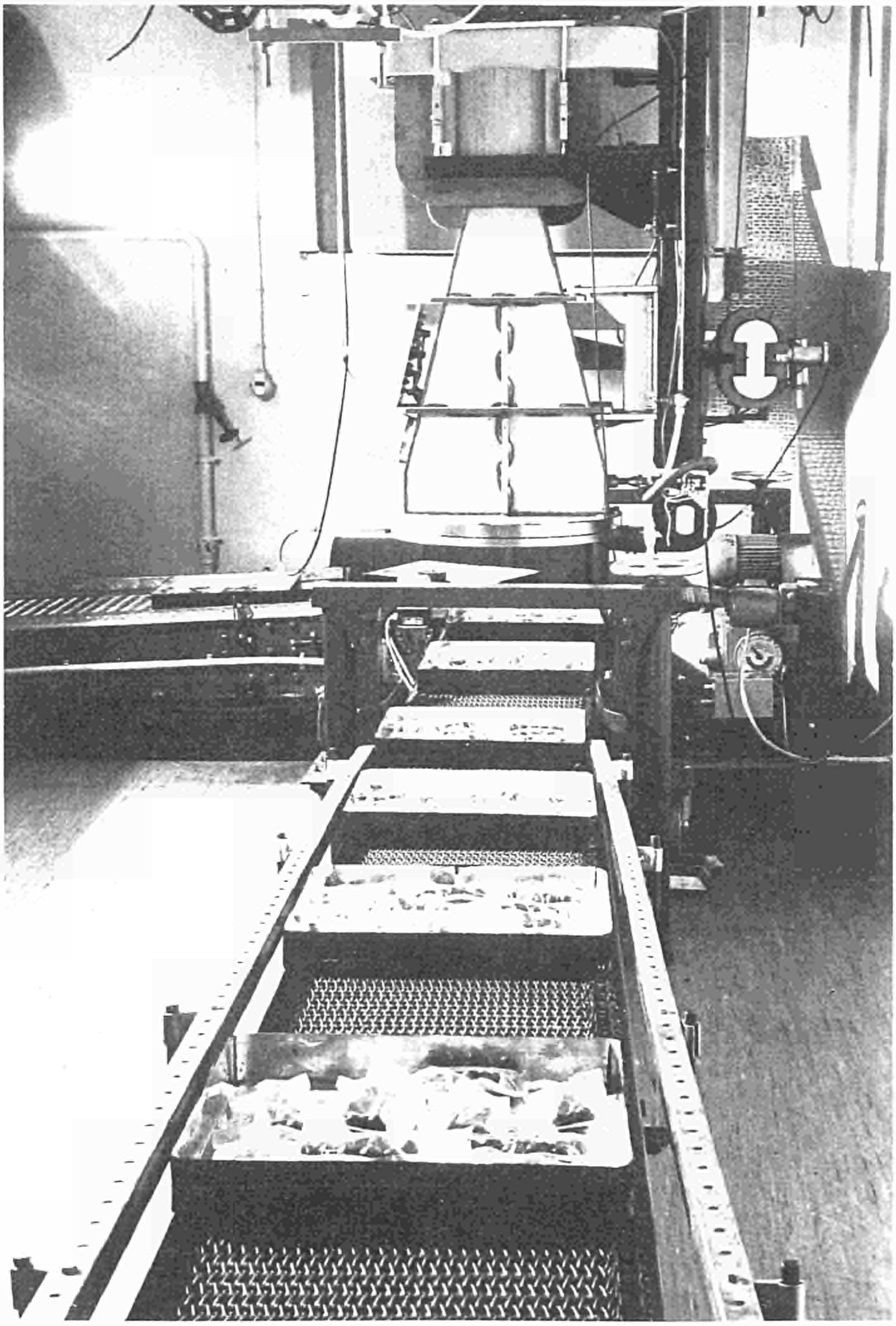


Figure 7: Linear electron accelerator of the Institute for Radiation Technology of the Bundesanstalt für Lebensmittelfrischhaltung, *Karlsruhe.*

— cost-free trial irradiations for industrial firms willing to test the irradiated products as to their applicability and to send the Eurisotop Office a test report (about 400 irradiation contracts, irradiations of 15,000 samples);

— an exhibition on irradiation technology, which was visited by about 350,000 persons;

— information conferences and courses on irradiation technology (about 120 lectures and 100 film-shows before a total of 7,000 listeners).

This action attracted widespread publicity in the press, radio and political circles. The growth of interest in irradiation technology in various industrial sectors can be inferred from the wide range of products on which test irradiations were carried out.

It is still too early to give a final report on the results of the *IRAD* campaign. At all events it has contributed largely to making irradiation technology a public talking point. In various industrial sectors working groups on irradiation technology have already been formed. More public and private money is being devoted to the development of irradiation technology. Working programmes have been prepared. Many laboratories are taking up irradiation technology as an additional subject of study. Various industrial firms have begun to include irradiation technology in their production chain or to make the necessary preparations for doing so. EUSPA 8-12

Literature: Situation in the US: (1) E. E. FOWLER: Radioisotopes and radiation developments in the US 1967. *Eighth Japanese Conference on Radioisotopes,* Tokyo 13-16 November 1967. (2) J. E. MACHUREK, G. R. DIETS, H. STEIN: Current status and future prospects for commercial radiation processing. *International Conference on the peaceful uses of atomic energy,* Geneva 1964. (3) J. KIVEL, M. S. CHATTERTON, R. J. F. PALCHAK: Microbial inhibition systems employing radiation. *NYO* 3736 2. (4) C. N. KLAHR, M. S. COHEN: Fabrication of semiconductor devices by neutron transmutation doping. *NYO* 3124 2. (5) H. LAFFERTY JR., J. E. CARDEN: Research and development projects. *TID* 24349 (1967).

Situation in Japan: Technical summary report. *Eighth Japanese Conference on Radioisotopes,* Tokyo 13-16 November 1967.

Situation in France: P. LEVÊQUE: Applications des rayonnements en France. Gif-sur-Yvette, Vol. I-IV (1966, 1967, 1968).

Situation in the European Community: *Following Eurisotop Office brochures on the IRAD action:* No. 26 in Bremerhaven; No. 27 in Kiel; No. 28 in Düsseldorf; No. 29 in Courtrai; No. 30 in Charleroi; No. 39 in Lyons; No. 40 in Munich; No. 41 in Rome (in preparation); No. 42 in Milan (in preparation).

