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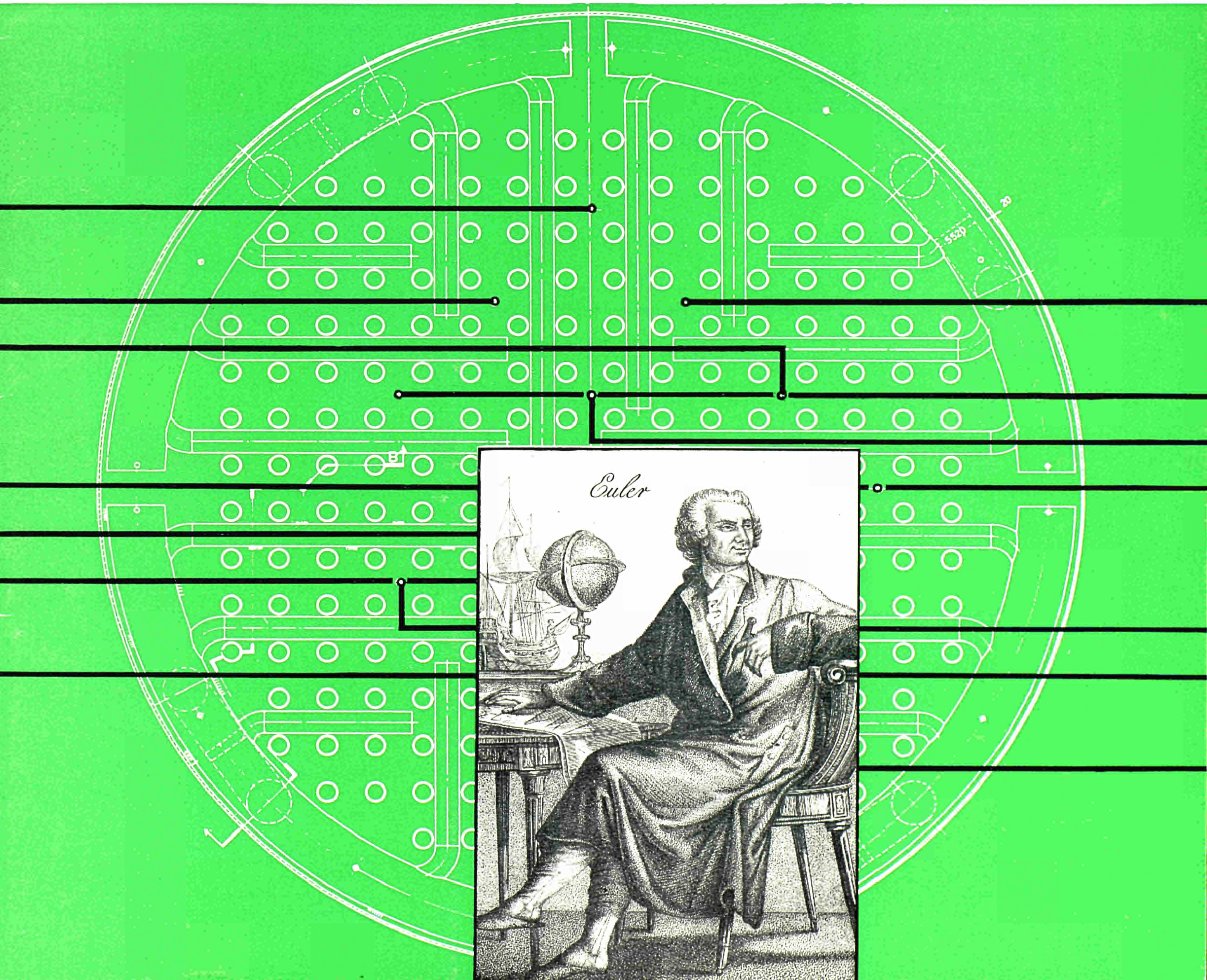

EULER: a research programme is named after the famous mathematician (see page 83).

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spectra

Scientific and Technical Review of the European Communities (ex-Euratom-Review)

1970-3

There is little dispute about the desirability of coordinating and unifying research efforts within the Community — in theory at least. But if one takes a close look at what has been done up to now, and what is now being done, it has to be admitted that achievements hitherto have been modest and that there is a widespread sense of dissatisfaction.

It is this problem which Dr Michaelis and Dr von Moltke tackle in the following article. At the same time they try to give the gist of a recent communication from the Commission to the Council of Ministers, which proposes a procedure for information pooling and consultation between Member States in matters of research and technology.

Nothing very original in that — will no doubt be the first reaction — why such a modest proposal ? However, if one stops to think, it will be seen that, while the proposal is far from revolutionary, it nevertheless goes to the root of the problem. It amounts to treating a joint research project as merely an end-product, the important thing being to know why it has been carried out on a Community basis and why other projects have been conducted on a strictly national footing or formed the subject of collaboration between two or three countries only. For this purpose it is necessary to have a whole series of preliminary exchanges of information and consultations, the efficacy of which will depend upon the frankness with which they are conducted.

European research seeks new dimensions

It could hardly be said that the coordination of research within Europe has up to now been brilliantly successful. The Commission of the European Communities has recently proposed a new formula which it hopes will open up brighter prospects.

HANS MICHAELIS and HEINRICH VON MOLTKE

THE CONFERENCE of European heads of state or government on 1 and 2 December in The Hague has generally been hailed as a significant event because of the fresh impetus it gives to European integration. One of the results of the Conference concerns technological development in the Community. This is item number 9 of the final communiqué, in which the heads of state or government reaffirm their readiness to continue more intensively the activities of the Community with a view to coordinating and promoting industrial research and development in the principal pacemaking sectors, in particular by means of common programmes, and to supply the financial means for the purpose.

To translate this statement into action, the Commission has now proposed a number of possible first measures in a memorandum to the Council on 17 June 1970, expressing the hope that they can be discussed at a special session of the Council attended by the ministers concerned. The Commission's proposals cover a whole range of important research policy topics which are at present the responsibility of a variety of bodies because of the considerable fragmentation of European joint effort, namely nuclear energy, data processing, space, pollution, scientific and technical information and documentation, and the training of research workers. Each of the proposed measures would warrant more detailed attention in itself. In this context, it is however not so much a question of entering into discussions of particular topics as of bringing out a general idea underlying the proposals as a whole.

This general idea is linked with two observations. The first has already been briefly mentioned, namely that the particular problems referred to by the Commission are normally dealt with in a variety of international bodies, which also differ in their composition. This is unfortunately a unique phenomenon. There are altogether some 30 European and international organisations concerning themselves with research matters in which the Member State Governments are represented.

This state of affairs, however regrettable, must be accepted as a fact for the time being. It is a different matter whether the six Member States should not seek to obtain a general view of the practical problems of research policy in the framework of the Council of the European Communities, without prejudice to the competence of other organisations. The member governments are in fact entirely free to raise questions of particular importance to the future development of the economic union for policy discussion in the Council, even though decisions in a wider context cannot of course be anticipated. The advantage of such a procedure would be that for the first time there would be a general framework for the discussion of research policy matters in the Community. This would be a powerful corrective to the present hiving-off into sectors of European joint effort, which makes the solution of specific problems so much more difficult because it is usually impossible to balance out the interests of the Member States in the confines of a narrow sector of research.

It is obvious that a single Council discussion of the immediate and pressing problems of scientific and technical cooperation is not enough. Even if completely successful, this meeting cannot yield end results consonant with the Commission's proposals, but only introduce a set of first measures. In the long run, too, there will be other matters to be considered in addition to those outlined by the Commission in its memorandum. What is needed, therefore, is an acceptance of general

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discussion on matters concerning research and development as a permanent arrangement. Only in that way will the Council be able to fulfil its rightful policy role in this field which has too long been fragmented.

So much for the first observation. The second concerns a different kind of barrier. So far the accent has been only the compartmentalisation of scientific and technical cooperation in Europe. However damaging it may be to the success of efforts in this field, it is not the only reason for the want of satisfactory results. An equally important factor is the independence that cooperative projects have often assumed with respect to national programmes already existing or developing concurrently. Lack of coordination between national and international schemes has often resulted in the development of a competitive situation which has most seriously jeopardised the continuance of international projects. Examples from the nuclear and space sectors will readily spring to mind in this connection. If a radical improvement is to be achieved, the artificial barrier between cooperative and other schemes must be removed, not so much from the point of view of their fulfilment as from that of discussion of them in a Community context. This would have the advantage not only of enabling cooperative projects and programmes already implemented to be more clearly integrated in the body of measures necessary in any given sector, but also of placing the Community in a better position to survey national measures and to suggest how they can complement each other.

To revert to the Commission's proposals, it is now evident why the Commission has expressed the wish that there should be a special Council meeting of the ministers with responsibility for all the specific matters it has raised.

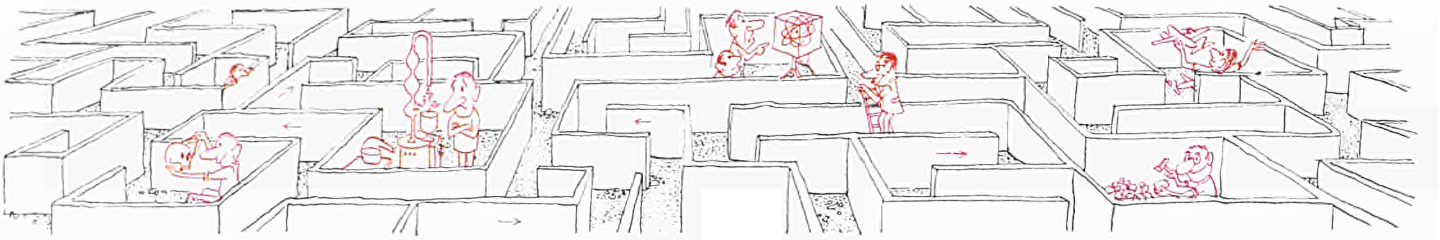
At the same time, however, the cruciality becomes clear of a proposal for action which is included among the suggestions made by the Commission in the memorandum and which on first reading appears relatively insignificant. This is the proposal that the Council should adopt a resolution on the following points:

"a) Obligation of the Member States to hold consultations in the Council at regular intervals on the Member States' more important research and development projects before a start is made on them, irrespective of whether they are undertaken at national level or by a Member State and one or more other states in collaboration;

b) obligation of the Member States to inform the Council for this purpose of:

   i) large-scale advanced technology projects for peaceful purposes, funded in whole or in part by public authorities;

   ii) projects for developing large research instruments;



iii) financing measures taken by the public authorities which might play a decisive part in the development of a scientific and technical research sector in the Community,

to the extent that they conform to the criteria laid down by the Council on the Commission's proposal as to type and scope; this information is to be passed to the Council as soon as the technical characteristics and the scope of the project have been sufficiently well defined, but not later than six months before the first appropriation in a draft budget."

What can be achieved by this procedure? What will be expected of the Member States in this connection? And lastly, what are the results which do not accrue to the Member States from the procedure but which for the time being can be envisaged at the most as a distant goal?

These are the questions which are prompted by a perusal of the proposal and which will be briefly answered below.

Better information

Mutual information is the point of departure of all consultation. It is at present by no means an organised process and where applied, is sporadic and incomplete. Research and development policy in the Member States has a strongly national bias. This cannot be said to be surprising at the present time, because approaches towards a conception transcending national frontiers have so far been confined to specific fields or individual projects. What gives cause for concern, however, is the fact that a country's plans are for the most part drawn up without reference to those of its neighbours. Consequently, projects from the outset frequently contain arrangements geared entirely to what in many cases are limited national conditions. And instead of complementarity and cross-fertilisation we often find mere parallel activity. Accordingly, the potential inherent in thinking on the wider, European scale is at present being largely unused in research planning, including purely national research planning.

Matters would be different if the Member States would notify each other of their more important projects through the Council. This applies primarily to major projects in advanced technology, in so far as they are funded or financially assisted by the public authorities (reactor prototypes, development projects in civil aviation, projects for new forms of long-distance transport, etc.), and also to costly major research instruments (such as radio telescopes, major radiation sources, particle accelerators, and oceanographic research ships. In certain fields, moreover, which by their nature do not involve such heavy investment, there might also be some interest, where special public funding measures of particular importance to the development of the sector are concerned, in stipulating a similar obligation to provide information. If there is agreement on the basic idea itself, it should not be difficult to agree also on more precise criteria regarding the type and scope of projects to be communicated. Whether these take the form of a list of examples or jointly determined threshold amounts for the investment required is a secondary consideration.

It must be emphasised that it should make no difference to the obligation to communicate them whether the schemes are organised on a national basis or in collaboration with other countries. The most important reason for this stipulation has already been stated in the introductory remarks, in connection with the artificial barrier between national and joint projects. There is a further reason, which is no less significant from the policy point of view: namely, the sometimes quite

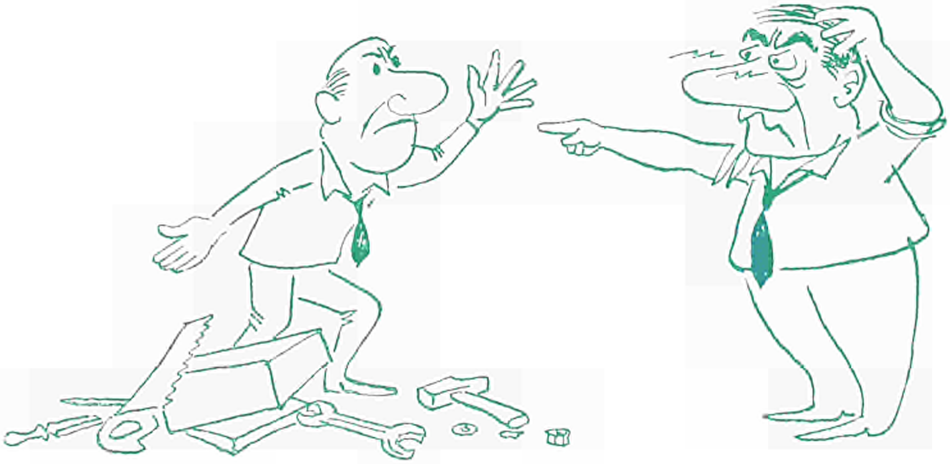
understandable attempt by the Member States to take refuge in a kind of undercover diplomacy if they are looking for partners in major projects. Information on contacts of that kind percolating at a later period usually provokes considerable resentment in the other countries, very much to the detriment of the climate of confidence between the Member States. For this reason, too, an open-house policy is to be recommended, at least as far as informing the Community and the other Member States is concerned. At the same time, the Member States should under no circumstances be denied the right to seek the collaboration of their partners, provided an open discussion has previously taken place in the Community framework.