Eurisotop Office working documents No. 53: minutes, 23-24 February 1967, irradiation of foodstuffs; No. 79: minutes, 19 October 1966, polymerised wood; No. 80: minutes, 10 May 1967, polymerised wood.

Autoradiography and the study of irradiated nuclear fuels

Original techniques for the radiographic study of irradiated fuels have been developed by the BR-2 *(Mol) Reactor Operations Group* (GEX).

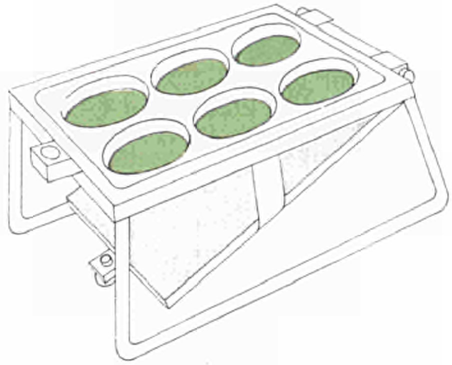


Fig. 1: Schematic view of the exposure device for beta.gamma autoradiography developed by GEX, *Mol.*

ROGER NAUCHE

AUTORADIOGRAPHY is not a new process; it was towards the end of the last century, in 1896, that Becquerel noticed the effect of a uranyl salt on a photographic plate and thereby discovered, without fully realising it, both natural radioactivity and autoradiography.

A photosensitive emulsion enabled Villard, in 1900, to discover gamma rays. Then four years later, Step and Becke made use of autoradiography, in its simplest form, to demonstrate the distribution of radioactivity in a sample.

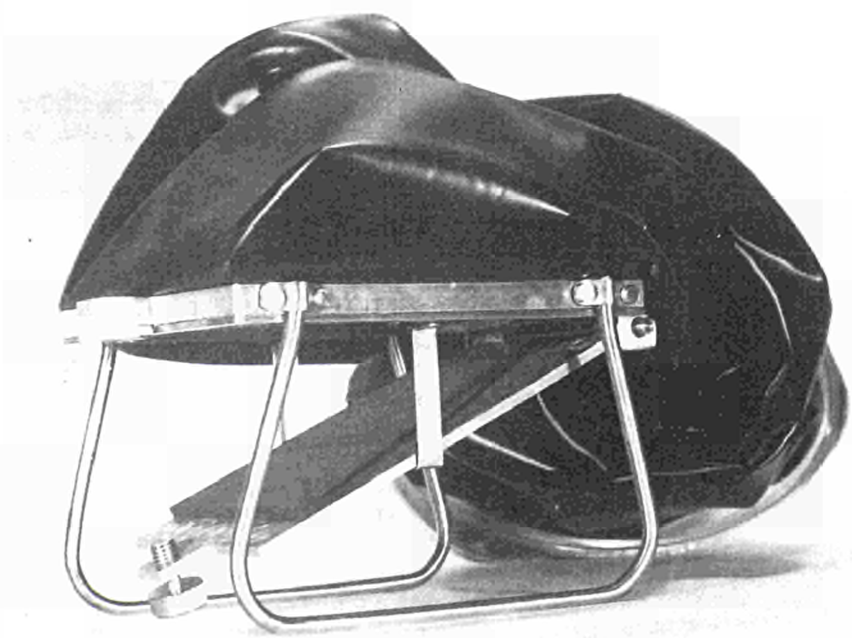
From then onwards this technique took a permanent place in the research scientists' armoury; it played—and still plays—an important part in the discovery and study of all sorts of phenomena (see *Euratom Bulletin* Vol. II (1963) No. 3, pp. 21-25, for the use of this technique in plant physiology).

Admittedly the methods of employing it remained very rudimentary for a long time; at first, for instance, little attention was paid to the problems of contamination through the handling of radioactive samples, which tended to distort the results—not to mention the health side of the question.

Gradually the methods were improved, particular attention being paid to the development of better emulsions.

It was not until 1932-33, however, that the method was successfully used, by Tammann and co-workers, in solving

Fig. 2: The exposure device fixed inside the opaque shielding sleeve.



ROGER NAUCHE is employed by Euratom and belongs to the *BR-2* (Mol) Reactor Operations Group. The techniques he describes resulted from joint work with J. Planson of the *Joint Research Centre's* Ispra Establishment and C. Van Loon of the *CEN*, Mol. The fuel element examinations referred to in the article were done on behalf of *BelgoNucléaire* under the Euratom/US Agreement for Cooperation.