With regard to the timing of the information, that it must be prior information is obvious, since it can otherwise do no more than confront the other Member States with a *fait accompli.* And, of course, the earlier neighbouring countries' plans are communicated, the greater is the benefit to any national planning discussions. Hence there should be a readiness to exchange information as soon as the principal characteristics of the project have been broadly outlined. A period of six months before the first budgetary appropriation is held to be a minimum. The reason is that cabinet discussion of the budget in the Community countries may vary in time by as much as three months, and the remaining three months are the minimum notice to be given for a consultation procedure.

Consultation

The Council should not only be a clearing-house for information on research policy. It should also be a forum for regular discussion on major questions of research policy. It would soon be apparent what additional possibilities such a widening of the horizon would offer. Through notification of an important national project, the lines of development likely to succeed in a specific research sector could be worked out in the Council, and the national projects communicated could then be integrated into the general framework. By this means alone the countries concerned might come to agree on a certain apportionment of the work. Countries which have not previously done enough in the sector in question might obtain valuable pointers to gaps in their research effort. All in all, a rational use of the Community research potential could be achieved without the exertion of any pressure, simply by the better understanding reached through joint discussion.

Naturally it will be objected that this idea is bound to involve further administrative complications and consequently impediments to the initiatives which are so necessary in this field. This objection should be taken quite seriously. The authorities through



which a major research project must pass are often many in number. Each additional one means further complications for the initiator.

The answer is that it should naturally not be the purpose or effect of a consultation procedure to paralyse initiatives by bureaucratic obstacles. On the contrary, it should offer the advantage of permitting a broader-based discussion of the necessary measures. If as a result of additional information a change is found to be desirable in the original project, this may be more than a little conducive to the success of the project. Naturally, however, under the Commission's proposals, each State remains free to decide whether it will give consideration to the national or the transnational aspect, and is so doing it will be exposed to public criticism. The earlier the State concerned decides to notify its project, the less serious is the purely temporal delay caused by discussions with an additional authority. All major projects, such as those mainly in question here, need considerable time to prepare, and therefore the rapidity with which the projects can be put in hand depends entirely on the promptness with which consultations are initiated.

More cooperation

In 1969, the proportion of international contributions to the total amount of public money spent on research by the EEC Member States was 11.4%. In 1967 it was 13.7%. There was thus a downward trend in cooperation. Against this background the Hague Conference resolution on the intensification of joint efforts in research and development is to be regarded as a signal to turn about. The Commission's proposal includes the organisational measures necessary to translate the declaration of intent by the heads of state or government into action.

Needless to say, the idea is not to aim at securing an obligation to cooperate in major research and development projects. What is meant is simply mutual consultation to ensure that all the available opportunities for cooperation are actually exhausted. It is obvious that there can be no such assurance without early information on the major national projects.

The States remain just as free in the matter of choosing their partners as they were in deciding whether to seek cooperation at all. In the present state of affairs it is not realistic or rational always to be urging cooperation involving all the Member States, however desirable this may be as a general trend.

A prerequisite for this would be solidarity on financing, which would have to be effective even in cases where not all the countries profited equally from a project—something which can hardly be avoided. To be sure, rules of the kind will be necessary in the long run but by then interests would have to be balanced out, not as at present in a narrow sector, but over the entire range of research and development activity in the Community. In the meantime, it would not be right to defer every advance until such a far-reaching policy arrangement comes about. In other areas of Community policy, such as trade policy, mutual consultations similarly preceded the achievement of greater solidarity. The same would apply to the common research and technology policy, which was first elevated to the status of a Community objective by a decision of October 1967 and which is therefore, despite the experience gained in a few fields, still in its early stages.

If at the same time the number of cooperation agreements can be increased, this will already be an appreciable step forward in the present state of affairs, even if not all the states always take part. Because of the many financial pressures on all the governments just now, every possibility of spreading the cost burden of major research and development projects must be welcomed. Sometimes, however, there is a conflicting factor in that any major research and development project can be viewed as an element of the scientific or industrial infrastructure, including its regional development aspects, and in fact is in many cases so regarded. Yet however justified such considerations may be, they should not be geared exclusively to the needs of individual Member States, but all the possibilities of trans-national cooperation should be explored in this case too. An oceanographic project in the Mediterranean is potentially of interest to both France and Italy. A radio telescope in the Eifel mountains may be of interest not only to German scientists, if a neighbouring country has no project of this kind at the time. Many more such examples can be found in the industrial sector to illustrate what is meant.

There remain cases where cooperation is in any case intended and where one might be tempted to dispute the advantages of consultation. Even then they can still be seen to represent progress, however, because discussion at Community level will take place before they are put in hand. Besides the resulting contribution to a climate of openness and confidence between the Community countries, R&D could in this way be linked with the other Community policies.

This last-named factor may be of immediate advantage in that it is not always easy, given the present appreciable differences in individual Member States' commitments in research and technology, to apportion major projects evenly among all the Member States. To that extent a balance might be found in a wider context of Community action, which might subsequently, for instance, include the industrial, regional, agricultural and social policies, particularly if such action can be financed 100% from the Community's own ressources. Even though it is also to be hoped that interests can be balanced out by means of a broad approach covering R&D in its entirety, this cannot be done in the short term, because the number of major projects involved and of firms taking part in them is necessarily restricted.

As regards the funding of projects, it should be reiterated that the Commission has deliberately refrained from making specific proposals for the time being. The Commission memorandum states only that there is a choice between a whole range of funding methods, from a system on a purely national basis to one of 100% financing from Community resources. That the latter possibility, or at least financing in part from joint resources, merits a certain preference is already evident from the text of The Hague communiqué quoted at the beginning of this article, which indicates that the necessary resources for carrying out Community programmes should be available.

In conclusion, the objectives of the Commission's proposal for action can be briefly summarised as follows:

There should be as much reciprocal information as possible, a point of contact for mutual desires as regards cooperation and a place for policy discussion on the prospects for furthering European R&D activity as a comprehensive whole. This last objective is in no way inconsistent with the *ad hoc* character of the proposed consultations. Every initiative originating in one of the Member States can be used as an opportunity to discuss what aims are possible and desirable within the sector concerned from a European point of view. It cannot be denied that this is only a pragmatic approach, and the mere fact that fields where there are no national initiatives will at first not be included in the discussions makes it desirable that consultations on objectives should be planned systematically at a later stage. Preliminary work on such planning is, moreover, already in progress. But the essential point is still that at least a start should be made—a step of significance with respect to the enlargement of the Community because it helps to bring out to the full the advantages offered by the new dimension. EUSPA 9-9

Biomedical engineering

Bioengineering, a hybrid discipline linking engineers, physical and life scientists, is expected to gain a tremendous importance in the years to come.

GOTTFRIED JUPPE

Is life science the big science of the future?

Everything points to the fact that the life sciences will undergo explosive growth in the 1970's. There is an increasing conviction that the taxpayers' money earns a high technological and sociological return if it is spent on research which relates to the life, health and welfare of man and improves his relationship with his environment. Biomedical engineering is of special importance here.

Biomedical engineering combines the efforts of researchers in the life sciences, such as medicine and biology, with those of the classical physical disciplines—physics, chemistry, engineering, mathematics and communications science—in helping to solve common problems. The symbiosis of the various disciplines, with their differing mental approaches, working methods and the complementary knowledge which each offers, throws up new possibilities of solving specific problems, which no single one could hit on on its own.

There is no fundamental difference between scientific discoveries regarding living matter and those of the physical and technological disciplines. It has now been realised that it is only their higher order which distinguishes the apparently bewildering complexity of biological systems from the simplicity and clarity of classical physical systems. Over the past two decades this approach has led to greater use of physical concepts and methods in biology, not without success. A classic example is the "cracking" of the genetic code.

Present-day technology has grasped the fact that nature has arrived at ideal solutions to complicated mechanical, chemical and communicational problems and has in many cases acted as a guide for the physical sciences. On the other hand, the present fund of knowledge of physical and technical methods simply begs to be used to acquire new information about complex biological systems. The results to be expected could, in turn, have a wide influence on technological systems by a kind of feedback effect.

Three broad areas of work are thus open in biomedical engineering:

1) a constructive task, namely, the application of engineering principles to the solution of important biological and medical problems;
2) an analytical task aimed at the elucidation of complex biomechanisms;
3) the problem of applying the acquired knowledge about the concepts and structural characteristics of biological systems to technical and technological systems.

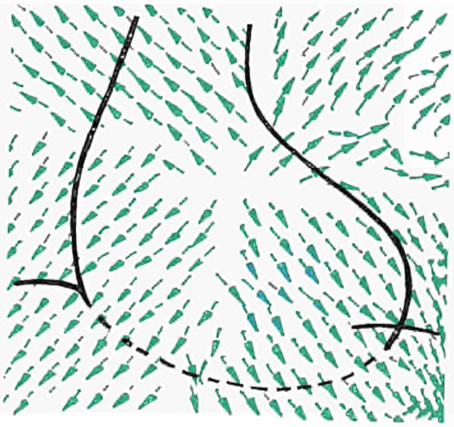
Medical diagnosis, therapy and rehabilitation

The development of bioinstruments for measuring biological parameters is indispensable to biomechanics. It forms the basis for a rapidly growing industry of great economic importance. The development of effective new medical equipment confronts the bioengineers with complex technical tasks. The design characteristics of bioinstruments entail a mass of technological problems, since particularly stringent requirements are laid down with regard to sensitivity, noise level, reliability, accuracy and safety and the ultimate in miniaturisation is often called for.

The measurement of important biological parameters, such as blood pressure, flow rate and composition or the characteristics of heart noise and beat is today not very accurate when performed by classical methods. It is significant that the old-fashioned stethoscope is still in use. As opposed to this method, the use of phonographic recordings for diagnostic purposes gives a much more objective and accurate observation of the heart beat.

However, even such modern techniques as the measurement of cardiac activity by electrocardiogram analysis could be developed considerably by means of a large number of electrodes to record and process the electrical signals at a large number of points on

Figure 1: *The electric "heart portrait" gives a representation of the series of electric fields which appear on the body surface in the course of a single heart beat and furnishes very detailed information about possible disturbances.*



GOTTFRIED JUPPE is on the staff of the Ispra Establishment of the *Joint Research Centre.*

the body. The resultant "heart maps" provide a mass of new and important clinical information.

A method for the "bloodless" measurement of blood pressure could be developed by using the Doppler effect, well known from classical physics. In addition, the magnetic field set up by the motion of charged particles in the blood could be used, for instance, to obtain information on the bloodstream.

The qualitative and quantitative location of radicals by electron spin resonance measurements might possibly be suitable for the early diagnosis of pathological tissue changes.

High-frequency currents could be used for measuring lung volume on the basis of the resultant changes in impedence.

Exciting medical developments are likely from the correct application of ultrasonics, lasers and fibre optics. In the future, laser beams, employed in conjunction with fibre optics, may solve such complicated problems as the visualisation of the inside of a beating heart. Echosonography, which is based on the use of ultrasonics, appears capable of detecting cancer of the breast, tumours inside the eye, detached retina and carcinoma of the liver.

The careful application of energy from without can make major new contributions to therapy as well as to diagnosis. By the electrical stimulation of muscles or nerve systems a certain degree of control over muscle functions may be restored to paralysed patients. Electrical currents passed through the brain can produce anaesthesia. Electrical stimulation of the carotid sinus nerve can be used to keep dangerously high blood pressure under control. Ultrasonics could be used in neurosurgery. Laser techniques show promise of being an effective tool for the destruction of cancer cells. Dermatology, even dentistry, are also disciplines in which lasers have great prospects of being put to advanced applications.

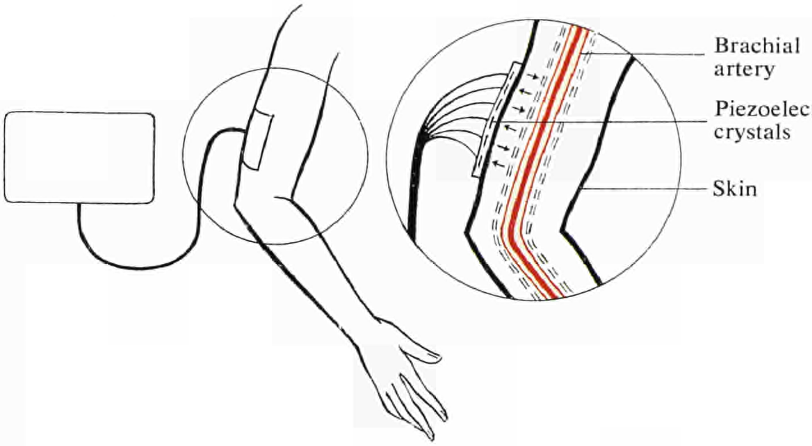
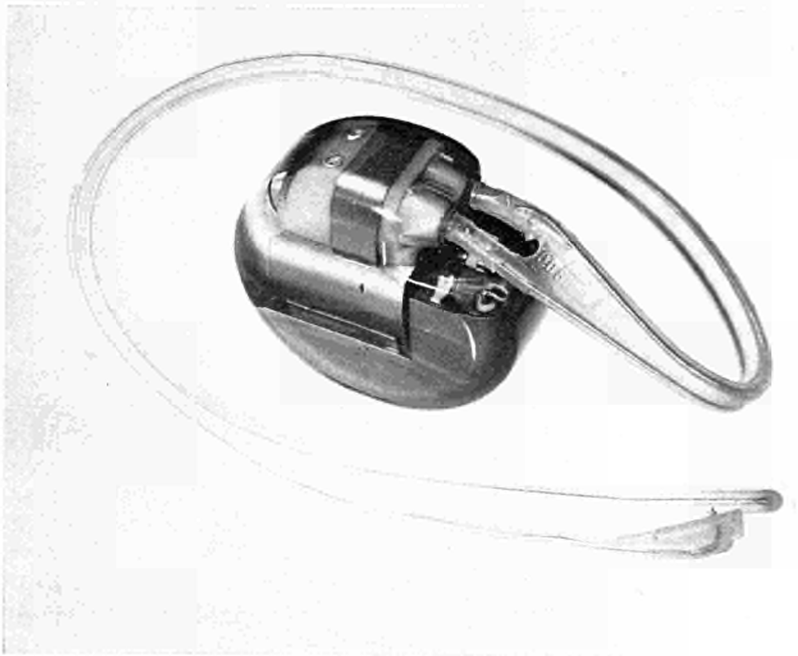
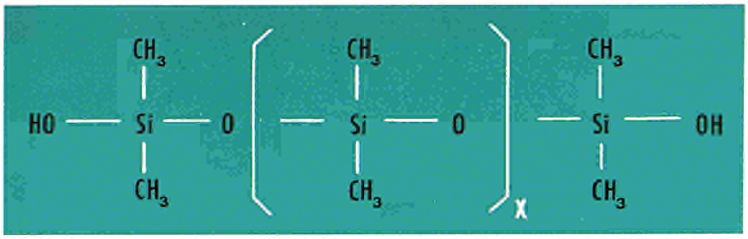


Figure 2: *Bloodpressure can be measured with high precision by an ultrasonic device, in which a small processing, unit (on the left) initiates a signal causing piezoelectric crystals to radiate ultrasonic energy. Some of this is reflected from the wall of the main brachial artery back to additional receiving piezoelectric crystals. The ultrasonic energy detected can then be related to the patient's blood pressure.*

Figure 3: *The* Medtronic *heart pacemaker, powered by an* Alcatel *isotope generator containing 150 mg of plutonium-238 and supplying 200 milliwatts.*





$$HO - \underset{CH_3}{\overset{CH_3}{Si}} - O \left(- \underset{CH_3}{\overset{CH_3}{Si}} - O \right)_x - \underset{CH_3}{\overset{CH_3}{Si}} - OH$$

Figure 4: *Of all materials investigated to date, polysilicones are those which are best tolerated by body tissues and fluids. They are therefore worth considering for making up artificial arteries, artificial hearts and other implanted organs.*

The development of temporary or permanent replacements for parts of the body and organs is a wide and important field of bioengineering. The design of prostheses or replacement organs is only part of the problem. Many others, such as the supply of energy to and the control of artificial organs, require solution and are equally critical. The development of heart-lung machines, enabling the human heart to be stopped during restorative operations, is already in the stage of technological maturity. Their use permits "open heart" operations; the machine is used to pump the blood through the circulatory system, continuously supplying it with oxygen and simultaneously removing the dissolved carbon dioxide.