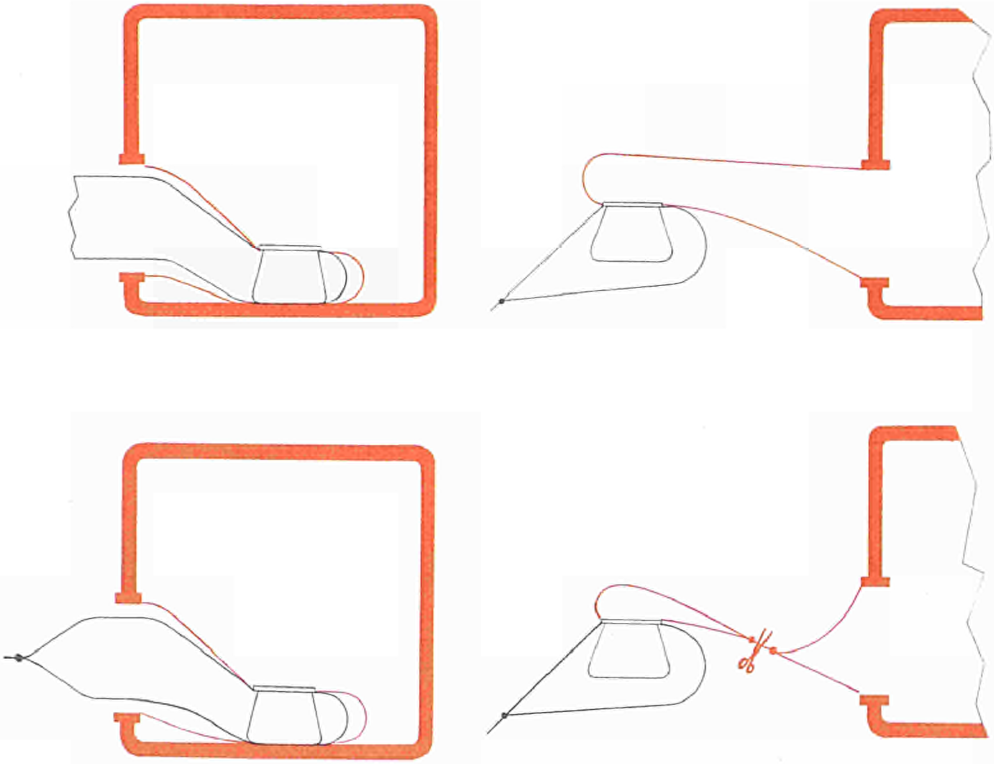


Fig. 3: Use of the exposure device in an alpha box. The first diagram shows the device in working position. The device, which can be seen in the middle of the box, is fitted with two PVC sleeves; the first is opaque (see Fig. 2) and the second (which may be transparent) is designed to provide alpha shielding in case the leaktight foil (in colour in Fig. 1) on the device is punctured. For this reason the end of the opaque sleeve is welded (see second diagram); thus the device can be taken out in a virtual alpha shield (third diagram) and removed completely (fourth diagram).

metallurgical problems, by means of the few natural radioisotopes available in those days.

However, in the field of metallurgy, it is perhaps the development of nuclear fuels that has brought autoradiography so much to the fore in the last twenty years. The process of developing a satisfactory fuel for a given type of reactor, not to mention subsequent attempts to improve its performance, entails irradiating test elements and then examining them when they are taken out of the reactor. At an early stage it was recognised as important to back up the destructive examinations with a metallographic inspection, so important, indeed, that a post-irradiation examination without a metallographic check would be unthinkable today. The changes undergone by the fuels during irradiation are mainly structural, some of them of primary importance from the technological standpoint. But when, in this connection, it is necessary to study the distribution of plutonium, for instance, which is an alpha emitter, or of fission products, which are essentially beta and gamma emitters, then autoradiography provides a very useful examining method, alongside the usual metallographic technique.

Autoradiography owes this success largely to the improvements in sensitive emulsions, especially where high resolution is required. But although the range of sensitive emulsions may fully meet the experimental requirements, the same cannot be said of the practical methods and apparatus used in each case. The *GEX* work at Mol was therefore aimed at overcoming this drawback, and efforts were made to improve the quality of the results obtained, to facilitate operations in shielded cells, to provide greater safety during the insertion and removal of the sensitive emulsion, to protect the emulsion from stray radiation, and to eliminate all risk of contamination of the films used.

Beta and gamma autoradiography

One of the fruits of this work was the invention of a device for the beta and gamma autoradiography, in a shielded enclosed space, of samples that have previously undergone metallographic preparation. The device consists of a mechanical unit (see Fig. 1) and a light-excluding leaktight sleeve. The assembly is shown in Fig. 2.

The mechanical part consists basically of a fixed support plate (in white in Fig. 1) with a series of guide holes bored in it; the samples to be examined are placed in the holes. The plate is supported on two feet. Its underside is covered with a thin foil of mylar aluminised on both sides (in colour in Fig. 1) which keeps the light from the film and acts as an alpha screen. A moving tray on an axle (grey in Fig. 1) with a clamping device brings the film into position against the mylar foil. The apparatus is fitted with an opaque sleeve with which a film can be inserted or

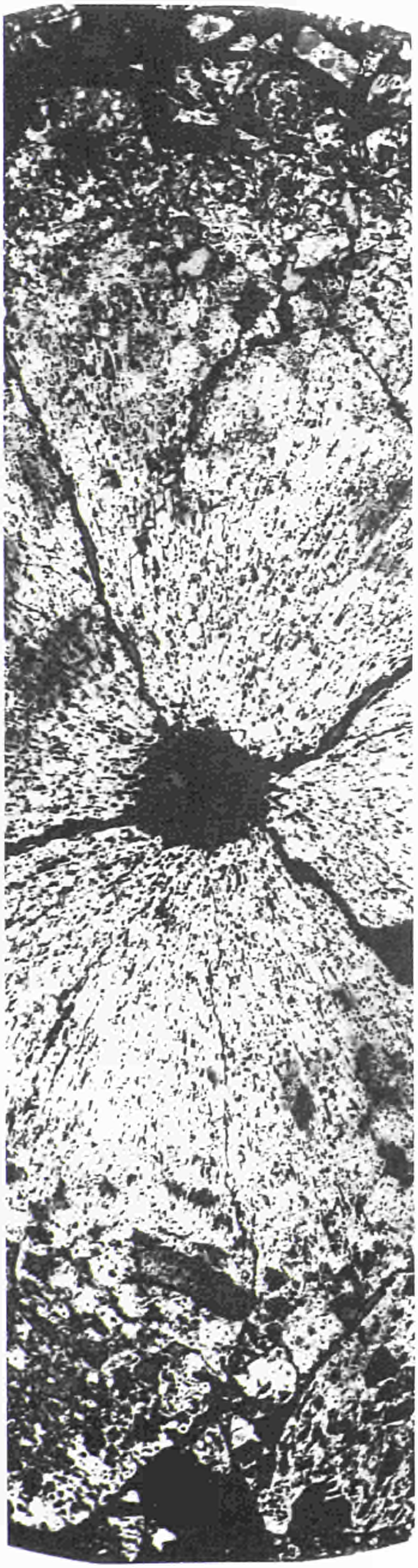


Fig. 4: Part of a macrograph of an irradiated UO_2/PuO_2 fuel element (enlarged 25 ×).

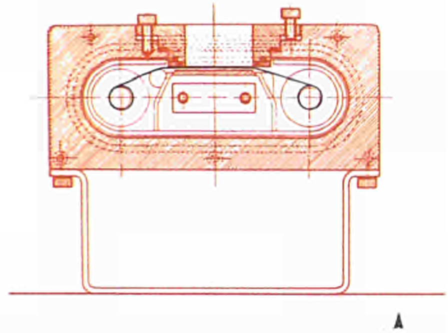


Fig. 5: Automated version of the exposure device. This version is more compact than the original one, since only one hole is needed to take the samples. The film is in roll form, so that several pictures of the sample, or even of a series of samples, can be obtained simply by rotating the spools.

removed without being exposed to the light.