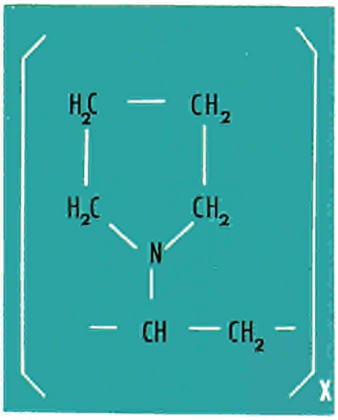
The ultimate aim of the bioengineer, however, is the development of a transplanted artificial heart that can reliably take over all the functions of the natural organ. It is clear even today that this method of replacing a diseased heart has better prospects of success than the transplantation of a healthy heart from a donor.

An encouraging sign for future possibilities for the implantation of artificial hearts is the great success so far with operatively implanted heart pacemakers, which supply electrical pulses to the human heart and regulate its beat. Today, patients fitted with pacemakers have almost a 100% chance of surviving the first 12 months after the operation and thousands of patients whose impulse-conducting nerves are diseased can be helped in this way. The usual type of heart pacemaker at the present time is a tiny generator which transmits pulses, with an amplitude of about 6 volts and a length of about 2 milliseconds, to the lower part of the heart, the ventricle, via peripheral veins or directly implanted electrodes. The power supply is usually obtained from implanted mercury batteries which require replacement by an operation every two or three years.

Colossal research efforts are still necessary, however, for the development of an artificial organ that can completely take over the function of the human heart before even partial success can be considered to have been achieved in this field. Even so, attempts to fit patients with an artificial heart pump have already resulted in their surviving for over 60 hours. A heart that works perfectly, however, must possess characteristics which ensure that it can remain in the human body for up to 250,000 hours without a physical failure of the artificial heart or pathological effects in the patient occurring.

The prevention of blood clotting at implanted foreign bodies and the development of a suitable material for the blood pump chambers are problems which are still far from a satisfactory solution. Embolism and thrombosis effects, which have occurred shortly after all attempts at implantation so far, are the key factors here. Furthermore, blood, which consists of living cells, is severely damaged in an artificial blood pump. A possible solution might lie in the development of artificial blood. An encouraging fact here is that polyvinylpyrrolidone, a synthetic polymer, has been used for years as a partial blood surrogate. A synthetic blood that takes over completely the role of the natural fluid must, however, be capable of reversibly fixing and conveying oxygen and carbon dioxide, which polyvinylpyrrolidone (or the other plasma substitutes which have been developed), are unable to do. Producing a suitable energy source and supply system is just as problematical. Since the tissue tends to reject power lines running through the skin, energy sources other than external electric batteries must be sought. One possibility is to implant batteries that can be recharged by radio transmitter. Another would be to replace them by thermocouples, one junction of which is heated by an implanted long-lived alpha or gamma source. Yet another would be to generate current electrolytically by immersing two electrodes of a battery in body fluids. The mechanical energy of a moving organ could also be converted into electricity with the aid of piezoelectric crystals. The expansion of the aorta, for example, could be used for this purpose.

Figure 5: *For over 30 years polyvinylpyrrolidone, an artificially synthesised substance, has been used successfully as a partial substitute for blood plasma.*



Lastly, biological fuel cells might even be possible by using the starch sugar and the oxygen in the blood. These could be made to react to produce the energy needed. Problems which have still to be solved in the development of these fuel cells are (a) the blood's bad electrolytic properties (b) separating the oxygen from the blood without damaging the other blood constituents and (c) the production of a suitable catalyst for the cold combustion involved.

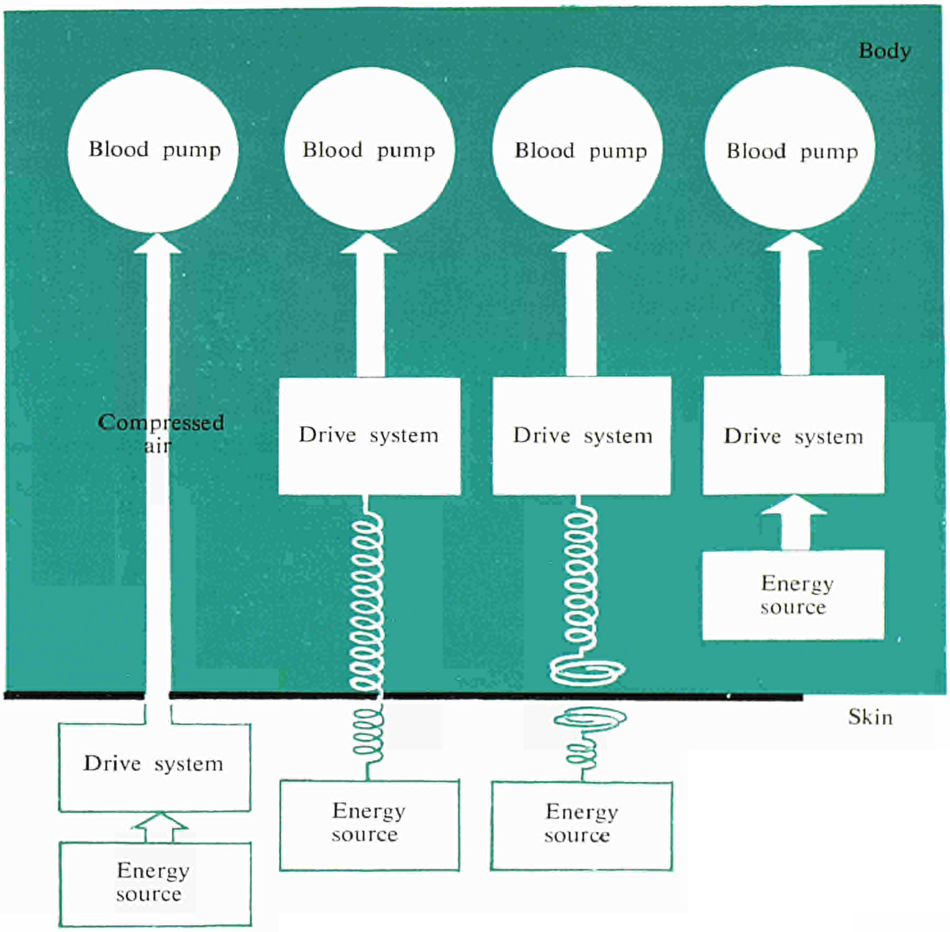
The development of artificial kidneys has made greater progress. Chronic kidney patients can not only be kept alive by periodic haemodialysis with large artificial kidneys, but can even live a more or less normal life. The development of an implantable artificial kidney, however, is still far from realisation. At the present moment the membranes needed for the exchange of fluid and electrolytes are still measured in square metres! Miniaturisation poses special problems in this case. The natural organ is not just a passive filter; it also has an active role in that it produces various secretions by which waste products are fixed and processed prior to elimination. This function must also be borne in mind in the case of the artificial kidney.

There is every likelihood that prosthetic devices, such as artificial limbs will be substantially improved in the near future. The discovery that prosthetic devices can be driven and controlled by microcurrents generated in the human body may well lead to revolutionary developments.

It is now recognised that signals controlling the nature, magnitude and direction of muscle and body movements, can be generated in the muscles bioelectrically from the brain. These control signals are generated by conscious thought or reflexes. It appears possible to pick up such currents even in the remaining stump muscles after the amputation of limbs, and use them to control a servomechanism, e.g. an electrically operated hand. These EMG pulses produce voltages

Figure 6: *Possible artificial heart systems* (from left to right)*:*

1) *Up to now, the system which has been most thoroughly tested and is technically speaking the simplest. The external drive mechanism functions by means of the alternate inflation and evacuation of air sacks arranged in the blood pump. With this system a patient was successfully kept alive for 60 hours.*
2) *Another system which has been tested is one in which a miniature electric motor is implanted in the abdominal cavity. Batteries outside the body provide the energy. This artificial heart, which weighs less than 2 kg and is 12 cm in diameter, kept a calf alive for 12 hours.*
3) *An electrically driven pump is also used in this artificial heart. The implanted batteries are charged by radio transmission. The advantage of this system is that no electrical leads passing through the skin are required.*
4) *The energy supply for the electrically driven pump could be obtained by electrolysis from two electrodes immersed in the body fluids, from biological fuel cells or from piezoelectricity.*



of only 10-1,000 microvolts for a period of 1-10 milliseconds, thus making it comparatively difficult to identify them.

Man/environment relationships

Until now the traditional sciences have been essentially concerned either with the entity "man" on the one hand, or with the entity "machine" on the other. In the former case physiology and psychology have amassed a wide knowledge of the human body and human behaviour. In the latter case the traditional engineering sciences have built up a similar fund of knowledge of materials, structures and systems.

The characteristics of its operator exert a direct influence on the design of any machine, while its characteristics in turn have a considerable influence on the operator. It is therefore indispensable to view and analyse both the machine and the human operator as parts of the general man-machine system and to draw the necessary conclusions. Major studies of this kind have been carried out on astronaut-vehicle systems and were one of the decisive factors contributing to the success of the space projects carried out so far. Any other man-machine system, however, can also be made safer and more effective if care is taken to achieve optimum integration of the human and machine characteristics.

In the case of man-vehicle systems this can be done by better matching of the mechanical details to the driver. The role played by hardware aspects, such as improvements in materials, mechanical components and machine ancillaries, is rather a secondary one here. Software improvements are more important, such as those achieved by bringing order into traffic system. Important software improvements can spring from fundamental knowledge of the mechanism of human information processing by the sight, hearing, touch, nerves and brain.

The influence of physiological and mental factors on the operation of machines must also be studied thoroughly, such as fatigue, powers of concentration and attention, memory, motivation, work cycle and other neurophysiological reflexes which are directly related to human activity on a machine. An important requirement in the near future will be studies on optimum traffic systems. But in the case of countless other man-machine systems, too, it is necessary to fuse the "man" factor, with its manifold characteristics, with the "machine" factor, which has numerous parameters and offers possibilities of change, into a single entity under the best possible conditions. The road here runs through the theoretical study of models of the corresponding systems.

Modern technology offers drastic possibilities for altering the natural environment. We are also capable of surveying the limits of the feasible in the adaptation of human characteristics to an accustomed or unaccustomed

environment and the laws involved. Features of the environment that affect mankind's sense of wellbeing and may be harmful in the short or long term must be thoroughly probed. These include such up-to-the-minute problems as the elimination of man-made waste, namely the industrial contamination of air and water or the poisoning of the human environment by pesticides and herbicides. Both questions—the adaptation of mankind to these conditions and the changing of the character of the environment—must be thoroughly studied before the phenomenon can be elucidated as an entity. Almost the same applies to other proven or probable environmental nuisances such as radiation, cold and heat, microwaves, ultrasonics and noise. A thorough understanding of these and other environmental effects is also a prerequisite for dealing with problems relating to the human colonisation of other planets, which will some day arise.

Data-processing

Data-processing plays a major role in the wide field of bioengineering. Digital computers can be used as measuring instruments for analysis purposes or to solve problems. They can also be used to simulate biological systems. The analysis and coding of complicated electrocardiogramms recorded by a large number of electrodes and the monitoring of physiological and psychiatric experiments involving numerous parameters are practically inconceivable without the use of computers. A complete diagnosis by computer in the near future is far from being merely a utopian dream. Computers are already assigned the supremely important job of logging, monitoring and controlling critical physiological variables during operations and in the post-operative phase, these being tasks which they can carry out more reliably and quickly than humans.