Experience showed that in certain cases the mylar foil could be punctured accidentally. To guard against this risk, in addition to the opaque sleeve a second sleeve was attached, which in case of rupture can be easily welded so as to maintain leaktightness. Fig. 3 shows how to remove the instrument when the film exposure is completed.

The samples are placed in position by means of ball-jointed tongs. In most cases it is obviously impossible to estimate exactly the activity and energy of the radiations emitted by a sample. Hence the advantage of having six guide holes in the fixed plate, for they enable an empirical method to be applied, which consists in making six consecutive tests on the same film with different exposure times. The end result is autoradiographs of different densities from which the best one can be selected.

The apparatus described above can be regarded as a prototype, for the ensuing work aimed at perfecting it has already led to an automated version (Fig. 5). A laboratory equipment maker has in fact applied to the Commission of the European Communities for a manufacturing licence.

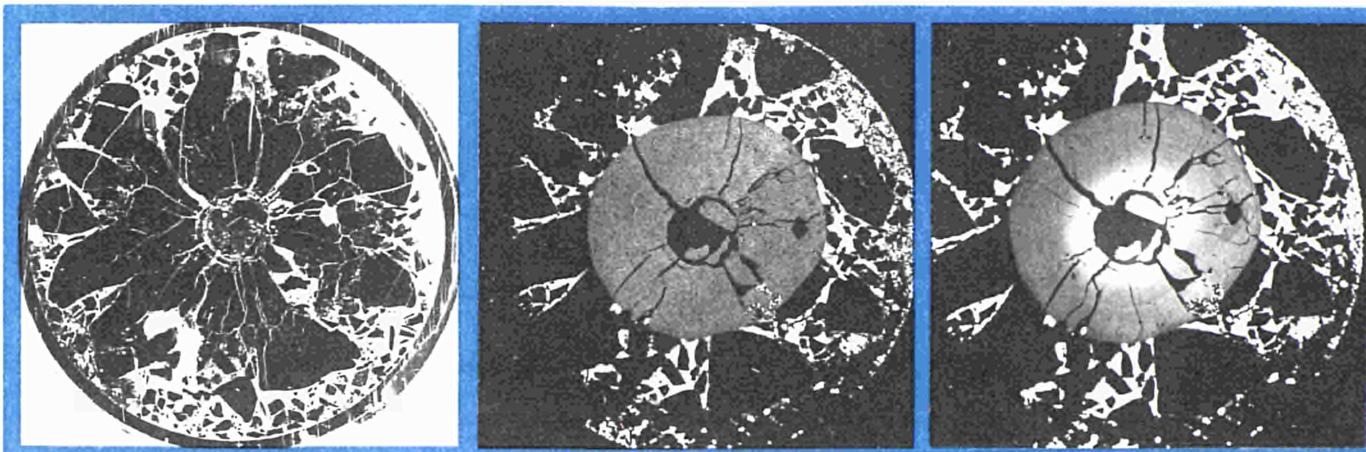
Alpha autoradiography

The *GEX* has also developed a method for detecting alpha radiation. In this case, instead of sensitive emulsions, sheets of cellulose nitrate or similar substances are used for the autoradiography. When a charged particle passes through a substance of this type, it leaves behind a damaged area which can be shown up in relief on the plate by means of an appropriate chemical attack.

The method offers a certain number of advantages. No darkroom work is needed; ordinary products are used for the chemical attack; cellulose nitrate is insensitive to beta and gamma radiations; lastly, the cost of the material is very low, in the region of 3 u.a. per sheet of 21 × 29 × 0.5 cm.

Since cellulose nitrate is insensitive to beta and gamma rays, the autoradiographs obtained by this method only show the regions where the alpha emitters are concentrated. This means in practice that data are collected on the formation, migration and diffusion of plutonium (the alpha emission from uranium 235, for example, is negligible compared with that from plutonium).

As practised at *GEX*, the exposure and development operations take place inside a lead cell equipped with a stainless steel alpha box. Certain special precautions are imperative. For instance, the positioning of the sample on the cellulose nitrate sheet must be done quickly and precisely, to avoid a double image effect. This can occur if the sample is moved during exposure or if the time taken to bring it into position and set it down is

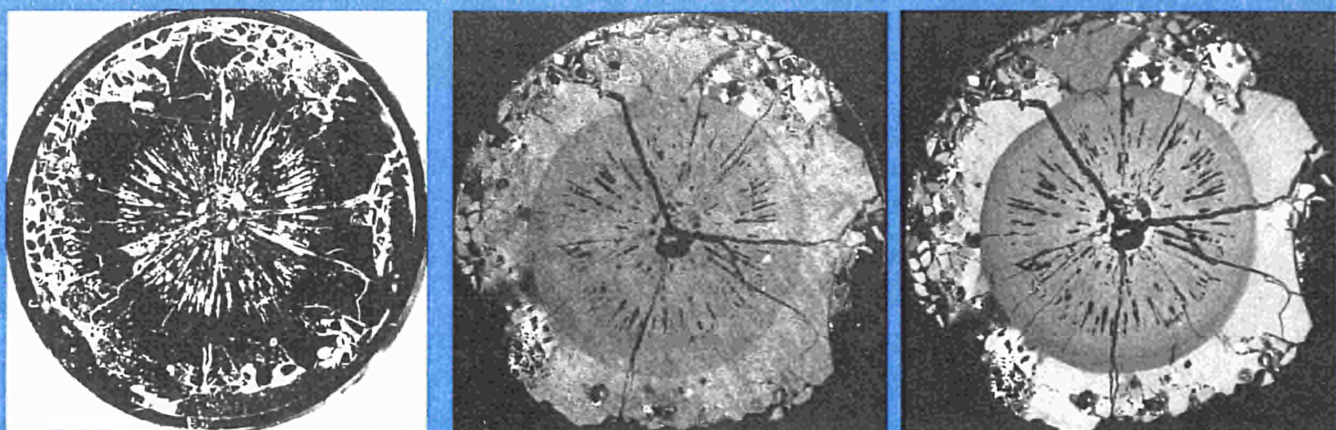


too long in relation to the sample's activity. The sample must be cleaned meticulously in order to avoid excessive contamination of the plates and, more particularly, to eliminate the effect of "poisoning" of the picture which may lead to incorrect interpretation.