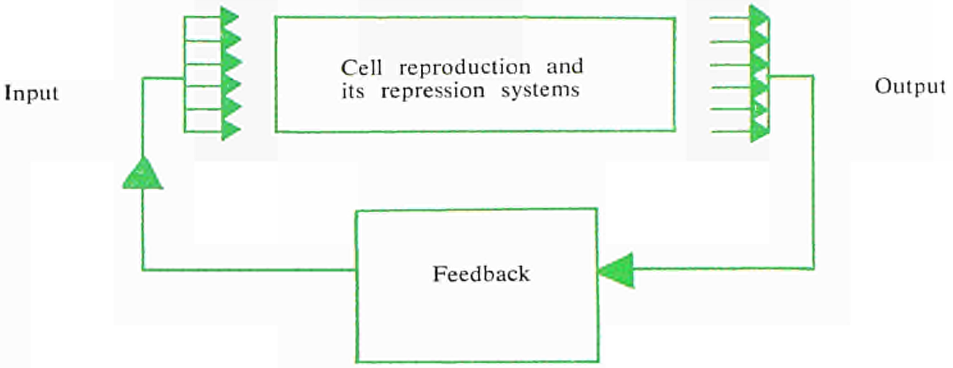


Figure 7: *Cybernetics interprets the cancer pathogenesis as a consequence of errors along the cybernetic circuit regulating cell reproduction. The feedback system controlling the equilibrium between the factors for cell reproduction and for its repression is not working correctly.*

Computers can be used for the rapid and accurate analysis of photographs. The information required, say in the case of X-rays, is extremely reliable and is produced in a fraction of the time normally taken. Acoustic signals can also be analysed by computer. It appears to be possible to produce languages synthetically. This exciting development, a kind of humanisation of the computer, also holds out promise of yielding considerable knowledge about biological methods of signal recognition and intelligent biological systems. And it is not even fantastic to believe that in the more distant future implanted computers might be capable of taking over some of the functions of the human brain.

Cybernetics has a special task to perform in bioengineering. It can supply important data on the basic principles of data handling and control in biological systems. The study of certain neurological reflex systems such as the servomechanism of the pupil in mammals or the movements of the eyes and hands has over the past few years led to discoveries which are of practical usefulness in the aviation and space industries. Studies on feedback phenomena for obtaining a constant glucose concentration in the blood, which were elucidated by cybernetic models, led to new ideas via new methods of treating diabetics.

Cybernetic models exercises can even supply a fresh impetus in such complicated matters as the formation of cancers. Many, or even most, sicknesses appear to have their roots in pathophysiological mechanisms which do not result in the failure of a single element but manifest themselves rather in a loss of control in the interactions between a large number of elements.

The ageing process, too, is probably based on the faulty control of information. The vital chemical processes in the body are controlled by DNA molecules, the basic chromosone building blocks. Provided that the information transmitted by the DNA is clear, the system functions. However, if certain factors, e.g. radiation or chemical changes, cause defects during DNA reproduction, the information is garbled and the ageing process results. Systems analysis can provide considerable insight into the fundamental principles of information and control in biological processes.

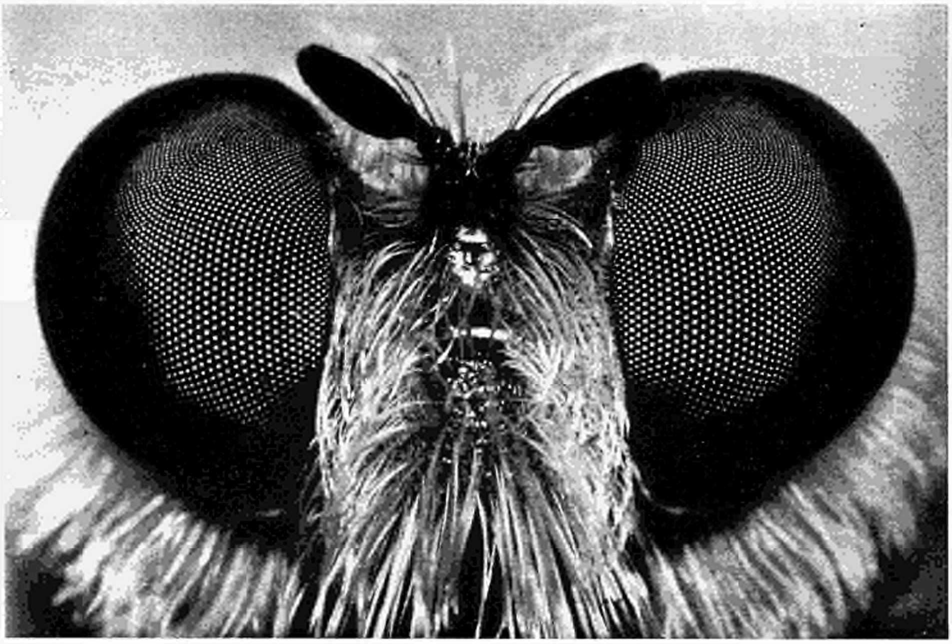
Bionics

In many mechanical, biophysical and biochemical aspects and in the information processing of biological systems, Nature has often hit upon solutions which have so far evaded the endeavours of human research. The aim of bionics is to decode these concepts and from them to draw conclusions benefiting man-made technical systems.

Up to now engineering has not found a complete solution to the problem of the recognition and direct processing of two-dimensional signs. Only one-dimensional functions, current vs time, can be conveyed electronically. Two-dimensional phenomena, as in the case of television, for instance, therefore had to be converted into a one-dimensional grid pattern. In the eye and cortex, the biological recognition apparatus, Nature, on the other hand, has discovered a means of processing visual data on a genuinely two-dimensional basis.

Nature solves location problems by means of complicated sensors, the use of multichannel systems and by sophisticated coding techniques. The location techniques developed so far by man are primitive in comparison. Radar, for example, works on a single channel, measurements are time-sequenced, the space covered by each measuring cycle is small and only one frequency is used. Knowledge of biological methods can provide fresh stimuli for the improvement of location equipment. In the very near future location systems will be of enormous importance for the control of traffic systems.

Figure 8: *The multifaceted compound eyes of a fly produce a mosaic made up of multiple images. They constitute an omnidirectional scanning system with which several targets can be tracked simultaneously. In comparison, man-made radar is rather primitive: it works on a single-channel principle, measurements must succeed each other in time and only small space segments can be observed within one measuring operation.*



In modern data processing man must to a great extent adapt himself to the computer's needs and language. Complicated programs are required which can only be written by specially trained experts. The fact that direct speech communication between man and machine, and vice versa, has not been possible so far has been a time-consuming drawback. This would drastically simplify computer operation and open up new fields of application, e.g. programmed instruction, even to the layman. The first stage in achieving this end will be the understanding of the biological principles underlying speech production.

Future outlook

Whatever importance is attached to the new discipline of bioengineering as regards the immediate future, characteristically it is the United States which is providing the outlay for the initial oriented research in this field. For instance, in the past two years a total of about 15 million dollars was spent on the development of an artificial heart, which is reckoned to have greater chances of success in the long run than the transplanting of a natural donor-heart. Even this amount is, however, extremely modest when compared with the about 65,000 million dollars which are spent each year on health in general. But in West Germany one in five of the population beyond middle age dies of heart failure. If an artificial organ were available which was really reliable and trouble-free, then most patients would certainly prefer to carry around a small reliable machine in their chest and thus, as one American scientist put it, "avoid the not too popular alternative".

In this field there is as yet no technological gap. Research workers in the life sciences, the exact natural sciences and engineering will in the coming decades strive to achieve successes just as great as those sought after in the classical natural sciences in past centuries. EUSPA 9-10

Biomedical engineering today

The extraordinary prospects ahead for biomedical engineering were discussed in the previous article, but it is already an economic reality.

VLADIMIRO MANDL

MEDICAL TREATMENT is increasingly regarded as a social right rather than a privilege. This fact, together with the increase in the population and rising costs of medical care, generates a constant pressure on and rising demand for care and services which can hardly be met simply by increasing the scale of existing health systems: they must be thoroughly revamped. In order to do this, methods of administration, prevention and cure in the public health field will have to come into line with modern organisational techniques and absorb recent progress in the physical, chemical and mathematical sciences, as well as the spin-off from military, nuclear and space research.

These innovations and the advances in the various fields of science have provided a broader potential basis for medical science and laid the foundations for biomedical engineering. Up to now, however, the dissemination and practical application of biomedical engineering have not been sufficient for the development of new medical equipment, for the prevention and cure of disease, the rehabilitation of the disabled and the general raising of standards of public health.

There are many reasons for this lag, and not all of them can be analysed here. The rest of this article will mainly be confined to a consideration of some aspects only of biomedical engineering, particularly problems relating to industrial processes and structures and a survey of the available market and its absorption capability aspects.

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Any discussion of the subject cannot, however, pass over the social aspects and the economic implications of the financing of medical research and its industrial application. In view of the diversity of these problems the analysis that follows will be divided into three parts dealing with the market and industries, research and, lastly, the social context in which the new medicine is evolving and working.

The data presented refer in the main to the position in the Community countries, but the problem of providing efficient medical care at reasonable cost is world-wide in scope.

Market survey: requirements, production and international trade

In order to simplify the market survey, clinical and medical equipment has been sub-divided into two main categories: electro-medical apparatus and surgical and dental equipment.

The aim of this sub-division is to identify more clearly the market trends and developments, because the electro-medical branch is marked by the fastest and most extensive uptake and application of technological innovations, particularly advances in electronic technology.

The market for electro-medical equipment in the Six member countries was estimated to be worth 153.5 million u.a. in 1969 and 145.6 in 1970[1]. This amounts to about 2.8% of all sales of electronic equipment, a modest percentage, admittedly, but one that is likely to rise, as is shown by the growth in the production figures for the last few years, which will be analysed below.

The biggest market in the Community is in West Germany (50%), followed by France, The Netherlands, Italy and Belgium (including Luxembourg). The United States market, on the other hand, is about two-and-a-half times as great, for a population only 8% greater than the Community's.

Production data are rather scant. Statistics with a sufficiently uniform basis are lacking because the product categories covered by national statistics vary from one country to another.

The only significant pointer is the growth rate for the period 1964-68. It remained at fairly high levels, as can be inferred from the increases in the general indices of industrial production[2] for the same period, given in Table I.

The relative rises were calculated for a five-year period covering 1964-68 and expressed as percentages of a base value of 100 for 1964. It is noteworthy that growth rates in respect of medical equipment are substantially higher than those for other industrial production. This is particularly marked in the case of Italy and less so for West Germany where production has already flattened out at fairly high levels.

Information on international trade is massive and detailed. Data on imports and exports of medical equipment (i.e. electro-medical apparatus and surgical and dental equipment) for 1968 are presented diagramatically in Fig. 1. It can be seen that West Germany alone accounted for 70% of the Community's exports, but a mere 23% of its imports.

The world's largest exporter of electro-medical equipment is the United States (40.4%), followed by West Germany (21.6%), Switzerland (12%), the Netherlands (6.6%) and Italy (4.2%)[3].

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[1] *Electronics,* 22 December 1969.

[2] *Statistical Office of the European Communities:* General Statistics on the Communities, Ninth Edition, January 1970.

[3] *Biomedical Engineering,* March 1970.

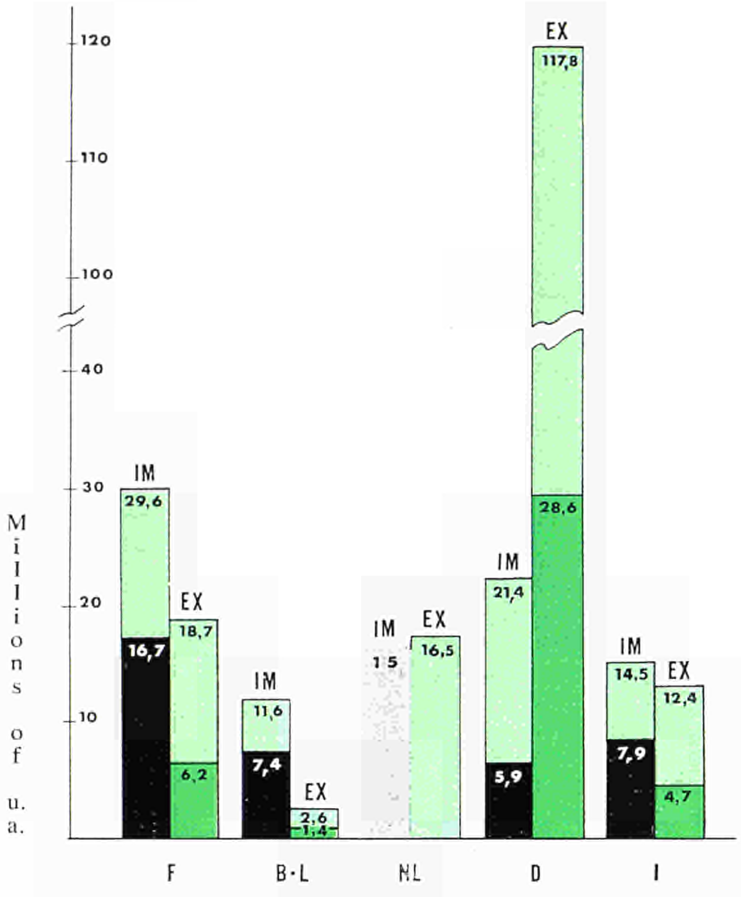

Figure 1: *Imports and exports of medical instruments and apparatus by the European Community Member States.*

Intra-Community trade is shown in black and full colour. The data refer to 1968.

France is the biggest importer of medical equipment in the Community, followed by West Germany, The Netherlands, Italy and Belgium (including Luxembourg), in that order.

Intra-Community trade accounts for 50% of Community imports and 24% of exports.

This brief review shows that the Community's medical equipment industry is in a strong position in the world context and intra-Community trade is quite strong. In order to retain this position the following are called for: investment in research to develop new products continuously or to improve the performance and reliability of existing ones; a reduction in the lead-times for applying the results of research and, lastly, a comprehensive after-sales network capable of providing efficient maintenance and rapid repair of equipment as complex as medical equipment has become.

Research

Every country spends a greater or lesser proportion of its resources on research in the medical and public health sectors.

Table II gives the estimates of public funds budgeted for 1969 for general health research in the Community countries and the United States. The figures include all research of a general and medical nature, research into food and nutrition, public health and schemes for the general promotion of the medical sciences[4]. The wide disparity in spending both between indi-

Table I: *Comparison of the growth rates for overall industrial production and for the production of medical, surgical and dental equipment and apparatus.*

	D	F	I	B	NL
Percentage growth rates for overall industrial production for the period 1964-68 (1964=100)	17.5	14	35	12	30
Percentage growth rates for production of medical, surgical, dental equipment and apparatus for the period 1964-68 (1964=100)	58.8	79.3	174.3	97.5	Not available

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[4] Data collected by the Statistics Expert Group set up by the *Working Group on Technical and Scientific Research Policy*, and published by the European Communities. The data relating to the United States are from vol. XVII *NSF* "Federal Funds for Research Development and other Scientific Activity".

vidual Community countries and between the Community as a whole and the United States is evident. This can hardly fail to have an unfavourable impact on industrial production and competitive capacity vis-à-vis non-member countries.

Aims and methods vary considerably between countries, but a common trend is visible towards giving this type of research a multi-disciplinary character and promoting a greater or lesser degree of cooperation with industry working in the health field.

The first of the above needs arises from the inherent nature of the problems involved, which demand skills that go beyond the medical field. The second is considered necessary to ensure that the results of laboratory research are embodied into facilities and services available to a wider public. Such cooperation is highly desirable, with regard to the applications of biomedical engineering as in many other fields, and should also permit a continuing dialogue between the users and producers, in order that the final product may come as close as possible to meeting the medical profession's needs and to being compatible with industrial capabilities and requirements.

Biomedical research is mostly conducted in university institutes and teaching hospitals. In some States, however, a need has been felt for the establishment of suitable pilot centres which can supplement existing teams, bring to bear a wider range of interdisciplinary skills and if necessary be consulted on more difficult technical problems.

Social aspects

When placed in a wider context medicine cannot be considered simply as a science; it is also a social service and its advances or failures have an impact on society as a whole, which expects medicine to provide solutions to many of its problems of health and general welfare. The age we live in is marked by rapid progress and change, and medicine is not always capable of fulfilling the needs that society anticipates or expresses, while society is only vaguely aware of the new capabilities of modern medicine and their social implications.

For example, whereas society requires more extensive, efficient, low-cost health services for the prevention of diseases, traditional medicine still seems directed mainly towards the healing of pathological processes that are already at work rather than forestalling them.

Nevertheless, the prevention of disease by means of mass screening to ensure its early diagnosis, in persons considered healthy, would be much more effective and is far from being a utopian aim. Apart from its obvious benefits to public and private health, this type of care is also, in the opinion of experts, less expensive than the sum of the cost of subsequent cure plus the loss of income due to the temporary incapacitation of the sick. It is also technically practicable and is already in operation in some countries, although covering only a small fraction of the population. Its large-scale implementation would, however, entail a thorough reorganisation of the administration and provision of public health services and the integration of medicine with other scientific disciplines, e.g. cybernetics, information processing, telecommunication, biochemistry, biophysics, electrochemistry, as well as the social and economic sciences.

The other side of the impact of medicine on society is represented by the high cost of some of the treatment made possible by modern technology: this helps to spotlight the colossal gap between the demand and availability of medical care. To give some examples, the cost of a heart transplant can be as high as 50,000 u.a., excluding the cost of postoperative treatment. Keeping a child with leukemia alive for a year costs 30,000 u.a., while the cost of dialysis, which enables patients suffering from serious kidney deficiencies to lead a practically normal life, is estimated at 71,000 u.a. over nine years. A kidney transplant, which should ensure 17 years' survival, costs on the average 44,500 u.a., provided that a donor can be found, of course.

A patient can rarely afford such expensive treatment, so who should step in? The state or social security schemes? This one problem is not only a financial one but concerns also the availability of trained staff of whom there is a fairly general shortage in hospitals. A heart transplant, for example, apart from the cost quoted above, calls for a large team (up to 25 doctors) and intensive postoperative care requiring the services of four or five nurses for a period of six to twelve weeks.

One more out of many cases deserves to be quoted; in the United States, over the last four years, less than

Table II: *Health research—public funds budgeted for 1969.*

Public spending on R&D	D	B	F	I	NL	EEC	USA
1. in millions of u.a.	139.6	12.4	91.6	26.2	33.3	303.1	1232
2. as a percentage of total public spending on R&D	9.7	11.7	4.6	7.9	12.3	7.3	7.2
3. per capita, in u.a.	2.3	1.3	1.8	0.5	2.6	1.7	6.4
4. per capita: Community average=100	135	76	106	29	153	100	

10% of needy patients suffering from serious kidney failure were put on dialysis—the other 70,000 were allowed to die. The cost of a six-year plan to provide dialysis for 18,000 patients and kidney transplants for another 4,000 was estimated at 800 to 1,000 million u.a. Even this would solve only part of the problem and ensure the survival of a minority of the patients. Besides this, there is the possibility that the implementation of such a scheme which, although effective, would be palliative in nature, might postpone the time when more advanced concepts for the prevention, rather than the cure, of kidney failures are developed.

Admittedly human life is beyond price, but since present-day society has finite material and human resources, the problem of their rational and optimum utilisation has to be faced even in the medical field.

Conclusions

The aim of medicine is to improve life, not to make it eternal. That objective is now closer than it was and could even be achieved, provided that society is aware of its own problems, and recognises and decides to take on those responsibilities that cannot be delegated to others; provided that medical science can bring itself to respond more quickly and fully to social needs; and provided that industry can take up and develop the results of research and anticipate what products and services are required by modern medicine.

The processes involved are certainly long and complex and can only proceed gradually, but the first step towards their completion is to take stock of the real situation in all its many aspects. EUSPA 9-11

Products classified as "Electro-medical apparatus"

- Electrocardiographs
- Ultra-violet ray, or ultra-violet and infra-red ray apparatus
- Diathermy apparatus (using high frequency, very high frequency, or ultrasonic waves)
- Other electro-medical apparatus
- Apparatus based on the use of X-rays (solely for medical uses)

Products classified as "Medical, surgical and dental instruments and appliances"

- Dental instruments and apparatus
- Anaesthesia apparatus
- Special diagnostic apparatus (excluding electrical diagnostic apparatus)
- Syringes
- Other medical, surgical and veterinary apparatus
- Mechano-therapy appliances, massage apparatus, psychological aptitude testing apparatus
- Ozone therapy, oxygen therapy and artificial respiration apparatus
- Miscellaneous breathing appliances, including gas masks
- Artificial parts of the body, excluding artificial teeth and eyes
- Deaf aids
- Orthopaedic appliances
- Splints and other fracture appliances
- Apparatus based on the use of radiation from radioactive substances for medical purposes

RESEARCH NEWS FOR INDUSTRY

Under this title *euro-spectra* regularly reports some of the new processes or equipment recently developed at the *Joint Research Centre's* establishments or at the works of firms or institutes performing research under contract to the Commission.

It will be recalled that, under the Euratom Treaty, knowledge thus acquired by the Commission can be communicated to interested firms in the European Community under favourable conditions.

Any firms interested in acquiring a deeper insight into these possibilities should write to: Commission of the European Communities, D.G. XIII-A, 29, rue Aldringer, Luxembourg.

Leonardo Eulero.

EULER

Liquid rods for nuclear reactor control

The EULER *programme has led to the development of shutdown devices based on the use of liquid poison. What are their advantages over the traditional systems?*

ALBERTO AGAZZI, ARMANDO BROGGI, SERGIO GALLI DE PARATESI

ALBERTO AGAZZI, ARMANDO BROGGI and SERGIO GALLI DE PARATESI work at the Ispra Establishment of the *Joint Research Centre*.

WHEN IT was decided at Ispra, at the end of 1966, to go ahead with a systematic research and development plan in the field of poison liquid control rods, everyone was aware that numerous problems would have to be cleared up during the programme, problems of chemistry, physical chemistry, neutronics, dynamics and engineering. It would have to be demonstrated that the liquid absorber rod, the principle of which had already been published, could emerge from its ideal sphere to take its place in practical reality (1)[1].

The time was ripe for development of the concept: on many sides the study was regarded with favour and the potential advantages were being advocated, though with some reserve. Nor were certain detractors lacking. These, the traditionalists, based their opposition on the experience of the twenty years from 1946 to 1966 and it was not by chance that they belonged to the ranks of the designers of solid control rods. Furthermore, it was known that a certain diffidence would have to be overcome, mainly of psychological origin, inherent among nuclear safety circles.

In this stimulating climate was launched the programme "Expériences Utilisant Liquides Empoisonnants pour Réacteurs", the initials of which we gladly adopted to form the acronym *EULER*, a reminder that the great mathematician also passed into history as a skilled perfecter of several branches of applied science, including

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[1] For (...) see Literature.

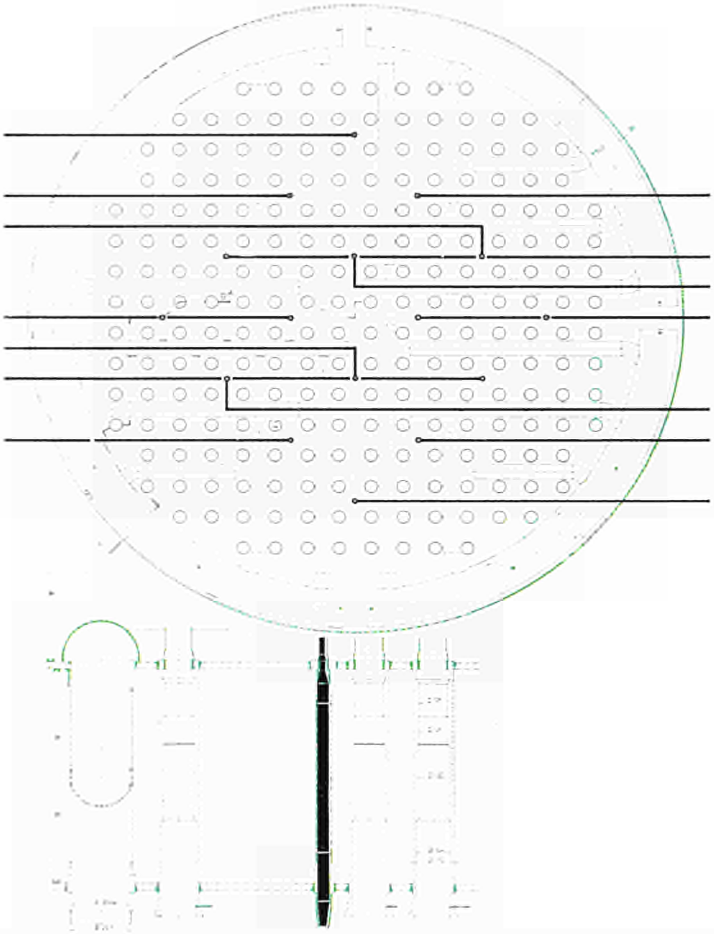


Figure 1: *Above: in-core layout of a liquid rod system; below: detail of lower reactor zone with a rod penetration.*

hydraulics. And this seemed to be a good omen.

Why a liquid rod?

The method most generally used to vary the multiplication factor in a nuclear reactor is that of inserting or withdrawing a substance, e.g. boron or cadmium, which has a large neutron capture cross-section. This is what is done in the vast majority of thermal reactors, where rods or plates of boron (or boron carbide) steel or cadmium steel are inserted into the core to scram or more generally to control the reactor.

For scram purposes all possible advantage is taken of the potential energy of the rod, which in its extraction position is suspended in readiness above the core. Where particular conditions make it necessary, other forms of energy are used, such as hydraulic or pneumatic energy or compression springs. This applies in cases where the actuation has to be exceptionally rapid and/or has to take place from the side or the bottom, or where marine or space reactors are concerned. By now hundreds of designs of solid absorber rods with a thrust mechanism attached have been developed. Some excellent examples, designed for reactors already on the market, are backed by years of satisfactory operation and have been incorporated into the official standards. It must be said, however, that in a good many other cases their operation has been defective.

It is well known that the constant progress in reactor technology often has the effect of complicating reactor design and operation. Ever greater unit capacities, cores of far more compact structure, substantially higher primary fluid temperatures must be named as the most obvious causes for this phenomenon. Not infrequently the problems relating to the traditional means of control are harder to solve.

Considerable difficulties cropped up in connection with certain types of reactor with pressure tubes immersed in the cold moderator. In these the free space between the channels—especially at the channel ends—is so limited that a suitable arrangement of solid rods would be feasible only by removing an equal number of fuel elements. But the calculations show that this would entail a completely unacceptable loss of power (e.g., 8% for a 250 Mwth reactor). Moreover the operation of the fuel element loading and unloading mechanisms does not leave any space beyond the channel ends where solid rods can be positioned when extracted. This is no negligible obstacle in the case of vertical-axis reactors, even though in general loading and unloading are fortunately done from one side by means of a single handling machine. Often, however, the free side is where the high-temperature coolant outlet is located, and this raises other and no less baffling difficulties as regards the positioning of the control mechanisms.

A brillant solution to these problems came from Canada and is one of the most significant examples of innovation in the field of scram systems. It is based on the principle of rapidly lowering the level of the moderator by running it off into a toroidal tank surrounding the main vessel (2). This technique, successfully applied to several reactors, is nevertheless intrinsically limited, for apart from its relatively slow dynamics (several seconds, hence not fast enough to cover the maximum credible accident requirements for certain European projects), for large units it introduces engineering complications of such magnitude as to discourage its adoption (3).

One easily sees why at this point serious thought was given to the so-called liquid rod, which is simply, in many cases, a small-diameter metal tube which runs through the core from bottom to top and into which a neutron-absorbing liquid is injected when the reactor safety system demands it. From the designers' viewpoint it is a winner on account of the following exclusive properties (Fig. 1):

- easy penetration through intricate primary circuit configurations,
- flexibility of adjustment to any route inside the core and in the adjacent zones,
- saving of out-of-core space, to a height at least equal to that of the active zone, which would be needed to hold the solid rod in readiness.

The systems developed by Euratom

Two liquid rod systems of different design have been developed at the Ispra establishment. In the "bubble tube" system, during normal reactor operation the liquid poison level remains steady across communicating vessels at the core inlet (Fig. 2a). When the safety signal switches the scram valve, the propelling gas expands in the poison storage tank, driving the poison into the rods until the lower end of the bubble tube is uncovered (Fig. 2b). This causes partial evacuation of the gas to the header above, until the liquid, its thrust spent, flows back to cover the tube end. The pressure of the gas left in the storage tank ultimately balances the liquid column in the core (Fig. 2c). Special hydrodynamic brakes (4) can be applied at the rod outflows to facilitate this operation. In the type shown in the figure, the fluid enters the braking drum tangentially, forms an energy-dissipating vortex and emerges centrally towards the header above the rods.