Figs. 6 and 7 give an idea of the results that can be obtained by the techniques described above. EUSPA 8-13

Bibliography: (1) C. SAYAG, R. NAUCHE: Examens radiographiques sous eau d'éléments irradiés. *Proceedings of the International Symposium on Working Methods in High Activity Hot Laboratories*, Grenoble 15-18.6. 1965, ENEA/OECD Vol. 1 p. 41-55. (2) R. NAUCHE: Autogammagraphie en cellules blindées α, β, γ sur échantillons irradiés de faible encombrement. *Paper presented at Tenth Hot Laboratory Study Committee*, Casaccia 22-23.9.1966. (3) R. NAUCHE, C. VAN LOON, J. PLANSON: Développement d'un dispositif pour une technique d'autoradiographie sous protection α. Report EUR 3928f.

Figs. 6 and 7: On the left, macrographs, in the centre, alpha autoradiographs, and on the right, beta-gamma autoradiographs of UO_2/PuO_2 rods irradiated in the BR-2 *high-flux test reactor (enlarged 5 ×). On the macrographs can be seen the distribution of various grain sizes and melting at the heart of the rod. The alpha autoradiographs show the distribution of the plutonium-containing substances, whilst the beta-gamma autoradiographs reveal the fission products mainly.*



Deliberations of the Council of Ministers on European technological cooperation

Meeting in Luxembourg on 30 June 1969, the Council of Ministers of the European Communities held a wide-ranging discussion on European cooperation in technology, Euratom's future activities and the Community's policy for the nuclear industry.

It was hardly expected that specific decisions would be adopted, if only because the new French government has not had time to study the latest documents. However, at least the exchange of views was very frank and a timetable was drawn up, which some will find very tight but which has to enable a multiannual nuclear research programme to be adopted before 1 January 1970 and the procedures laid down for non-nuclear technological cooperation with non-member countries to be implemented when the Council of Ministers holds its next meeting, scheduled for October next.

Framing of a nuclear industrial policy—Discussions were based on the analysis of the situation as presented by the Commission both in the "White Paper" (published towards the end of 1968) and in its proposals relating to Euratom's future activities (see *euro-spectra*, Vol. VIII (1969) No. 2 p. 57). The Council acknowledged the usefulness of *electricity producers coming together periodically* to take note of each other's viewpoints, intentions and technical experience. The Commission was accordingly instructed to ease the way for such consultations, and more generally to submit to the Council *every worth-while proposal* for furthering the speedy growth of nuclear industries in the Community, as provided by the terms of the Treaty.

Multiannual nuclear research programme—The Council agreed to continue studying the Commission's proposals with a view to arriving at a *joint programme "having as broad a basis as possible"*. The concept of "complementary" programmes (financed only by those Member States interested), which was introduced in 1969, has been discarded, the President of the Commission having given the governments a solemn warning against the danger inherent in this formula, nothing more nor less than a cancer which threatens to invade other sectors and thus gradually destroy the entire Community.

In order, however, to ensure *optimum use of the Joint Research Centre* in any circumstances, a study will be set on foot to determine the possible subject matter and the legal and financing procedures for *so-called "special" programmes*, i.e. research carried out at the request and the expense of interested firms or governments. Meanwhile any decision regarding a possible cut in the Joint Research Centre's staff has been deferred to 1 November 1969.

Installation of uranium enrichment capacities in Europe (see p. 93)—The Council decided to proceed with its study of the problems involved, while awaiting the opinion of the Euratom Scientific and Technical Committee, which will be holding a meeting on this subject on 11 September 1969.

Cooperation in non-nuclear technology—The Council had a discussion on the basis of the report submitted by the Working Group on Scientific and Technical Research Policy (Aigrain Group). It decided to *act quickly*, since *before 15 July 1969* a committee of senior officials from the Member States was to start examining, in conjunction with the Commission, the technical aspects of the cooperative projects adopted, while the Permanent Representatives of the six Ministers will continue studying the Aigrain Group's report so as to be able to submit to the Council of Ministers *before 1 October 1969 priorities* for the planned cooperative activities and a *list of the non-member countries* who will be called upon to cooperate in them.

Extension of Dragon Agreement

On a proposal by the Commission, the Council of Ministers decided on 30 June 1969 to continue Euratom's participation in the *Dragon* high-temperature gas reactor beyond 31 March 1970, the date when the present Agreement was due to expire. The extension is for three years, i.e. up to 31 March 1973.

The technical programme for these three years is to include the following items:

—operation of the reactor, if possible at a power of 25 MWth from mid-1970 onwards;

—fabrication of feeder fuel for the reactor's own requirements and fabrication of experimental fuel, and a research and development programme associated with this objective;

—services to be rendered by the *Dragon* team to industry, more especially as adviser in the field of nuclear engineering and materials;

—evaluation studies, in close liaison with industry, concerning the problems inherent in the design and safety of large direct-cycle power plants (using gas turbines).

The *Dragon* project celebrated its tenth birthday on 1 April 1969. Speaking on that occasion, Mr. Shepherd, the Project Chief Executive, said:

"... At a time when there is a tendency to decry the value of international technical projects it is particularly important to learn from the experience of *Dragon* about the effectiveness and problems of a joint enterprise rather than to base judgement on ill-informed commentary. Of course, the most important factor contributing to the success of any project, whether national or international, is its technical and scientific basis. If this is sound then the project, properly organised and managed, will succeed, otherwise it must fail irrespective of the ability of the engineers and scientists engaged and the skill of the management.

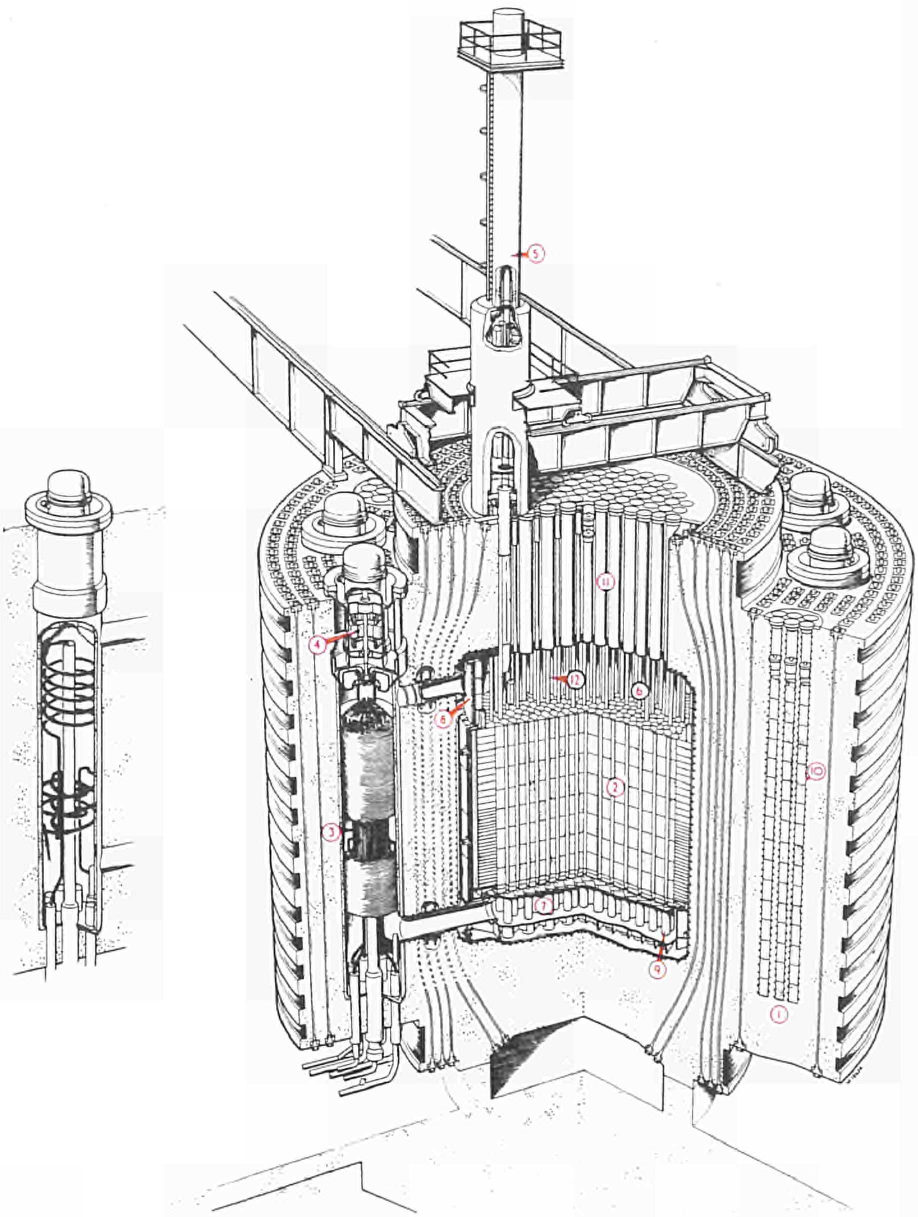
The *Dragon* Project is succeeding in meeting its objectives because the concept of the helium cooled high temperature reactor is fundamentally sound. Indeed, it may well be shown by subsequent developments, to be the most viable system to have emerged so far in the application of nuclear energy.

... Final judgement on the success or otherwise of the project, of course, can only be made when there are power plants based upon the high temperature gas cooled reactor technology actually built and operating".

Turning to questions concerning the project management, he said:

"... the organisation was divorced from national politics and reference back to the political area only became necessary when extensions of the project were being considered. The Board of Management and General Purposes Committee have been composed of members who were well able to pass judgement on the technical performance of the project and its members have at all times been primarily concerned with the success of the project as a whole rather than in advantages to the particular Signatory that they represented.

It is doubtful if any previous nuclear project has been carried out by a more



630 MWe homogeneous high temperature reactor.

1 *Concrete pressure vessel*
2 *Core/reflector structure*
3 *Boiler*
4 *Circulator*
5 *Refuelling machine*
6 *Coolant inlet plenum*
7 *Coolant outlet plenum*
8 *Thermal shield*
9 *Core support stand-off*
10 *Fuel storage/helium purification pod*
11 *Refuelling stand pipe*
12 *Control rod guide tube*

close-knit organisation in which the project management was given so much authority to carry out its task with such simple machinery for obtaining swift authorisation for the planning and execution of its details.

... Perhaps the most important justification for the collaboration, however, has been the international sharing of costs. Almost all areas of modern technology are expensive in their development and the individual countries of Western Europe are too small to match separately the advances that may be made by neo-continental communities such as the U.S.A. and the U.S.S.R. But, these countries, depending on industry for their well-being, cannot afford to fall behind in any major area of technology and it is essential, therefore, that they should act jointly in maintaining a reasonable position compared to the larger powers. If the *Dragon* project has been successful in showing that this can be done then it has more than justified the money that the Signatories have invested in it".

Why a uranium enrichment plant is needed in the Community

In the proposals it submitted to the Council of Ministers in May 1969, the Commission pointed out that the existence of Community uranium enrichment facilities would be a *major factor in ensuring dependability* of supplies for a vital energy sector and would at the same time constitute *a powerful means* by which the Community could directly contribute to *keeping prices at a reasonable and stable level.*

Joint design and construction of such facilities would be in line with Community thinking as regards industry, technology and research. It would avoid fragmentation of research and development efforts and would be the best way to ensure wide-scale and well-balanced participation by the Community's industties as a whole. Such equilibrium is particularly desirable since the various separation processes involve highly sophisticated techniques.

Alongside the work of the Community's institutions, two Member States (the Netherlands and Germany) have conducted negotiations with a non-Member State (the United Kingdom) with a view to constructing enrichment plants for civilian purposes using the ultracentrifuge technique. In the event of an agreement being signed, the German and Dutch governments have stated their intention of notifying the Commission pursuant to the procedure laid down in Article 103 of the Euratom Treaty.

The present situation renders it urgently necessary that the Community set up the requisite framework to ascertain the various options, draw up a short list and take a joint decision concerning the construction of an enrichment facility *adequate to meet a substantial proportion of the Community's requirements.* There will be heavy demand for enriched uranium in the Western world towards the end of the next decade. Furthermore, the Community is entirely dependent on outside sources and, in practice, on one single supplier for its enriched uranium; this is a matter of serious and legitimate concern.

Another basic aspect is the need to provide the European nuclear reactor industry with complete fuel cycle services. It can expand fully only if the enriched uranium supply is not likely to be threatened for economic, technical or political reasons.