In the "gravity" system, during normal reactor operation the liquid level is maintained below the active zone by gas counterpressure in the rods (Fig. 3a). The opening of the scram valve causes equalisation of the pressures in the gas space of the communicating vessels and hence eliminates the difference of level, so that the rods fill (Fig. 3b). With this system it is necessary to monitor the level under standby conditions, and this can be done in various ways. The most characteristic of the methods developed at our laboratory is shown in the figure. A small amount of gas is continuously injected by separate line into the rod outlet header. From here it passes into the small monitoring tank (in which the poison level is the same as in the rods) and thence bubbles up into the tank space upstream of the higher liquid level. If the gas counterpressure drops for any reason, the level rises in the rods and in the monitoring tank, stopping the bubbling. This enables the counterpressure to return to its nominal value. If, contrariwise, the counterpressure increases, the level drops, thus allowing a greater discharge of gas until the nominal value is resumed. For the device to function properly it is essential that the weight of the liquid column in the discharge tube be maintained in spite of the presence

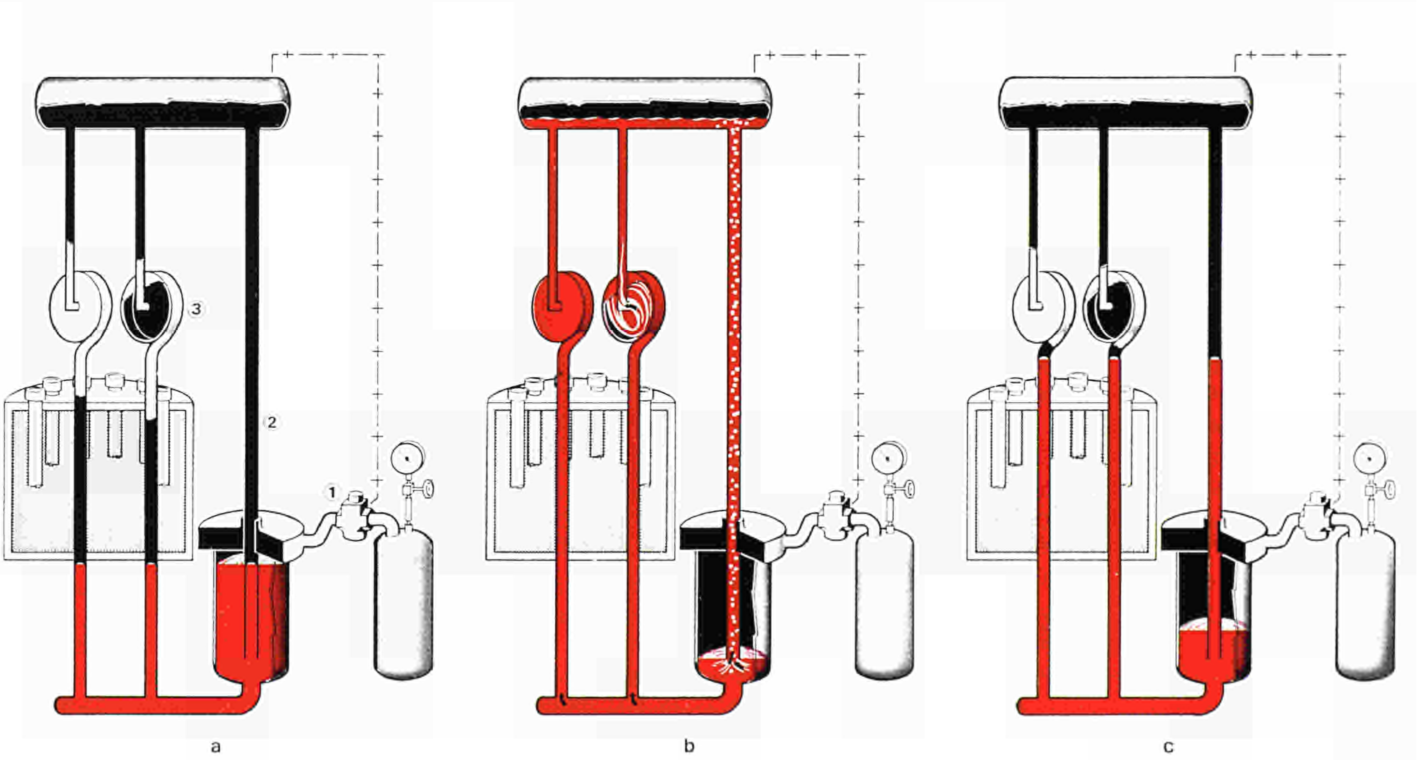


Figure 2: *Schematic diagram of the "bubble tube" system:*
1) *scram valve,* 2) *bubble tube,* 3) *hydrodynamic vortex brake.*

of the bubbles. For this reason the discharge tube must run higher than the upstream level.

Is the liquid rod any less safe than the solid rod?

We have mentioned a certain mistrust which the idea of liquid safety rods is liable to generate. It is probably due to the fact that in the first instance one tends to think that a liquid absorber may easily fail through absence, so that the probability of a serious loss of scram reactivity would be greater than with the usual solid rods. The arguments below will show that these impediments are largely of a psychological nature.

In the first place it must be noted that the liquid rods are distributed in the reactor in the form of circuits strictly independent of one another, and their number is determined on the basic of well known redundancy philosophies, exactly as is done with the solid rods. The object of this is to guard against major losses not only of liquid poison but also of propelling gas, and also against failure of operation of the scram valves. The latter's action can be further ensured by a battery array according to the classical safety schemes (e.g. of the two-out-of-three type).

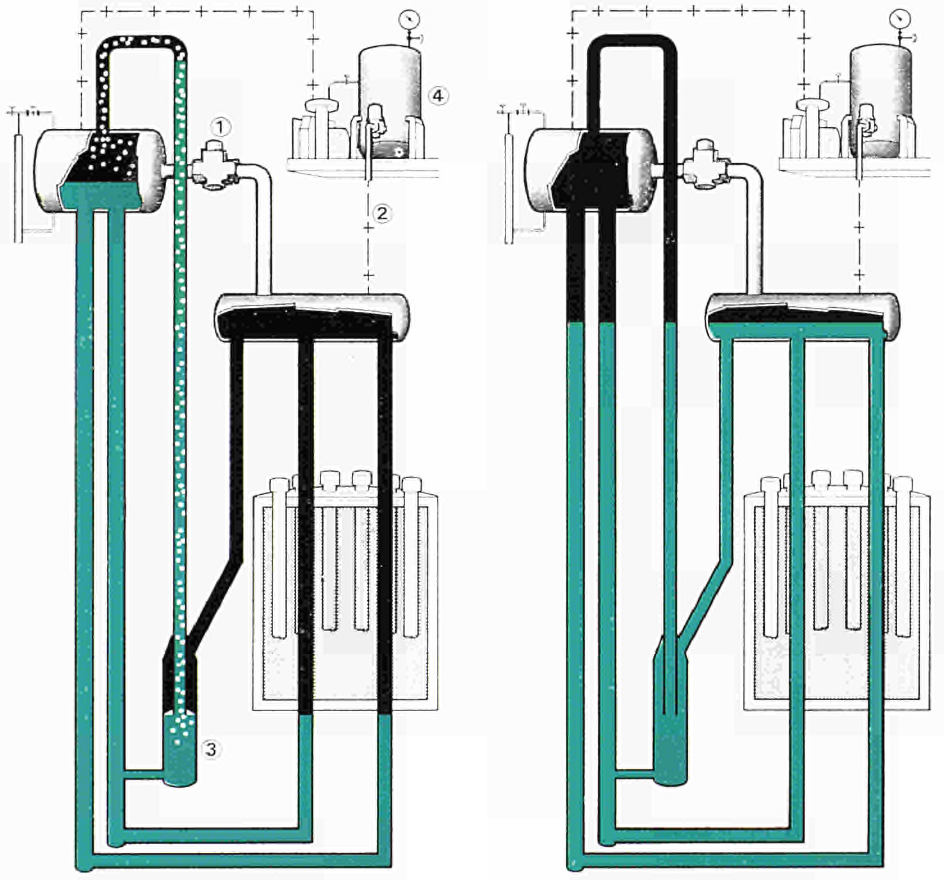
If we analyse the characteristics of the individual rod circuit, it will be seen that they conform to the optimum safety characteristics. The only component with moving parts is the scram actuating valve, a widely proven commercial unit which normally does not come into contact with the poison solution. The rest of the circuit consists of welded vessels and pipes, whose reliability in the field of nuclear engineering is extremely high, more especially where non-pressurised reactors with a cold moderator are concerned. Furthermore, the hydrodynamic braking devices are completely static.

Lastly, under normal operating conditions the circuit is isolated from every auxiliary branch by a double barrier of two valves in series, closed and de-energised. Hence a drastic loss of scram negative reactivity can be postulated only in the case of a serious accident, i.e. one involving a major proportion of the scram circuits.

Coming down to the actual processes of such a hypothetical accident, let us consider the cases of in-core and out-of-core accident separately.

In the first case (which might be the explosion of one or more pressure channels) it seems clear that the chances of the poison jamming in ovalised or bent tubes are truly negligible, precisely because the poison is—it does no harm to repeat it—liquid. And in this respect we think the liquid rod scores another point over the solid one. All the way to the limit case of a rod burst in the core, there appears to be no lessening of safety. Naturally what would happen in such a case cannot be regarded in the light of a regular shutdown, because the moderator would be contaminated by the solution, but the presence in the core of the indispensable shutdown reactivity would at all events be ensured.

In the second case (an out-of-pile accident) a sudden decisive loss of scram reactivity can only be caused by outright rupture of a certain number of sizeable pipes or vessels as a result of abnormal stresses inflicted on them. This type of accident comes under the heading of extraordinary events (earthquake, sabotage, etc.) or the more ordinary events classed under the heading "common mode failure" (5), which are strictly determined by the typical context of each reactor and from which solid rods are no more



a

b

Figure 3: *Schematic diagram of the "gravity" system:*
1) *scram valve,* 2) *monitoring gas valve and feed line to rods header,* 3) *level monitoring tank,* 4) *monitoring gas supply unit.*

exempt in principle than liquid rods. It is the reactor designers' business to build in, as far as possible, appropriate safeguards to protect the rods from such eventualities. In this connection it should be added that, according to the opinion of interested Japanese experts, better intrinsic qualities of antiseismic safety are recognisable in the liquid-rod circuits than in the traditional solid rods.

Better operational continuity for nuclear power plants through liquid rods

It is generally felt that the aspects of reliability and ease of access to the various components of a nuclear electricity-generating plant will have a decisive influence on the choices the electricity companies will have to make in the near future, on which will depend the commercial success of the various types of reactor (6, 7). One of the more important parameters for such evaluations is the plant's annual availability factor.

Both the liquid rod systems described above were expressly conceived to contribute to a high availability factor. Inside the biological shield they consist only of welded tubes whose leak-tightness characteristics, as already said, are among the best in the world. The other parts of each main circuit (tanks and scram valves) and all the auxiliary circuit components can be installed at a distance in zones accessible for maintenance. Any losses of liquid from the isolation valves can be monitored. Special studies have shown that the figures for spurious scram caused by faulty sealing on the isolation valves or false cut-in of the main valves are extremely low (8).

A fundamental problem—the poison

The studies in this field quickly turned towards aqueous solutions of boron salts, in which the high thermal capture cross-section of the base element is combined with satisfactory characteristics of solubility, chemical stability, economy and facility of supply. The use of boron dissolved in a carrier solution for nuclear reactor control purposes is no novelty, but of course it involves poisoning in really derisory concentrations compared with those needed to produce a liquid scram rod having the same efficiency as a solid rod. For that reason all previous experience obtained elsewhere has been of very little help to us.

From the chemical and physicochemical angle the search for the most suitable poison solution was carried out jointly with the laboratories of the *CISE (Centro Informazioni Studi Experienze)*, which was interested in our activities in connection with the *CIRENE (CISE reattore a nebbia*—fog-cooled reactor) activities. The choice fell on a H_3BO_3 solution in which as much as 35 g/l of boron can be contained at a temperature of 10°C, by addition of LiOH. The pH lies between 7.5 and 8.0, values compatible with the chosen structural materials. The "thermal utilisation factor" of a rod using this solution attains asymptotically, with an increased quantity of basic poison, the value of a solid safety rod of equal diameter; but it has been calculated that for certain thermal reactor cores

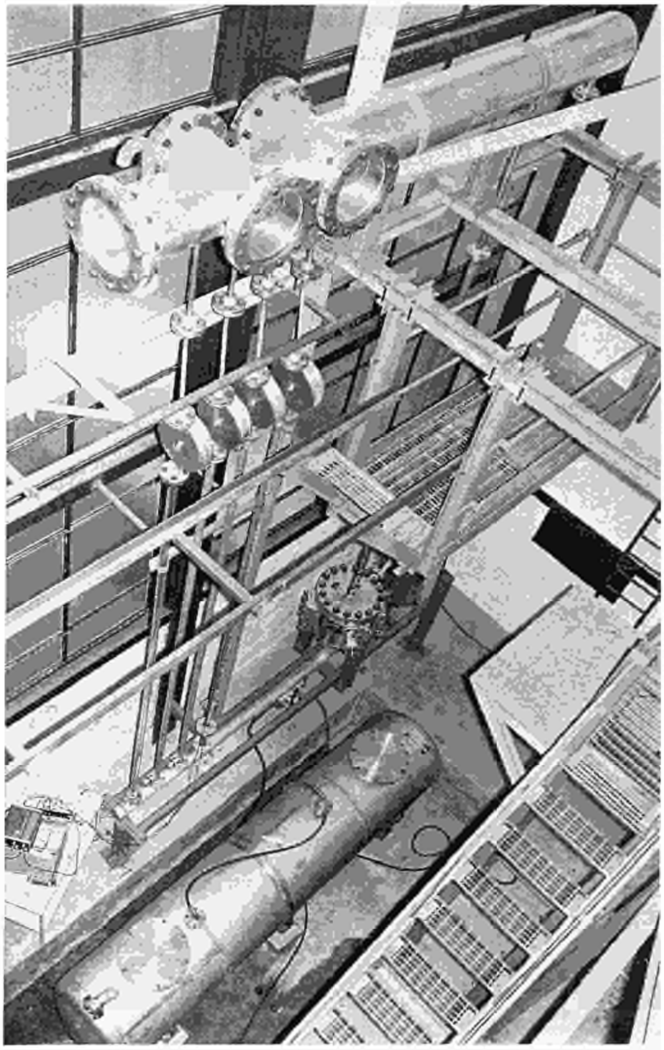


Figure 4: *Bubble tube system experimental assembly, showing the vortex brakes upstream of each rod below the header.*

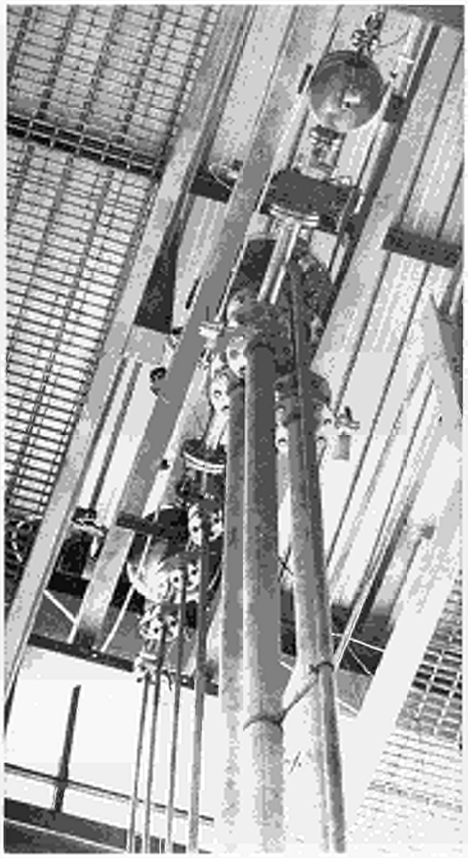


Figure 5: *View from below of the down tubes and poison tank (centre) and the header (left), on the "gravity system" experimental assembly.*

95% of the solid rod value can be obtained with boron concentrations of less than 20 g/l. The choice of H_2O as carrier liquid was prompted by obvious reasons of convenience, but there is nothing to prevent the use of D_2O. It should be noted that a singular property of a soluble poison rod system is that the concentration, and hence the controlled reactivity, can be modified subsequently to meet the real requirements of the reactor.