Of the various processes which can be employed as the basis for an enrichment facility, two (gaseous diffusion and ultracentrifugation) have such technical and economic characteristics as make it worthwhile to consider building large-capacity integrated plants or complexes.

Gaseous diffusion technology is proven and capable of major development, being particularly suitable for large enrichment plants operating at an attractive cost.

Within the Community this process was adopted for the Pierrelatte plant, built for military purposes. Planned to produce high enrichments, this unit is capable of supplying only small quantities at the low enrichment levels needed for civil purposes.

France, drawing on experience with Pierrelatte, is pursuing a substantial R & D programme aimed towards the large-capacity stages needed for a plant of several million kg separative work units a year; a pilot plant is to be constructed for the purpose of ascertaining its performances.

The ultracentrifuge process is at a less advanced stage of development, particularly where industrial experience is concerned, but its development potential is considerable. From the point of view of exploitation, essential experiments still have to be conducted to ascertain the working of several thousand units in cascade, the adjustability and flexibility characteristics, the lifetime of the centrifuges or of certain of their parts and, lastly, the economics of this process.

Both technically and as regards adjustment to requirements, the two technologies of gaseous diffusion and ultracentrifugation are in no way incompatible and in fact have complementary features; it is perfectly reasonable to contemplate the use of both processes in order to give the Community an integrated enrichment capacity, provided this is properly coordinated and planned.

As matters stand at present, it is impossible to choose between the different technologies that seem likely to provide the Community with good enrichment facilities. This being so, it is advisable not to give preference to any one solution as yet and to look for the best designs and operating procedures.

The Commission's proposals are therefore cast in four stages:

—*stage 1*, which might run up to the end of 1971, would comprise preparatory studies to compare the fundamental technical and economic characteristics of the different enrichment plants based on the two processes, with possible Community participation in the construction and operation of demonstration plants;

—*stage 2*, which might run up to 30 June 1973, would consist in study projects leading to a firm decision to build;

—*stage 3*, a short one, should open up the way, before 31 August 1973, for taking decisions on the choice of site and inviting construction tenders; meanwhile the possibilities of cooperation between the Community and non-Member States will be explored;

—*stage 4*, extending to the end of 1978, in which the construction of common enrichment facilities should be completed; the plant capacity should be capable of covering a significant percentage of the Community's requirements, which for 1980 are estimated at 5-8 million kg separative work units a year.

Consultative Committees on programme management

At its meeting of 30 June 1969, the Council of Ministers decided that "consultative committees on matters of programme management" should be set up. The object of this decision is to contribute to the efficient execution of Euratom's research and training programmes and to provide better liaison between the implementation of the programmes at Community level and the corresponding research and development work done in the Member States.

At the time of writing, such committees are planned for the following programmes: fast reactors, heavy-water reactors, high-temperature reactors, high-flux reactors, plutonium and transplutonic elements, condensed state physics.

In addition, the liaison groups or consultative committees already existing in the fields of nuclear standards and measurements, plasma physics and fusion, biology and health protection, and information and documentation will be made subject to the provisions of the Council's Resolution, whilst continuing to carry out the duties already assigned to them.

Conclusion of six "fusion" contracts

The Commission of the European Communities has decided to conclude six "contracts of association" in the thermonuclear fusion field. It will be recalled that in its resolutions concerning the 1969 programme and budget the Council of Ministers included this sector of research in the joint programme activities.

The contracts are to be concluded with the Commission's previous partners, namely, the *Commissariat à l'énergie atomique* (*C.E.A.*, France), the *Comitato Nazionale per l'Energia Nucleare* (*C.N.E.N.*, Italy), the *Stichting voor Fundamenteel Onderzoek der Materie* (*F.O.M.*, Netherlands), the *Institut für Plasmaphysik* (Garching, Germany), the *Kernforschungsanlage Jülich* (Germany) and, for the first time, with the Belgian Government acting on its own behalf *(Ecole Royale Militaire)* and on that of the *Free University* of Brussels.

These contracts will cover nearly all the work being carried out within the Community in the field of fusion.

The long-term aim of this work is to bring controlled thermonuclear fusion to industrial maturity. This calls for the use of plasmas with temperatures in the order of 100 million degrees and fulfilling certain conditions as regards density and confinement times.

The main problem here concerns confinement using quasi-steady-state magnetic fields.

The plasma may have either a roughly cylindrical shape (open configurations), in which case the major difficulty arises in connection with confinement at the extremities, or an annular shape (closed or toroidal configurations). The latter case is the more promising. Confinement and stability may be improved by electromagnetic fields of different frequencies. It is also necessary to investigate the various methods available for generating and heating the plasma.

In addition, work on plasma physics, which is needed in order to understand the basic phenomena, must not be overlooked.

Lastly, in order to ensure the best possible use of experimental devices and to permit optimum interpretation of experiments, efforts must constantly be made to develop appropriate methods of diagnosis.

Grants for coal and steel research

In pursuance of the *ECSC* Treaty, the Commission of the European Communities has decided, after obtaining favourable opinions from the Consultative Committee and the Council of Ministers, to subsidise certain research projects concerning the steel industry (nearly 4.3 million u.a.) and coal technology (4.7 million u.a.).

Two of the *steel projects* come under the five-year research programme on technical methods of preventing and combating atmospheric pollution caused by steelworks. These are, first, a project submitted by *Italsider* to develop a special coke quenching dolly, and secondly, a joint proposal by *Kloeckner-Werke AG* and *Hüttenwerke Salzgitter AG* concerning a new process for dry removal of dust from residual gases with high carbon monoxide content.

The other projects in this sector comprise research on metal physics, methods of analysing gases in steels, the pouring and solidifying of steel, automated pivoting of the bloom in heavy sheet mills, and a collective programme of research on measurements in steelmaking.

Lastly, two projects are to be extended, one on the automation of reversible rolling mills and the other on better utilisation of technical literature on steel.

The *coal technology* projects concern research on soil mechanics, special cokes, mechanical tunnelling and the cutting of thick seams. They also include research on remote inspection and control of an undercut face and on the propagation of radio waves in underground media, the use of flame-resistant fluids in underground installations, and deposits and release of firedamp in the solid coal.

Proposals for directives on "engineers"

The Commission has adopted three proposals for directives concerning the application of the right of establishment and freedom to supply services to various occupations, but chiefly to engineers.

The first proposal abolishes any measures which are liable to hamper engineers who are nationals of other Member States in obtaining access to activities for which they are qualified.

The second concerns the mutual recognition of diplomas among Member States and introduces transitional measures until such time as a final solution is found for this very complex problem. As an example, the text provides for two types of training for engineers and lays down the relevant minimum criteria; it also specifies the training criteria for skilled technicians.

The third proposal requires that those Member States which do not distinguish between the two types of engineer training indicated in the texts shall make the necessary arrangements to introduce this distinction into their legislation. The proposal further provides that the Member States shall ensure that their teaching systems offer engineers facilities for passing from one type of training to the other.

Can thorium compete with uranium?

In a recently published report (EUR 4264e) a group of scientists of the Joint Research Center's Ispra Establishment have reported the results of their investigations on the economic competitivity of thorium against uranium.

The analysis was carried out for heavy water moderated reactors and for high temperature graphite moderated reactors, which are the most promising users of thorium besides the Molten Salt Reactor.

For the heavy water moderated reactor the best thorium cycle is only about 0.02 mills/kWh cheaper than the best uranium cycle. A 25% reduction of the cost of enrichment and a 50% increase of the uranium ore cost would, however, make the thorium cycle cheaper by about 0.15 mills/kWh.

For the high temperature reactor, under present economic conditions, the best thorium cycle is about 0.2 mills/kWh cheaper than the best uranium cycle with a solid rod fuel.

The reason why thorium is more competitive than uranium in this latter case is mainly due to the fact that, in high temperature reactors, thorium cycles require less enrichment than uranium cycles.

Intergovernmental conference on patents

The resumed efforts to secure a "European patent" (reported in *euro-spectra*, Vol. VIII (1969) No. 2 p. 61) scored their first success on 21 May 1969, the opening date of the *Government Conference on the Introduction of a European Patent System*. Among the countries participating were Austria, Denmark, Greece, Ireland, Norway, Portugal, Spain, Sweden, Switzerland, Turkey, the United Kingdom and the Member States of the European Community.

During the inaugural session, the Conference elected as its Chairman Mr. Kurt Haertel, Chairman of the *Deutsches Patentamt* and of the committee set up by the Community countries which had done the groundwork necessary to the organisation of the Conference.

In view of the complexity of the problems to be solved, it was agreed to set up specialised working groups. The first of these was formed immediately, its terms of reference being to study the rules of law concerning patentability.

It is planned to hold the next meeting of the Conference at Luxembourg in the first few days of next year.

Revision of Euratom basic standards

The Community basic safety standards for the protection of the health of the general public and of workers against the dangers arising from ionising radiations are now being revised.

The group of experts on basic standards (created in accordance with Article 31 of the Euratom Treaty) have agreed on a new version of Title V of the basic standards text, which concerns the fundamental principles governing health surveillance of workers, with the result that the practical organisation of medical checks will be modified.

It is also planned to insert a new title, covering all provisions relating to health surveillance of the general public.

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Forthcoming conferences

—The Commission of the European Communities is arranging the following conferences:

• *Symposium on IRRADIATION OF POTATOES*, 1st and 2nd October 1969, Brussels. As part of its campaign for promoting irradiation techniques in industry, the *Eurisotop* Bureau is paying particular attention to the conservation of foodstuffs by irradiation. A number of symposia have been planned, the first of which, devoted entirely to the potato, is aimed at determining the advantages and drawbacks of irradiation, from both the scientific and the economic point of view, compared with other methods used for inhibiting potato germination. For further information write to *Eurisotop* Bureau, Commission of the European Communities, 200, rue de la Loi, Brussels 4, Belgium.

• *Second symposium on MICRODOSIMETRY*, 20-24 October 1969, Ispra. This second symposium has been organised to meet the need, expressed by the participants at the first meeting on dosimetry, which took place on 13-15 November 1967, to hold wide-ranging discussions at near intervals in this rapidly developing field. For further information write to Dr. H. G. Ebert, 200, rue de la Loi, Brussels 4, Belgium.

• *Information days on GROUND PRESSURES AND SUPPORT IN MINES*, 13-14 November 1969, Luxembourg. This is one of the key subjects in which the European Coal and Steel Community is encouraging research. For further information apply to Mr. L. Emringer, 29 rue Aldringer, Luxembourg.

• *Second conference on PRESTRESSED CONCRETE REACTOR VESSELS AND THEIR THERMAL INSULATION*, 18-20 November 1969, Brussels.

The first conference, held on 7-8 November 1967, was for the most part concerned with work financed by the European Community and dealt mainly with problems of construction and materials. This second conference is on a broader scale; not only has it been made open to specialists from non-Community countries, but the programme has been expanded to permit discussion of such matters as the methods of calculation used in designing pressure vessels and their insulation and the lessons to be drawn from the construction and operation of the most recent plants. For further information write to Mr. H. Benzler, 200, rue de la Loi, Brussels 4, Belgium.

Conference reports

The Commission has recently published the proceedings of three conferences:

• *Symposium on TWO PHASE FLOW DYNAMICS*, Eindhoven (Netherlands), 4-9 September 1967, EUR 4288e—Price: BFr. 1,500, $ 30.

• *Ispra NUCLEAR ELECTRONICS Symposium*, Ispra (Italy), 6-9 May 1969, EUR 4289e—Price BFr. 600, $ 12.

• *1968 Meeting of EUROPEAN LIBRARIANS WORKING IN THE NUCLEAR FIELD*, Stresa (Italy), 24-25 April 1968, EUR 4256e—Price: BFr. 165, $ 3.30.

Eurisotop Bureau publications

• The *Eurisotop* Bureau of the Commission of the European Communities has brought out Nos. 33 and 34 in its series of information books. No. 33, a monograph on *Radiation protection problems in the industrial use of radioactive substances*, deals with the hazards that may arise in the use of sealed and unsealed radioactive sources and suggests methods for efficient radiation protection and control measures.

At present the monograph is available in French; German and Italian versions are in preparation.

• No. 34 is a monograph on *Autoradiography*, by A. Kohn, head of the working group on the use of radioactive substances at the French institute of research on iron technology. The author has compiled a number of practical solutions to problems with the aid of this technology, and gives a detailed review of the processes.

The monograph is available in French; the German version is in preparation.

Both volumes can be obtained free of charge from the *Eurisotop* Bureau, Commission of the European Communities, Berlaymont, 200, rue de la Loi, Brussels 4, Belgium.

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