Each time the system is used, a residual film of solution remains on the inner wall of the in-core tubes, and experiments were therefore conducted on special mockups to measure it and establish efficacious scrubbing procedures. For surfaces of standard roughness it was found that the negative reactivity of the residue amounts to a few percent of that introduced by the empty zircaloy tubes. Ten minutes' scrubbing with demineralised H_2O only is enough to bring the value down to a few tenths of a percent.

The chemical characteristics of the solution components are such as to exclude the presence of any intrinsic residual activity. As the integrated flux to which the solution may be exposed is negligible, problems of radiolysis of the components need not be expected.

Research on prototypes

At the outset, in the absence of any existing standard for liquid rods, a set of quality criteria was evolved—veritable key postulates—in the light of which a certain number of basic circuits were designed, some of which have been patented (9). Under the aegis of the *ORGEL* Project the the two selected designs, namely the "bubble tube" and the "gravity" systems (the latter proposed by *CISE* (10)), were developed into two prototypes to check the feasibility of the design as well as the scram control system and the scram dynamics (Figs. 4 and 5). Both of them showed that they operate safely and satisfactorily. The bubble tube system in particular confirmed its excellent dynamic behaviour. At the same time mathematical models were developed of both systems, which allow simulation, with an approximation margin of better than 5%, of a wide variety of operational conditions in relation to the most varied circuit conditions. Consequently, by means of the digital codes *NIAGARA TB* and *NIAGARA PG* it is possible at the design stage to select the best geometrical and physical parameters to provide optimum dynamics for the future liquid rod assemblies (11).

Situation 1970: a stimulating situation

The positive results obtained during the first stages have opened definite prospects for the use and development of both the liquid rod systems. In 1968 the design of a shutdown system for a 250 Mwe power plant was prepared in connection with the *ORGEL* prototype call for tender. This was the first *EULER* activity carried out in collaboration with industry. The design provides for 36 rods distributed in nine groups including one redundant group.

In the subsequent context of *Joint Research Centre* assistance on D_2O reactors, the *EULER* programme is now running along guidelines both internal and external to Euratom (Fig. 6).

A bubble tube scram system (*CHARLES* project) has been planned for mounting in the *ESSOR* reactor alongside the existing solid rod system. By this means it will be possible to increase the currently available margin of shutdown reactivity and to intervene before burnout occurs in the feeder zone and in the reactor's various test sections. The system will consist of three circuits of two rods each. A test circuit, reproducing the path of the group of rods regarded as the slowest, is being erected at our laboratories. Commissioning in *ESSOR* is scheduled for the first half of 1971. This will be a major confirmation of the forecasts which assign to liquid rods an indispensable role wherever problems of bulk, penetration, fit with already existing structures, etc. render the use of solid rods difficult. The controls for the system, completely automatic with logical microcircuits, are now being built at our laboratories.

The full-scale prototype of the scram system for the planned *CIRENE* reactor[2] has been designed for *CISE/CNEN*. The rig (*MULTIBARRE* project) is at present at an advanced stage of construction and will be commissioned in the second half of 1970. This is a fully instrumented unit of the gravity type, using a level difference of about 14 m and diameters of 100 mm for the down pipes and 46 mm for the in-core tubes (Fig. 7). The object of the prototype is to serve as a general test facility before the real system is placed in the reactor, and also to provide data on the long-term behaviour of some of the components and the assembly as a whole. For this purpose the rig will be subjected to several thousand cycles of automatic operating sequences. Still in the same context we should mention the aid given to *CISE* in drawing up the specifications of the real system for *CIRENE*. In particular the entire parameter study of the dynamics was carried out with the aid of the *NIAGARA PG* code.

Two sets of studies and experiments are supported directly by Euratom, as necessary complements to the main programme of systems consultation and design.

The first set is designed to obtain information on the in-core corrosion behaviour—with particular reference to electrolytic corrosion—of the zircaloy-stainless steel joints between the rods and the rest of the circuit. These joints are in general located in line with the top and bottom reflectors, as in the case of the pressure tubes. An irradiation loop (*CECILE* project) will come into operation in 1970 in a peripheral channel of the *ISPRA I* reactor; its operating conditions will be as close as possible to the real conditions of use of the joints in power reactors. Samples of both the metallurgical type (obtained by explosion or extrusion) and the mechanical type (obtained by rolling) will be irradiated for a period of at least eighteen months. After withdrawal the joints will be subjected to metallographic examinations and to leaktight tests.

The second set is concerned with the designing and development of a new type of hydrodynamic brake. The vortex brakes whose operation is illustrated in Fig. 2 require appreciable space, which is in every case additional to that needed for the anti-streaming plug (a kind of shield against neutron leakage along the rod), mounted in the upper part of the rods. The new type of brake will have to occupy a radial space which is not greater than that taken up by the rod itself and at the same time satisfy the demands of efficient neutron shielding.

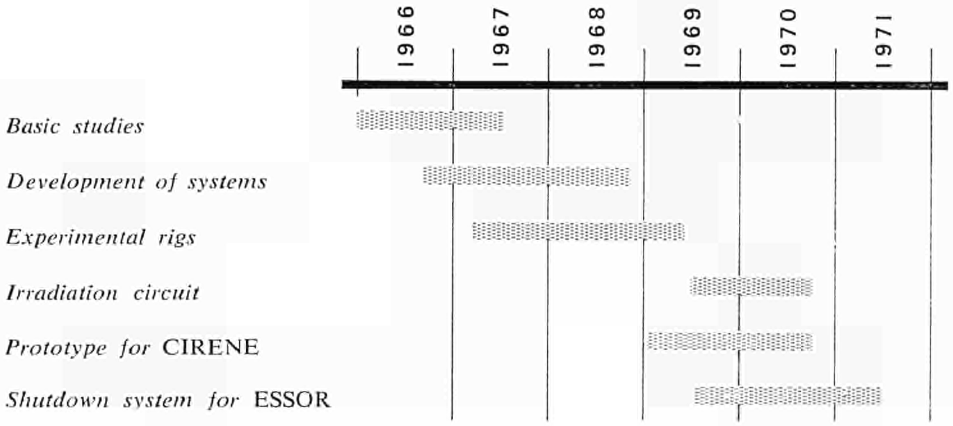


Figure 6: *Chart of work at Ispra on liquid rods since 1966 to date.*

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[2] Euratom-*CNEN* Contract of Association 008-65-1 *NTRI CIRENE III*.

Finally, a very recent event should be mentioned, the acquisition in France of the patents and related knowhow on the liquid rods. On 25 May 1970 the *Compagnie générale d'électricité* signed an agreement to this effect with the Commission. The agreement also contains a request for the immediate use of the skills acquired at the Ispra Establishment for the purpose of designing a liquid rod system for an advanced 600 Mwe thermal power plant.

This is the most significant milestone on the road to full demonstration of the industrial soundness of this Community programme. EUSPA 9-12

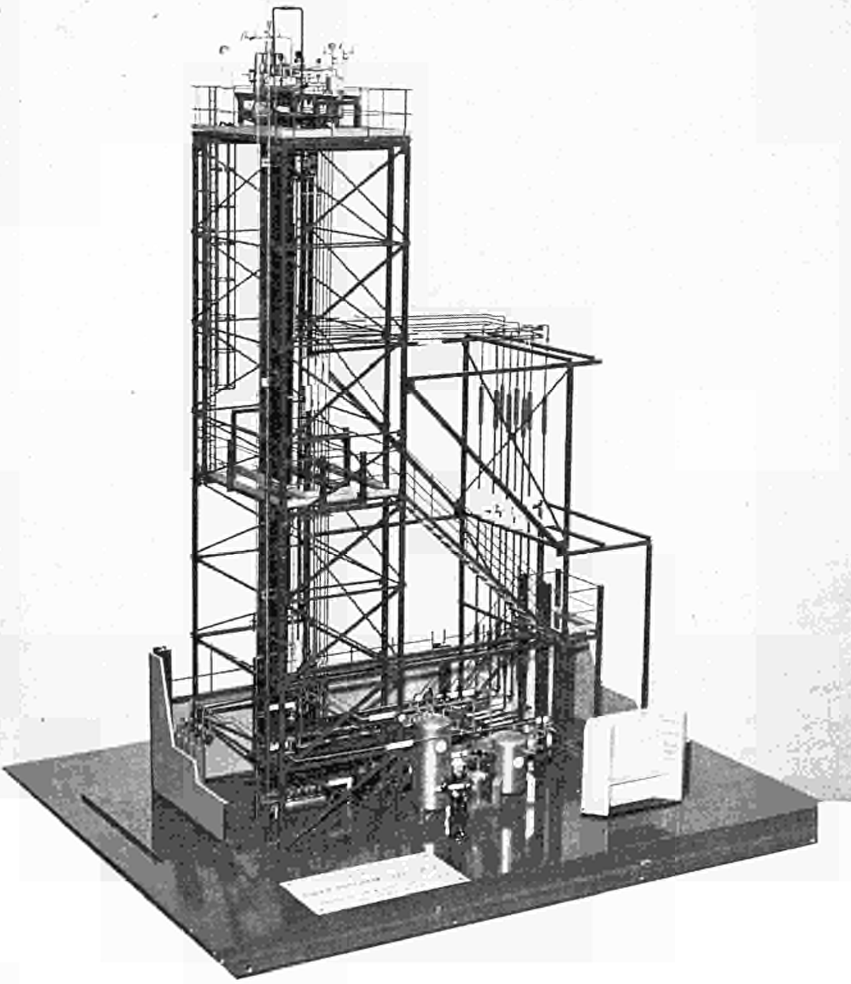


Figure 7: *1:16 scale model of the prototype multirod rig for the* CIRENE *reactor.*

Literature: (1) M.A. SCHULZ: Control of nuclear reactors and power plants. *Mc Graw-Hill Comp., New York (1961).* (2) *AECL Rep. CRR-1168 (1963) 6.* (3) M.A. SCHULZ: Incipient failure diagnosis for assuring safety and availability of nuclear power plants. *Conference Proceedings Gatlinburg (1967), CONF-671011, 33.* (4) Euratom Patent pending. (5) G. HESLEY: The reliability prediction of mech. instrum. equip. for process control. *Risø (S)R, 178, 3rd CREST meeting, Risø (1969) 6. (6)* S. BARABASCHI: Reattori avanzati. *Notiziario CNEN 3 (1969) 53.* (7) A.M. ANGELINI, L. SANI: Operating experience and prospects of development of nuclear stations in Italy. *Energia Nucleare 16, 2 (1969) 95. (*8) S. GALLI DE PARATESI, L. GHIURGHI, H. MESIK: Reliability assessment of a novel liquid rod shut-down system. *3rd CREST meeting*, Risø (1969). (9) a) Safety rods for nuclear reactors. *Belgian patent No. 678,235, French patent No. 1,516,630, Italian patent No. 808,703, Luxembourg patent No. 53,204, British patent No. 1,161,454, US-patent No. 3,414.476.* b) Safety rod systems for nuclear reactors. *Belgian patent No. 705,692, French patent No. 1,587,232, Italian patent No. 842,939, Luxembourg patent No. 56,462, British patent No. 1,177,895.* c) Liquid safety rod system for nuclear reactors. *Belgian patent No. 705,693, French patent No. 1,587,233, Italian patent No. 844,588, Luxembourg patent No. 56,452.* d) Control and safety rods for nuclear reactors. *Belgian patent No. 713,307, Italian patent No. 844,594, Luxembourg patent No. 56,354.* (10) Dispositivo di arresto rapido di un reattore nucleare mediante iniezione di liquido assorbitore di neutroni. *CISE patent (Italy) No. 800,935.* (11) A. AGAZZI, A. BROGGI, S. GALLI DE PARATESI, L. GHIURGHI: *Trans. Am. Nucl. Soc., 14th Annual Meeting Toronto (1968) 338.*

Technical Notes

The Commission's *technical notes* give descriptions of original results obtained under the Euratom research programmes. Their purpose is to enable firms to decide whether they should consider industrialising these results. Copies can be obtained on request from: The Commission of the European Communities, DG XIII-A, 29, rue Aldringer, Luxembourg.

— 4/C: Transmission system for processing data from a remote terminal on a computer

This system is used to establish an on-line connection between the measuring instruments in a laboratory and a remotely sited computer. Two modulator and demodulator units are used for transmitting the data at high speed over a coaxial cable.

The system has the following special features:

- simultaneous two-way transmission over a coaxial cable;
- d.c. pulse coding;
- fast bit rate and high reliability;
- use of digital and linear integrated circuits;
- extra channel for telephone messages on the same cable;
- inputs and outputs to international specifications.

Characteristics:

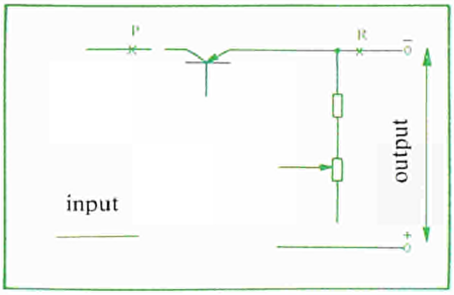
- bit rate, each way: 0-125,000 bit/s
- pulse duration in cable: 1 µs
- transmission distance: 0-5 km.

— 5/C: Power supply

This unit can be used to supply apparatus with d.c. power for a period of time that can be infinitely varied between 1 second and 3 minutes.

It consists simply of a relay with its contacts arranged in the output circuit of a transistorised stabilised power supply controlled by a built-in transistorised timing unit.

The contacts break the circuit at position R in the diagram when power supply stability is not of prime importance or, when stability must be maintained, in the position marked P.



— 13/C: Electron beam welding unit

The unit has an overall length of 15 m and was developed for the welding of metals and alloys by electron bombardment in vacuo; with it, qualities are possible which cannot be attained with other fusion welding techniques.

It can be used with work pieces ranging in size from very small to large (e.g. girth or longitudinal seams on tubes with a maximum diameter of 180 mm and a maximum length of 6,500 mm, girth seams with maximum diameter of 500 mm and maximum length of 500 mm). The penetration of the beams is over 20 mm with stainless steel; the focal spot is so small that weld seams are possible with steel of a minimum thickness of 2-10 mm.

— 48/C: High precision level gauge for difficult liquids (radioactive, corrosive, etc.)

This indicator was developed for the continuous measurement of the heavy water level in a reactor pressure vessel; it gives a numerical indication in millimetres. The depth is determined by measuring the water pressure and by using an arithmetical technique. A differential pressure gauge and an electronic device with integrated circuits are employed for this purpose.

Accuracy: to within 1 mm (20-80°C) with normal-level zone; to within 5 mm (20-80°C) in the overall measuring zone covering the entire height of the pressure vessel.

The device can measure and give a visual indication of the depth of any liquid.

— 52/C: Liquid detector

This device, flange-mounted on a liquid collector, was developed to detect possible leakages of organic liquid on a circuit and to warn the staff. It can be used in difficultly accessible places.

Senitivity: 1.10^{-3} organic liquid.

Fields of use: Detection of liquid leaks on tanks and lines in all kinds of plant (organic liquids, fuels such as diesel oil, petrol, etc., water). Since the device is explosion-proof, it can be used in refineries.

— 53/C: Differentiation of brightness levels by means of attenuation during photography and filming

When objects which appear as luminescent spots on a convex fluorescent screen, e.g. the diffraction patterns of slow electrons, are being photographed or filmed, the geometry of the screen and the position of the camera lens

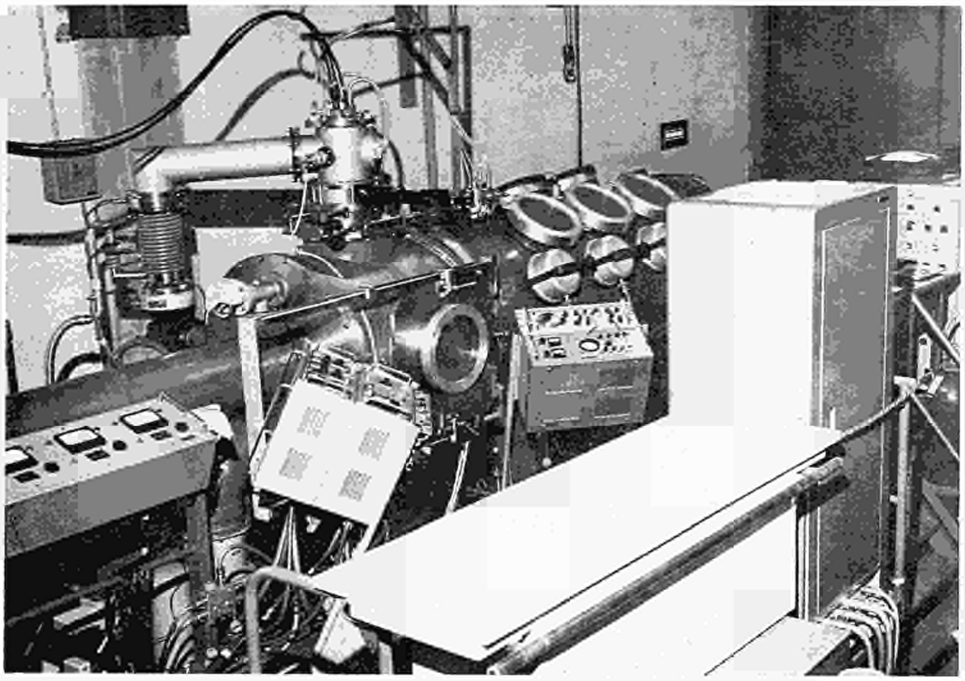


Figure 13/C: *View of an electron beam welding unit developed in Ispra.*

with respect to the centre of curvature of the screen cause the brightness of the resultant image to decline radially from the centre outwards, so that the extreme values cannot in practice be recorded in the same exposure.

In order to solve the problem an attenuator was placed in the path of the light rays forming the image on the film, thereby reducing the brightness range to an extent compatible with the latitude of exposure of commercial emulsions.

— 54/C: Automatic brightness control for photography and filming

Automatic control of average image brightness can be achieved my means of a light control unit remotely controlled by a photosensitive measuring system set to operate at a fixed level. This method can be used to achieve constant film exposure, particularly in making micrographs, where the camera has no lense.

This system is specially intended for use in scientific filming and confers great flexibility on cinemicrography by freeing the operator of the constant need to ensure correct film exposure.

— 60/C: Automatic digital equipment for tensile testing machines

This equipment was developed with the specific aim of providing an Instron tensile testing machine with a digital output unit by digitalising the analogue measurements, and enables the arithmetical and storage capacity of a computer to be used for analysing tensile test results.

Main characteristics

The equipment consists of a dial-type digital voltmeter, a series unit for the IBM 8 channel code, a high-speed tape punch and a self-contained digital unit which controls some functions of the machine and the whole of the digital measuring circuitry.

The test machine need not be modified before connecting the outomatic digital output equipment.

A stress plot and a punched tape are produced simultaneously for each test.

The tape consists of two parts:

(a) a static part containing all the data on the test to be carried out (fixed input data);

(b) a dynamic part containing the values measured during the test.

The stress curve can be plotted in two ways:

(a) stress *vs* time, being equivalent to the stress as a function of movement of the beam of the Instron machine (indirect strain measurement);

(b) stress *vs* strain. In this particular case the strain is measured by an extensometer fixed to the specimen (direct strain measurement).

Indirect strain measurement consists in measuring the load at regular intervals, determined by the digital control unit. This is known as "single digitalisation".

Direct strain measurement, or "double digitalisation", consists in measuring stress and strain alternately at regular intervals determined by the digital control unit.

Technical capabilities

I—*Dynamic section*

A selector switch is provided for selecting either single or double digitalisation.

(a) Single digitalisation: The stress is read directly at the output of the amplifier on the Instron machine's dynamometer and measured by the digital voltmeter.

The sampling rate is controlled by the control unit. A total of twenty rates are available, from about eight measurements per second to one every 80 sec.

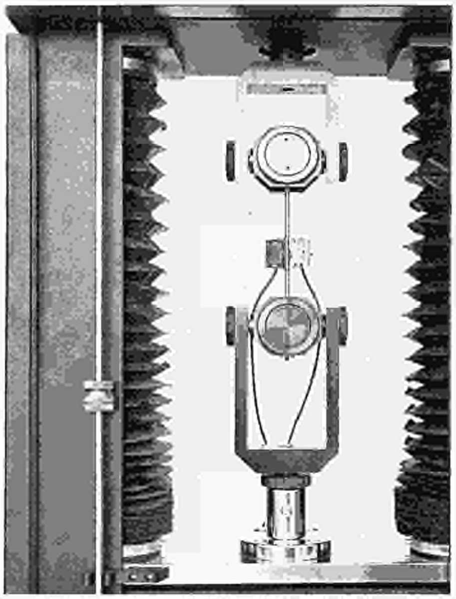
(b) Double digitalisation: Stress and strain are measured alternately by the same instrumentation as for single digitalisation. A relay, controlled by a digital control unit, connects the digital voltmeter to the dynamometer amplifier and the extensometer bridge. A special code is punched in the tape ahead of the measured value to indicate the type of measurement. There is a choice of 20 rates of sampling, from about four measurements per second (stress and strain) to one (stress and strain) every 160 seconds. In either case, all the strain rates available on the testing machine can be used but they are controlled by the digital control unit. The rates of sampling and strain can be changed at any time during measurement with no danger of introducing errors.

II—*Static section*

A total of 96 addresses are available for the fixed input data. Each address can take a maximum of six digits. These data are entered step by step.

— 62/C: Fixing device for the tensile testing of particularly brittle materials

This device was developed for the tensile testing of brittle materials using a specimen holder that exerts no bending or torsional moments. In particular it has been used routinely for plotting stress/strain curves at small loads, establishing the static modulus of elasticity of ceramic materials and testing irradiated and non-irradiated reactor graphite.



Two shafts at right-angles to each other and supported in needle bearings are arranged in the same plane, in the centre of which the specimen is suspended on a needle thrust bearing, so that all three compensating movements take place in the same plane.

Various removable shims can be used depending on the geometry or cross-section of the specimen.

This apparatus is used on tensile testing machines.

— 63/C: Digital flowmeter

This digital flowmeter is a small, simple digital computer giving a direct indication of the rate of flow of a liquid in the desired units: m^3/h, l/s. It allows for the effect of temperature on the measurement by measuring first the temperature and then the flow, which is corrected for the measured temperature.

The flow is measured by an orifice plate connected to a differential pressure gauge providing an electrical output signal, and the temperature by a thermocouple. In both cases the instruments are readily available through commercial channels.

The computer program can easily be modified, by means of an interchangeable panel, in order to adapt the apparatus to any flow-metering task.

It is used at Ispra on an organic liquid (polyphenyl) circuit with flows between 20 and 90 m^3/h and temperatures varying between 150 and 400°C.

The differential pressure gauge used is a Foxboro 311-B.

Accuracy is 1% but can easily be varied to suit operational requirements, subject to a small change in the number of logic circuits used.

— 328: Grip for nuclear reactor fuel rod clusters

The grip, of very simple design and consequently reliable operation, can grasp a number of parallel fuel rods simultaneously. The grasping and releasing movements are not remote-controlled but are effected automatically in a very simple manner.

(German patent 1,280,425, French 1,536,910 or Italian 701,339.)

— 484: Method and equipment for determining leakage from leaktight enclosures

This device can be used for the rapid and accurate measurement of the rate of leakage from leaktight enclosures, e.g. glove boxes.

It consists of a leaktight standard capsule provided with a micromanometer, a receptacle and a graduated test tube (the last-mentioned is unnecessary if the receptacle is graduated).

The enclosure under test is connected to the standard capsule and maintained for a certain time at the partial vacuum required for testing (the time required to produce a permanent deformation of the walls of the enclosures).

It is then disconnected from the standard capsule and maintained at the same partial vacuum, after which liquid is sucked from the graduated receptacle connected to the enclosure under test. The amount of leakage can then be calculated from the quantity of liquid removed in this way. When the enclosure is pressurised the procedure is identical except that liquid is added.

By embodying the standard capsule the method allows inherently for variations in the ambient atmosphere (low atmospheric pressure, pressure variations due to room ventilation, temperature, relative humidity, etc.).

The method was developed in 1963 and has been used in various laboratories. It is used primarily on enclosures containing dangerous substances and those of lightweight, non-rigid design.

— 573/789: Thermoelectric method of determining temperatures

The method is based on the partial return to the initial state of the heat-induced deformation of the crystalline structure of lengths of cold-worked wire which are introduced, with no electrical connections, into the area of unknown temperature. The degree of return to the initial state is subsequently determined by simple thermoelectric means. The method can be used to obtain temperature readings of up to

1,000°C and to determine the temperature distribution curves. It was developed for use in a nuclear reactor.

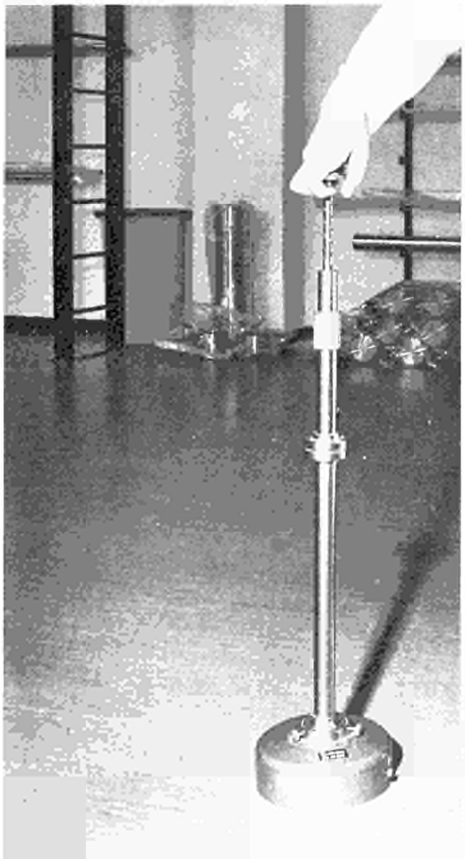
(German patents 1,255,346 and 1,285,209; French patent 1,460,458; British patent 1,124,136.)

— 870: Hand-operated device for sampling surfaces by wiping

This device, which consists of a bell-shaped foot and a spool transport system mounted accentrically on vertical springs, is used to obtain wipe samples for checks on radioactive contamination on surfaces in reactors and laboratories (radiation protection).

The wipe sampling process takes a few seconds and the spool capacity is about 50 samples.

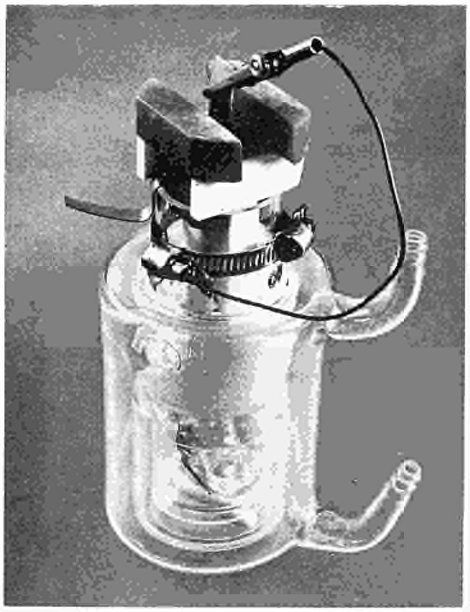
(French patent 1,530,008.)



— 1239: Apparatus for polishing metal specimens

This is a simple device in which a specimen, acting as an anode, is placed in contact with the electrolyte. It is used to obtain particularly smooth, very brigt metal surface on very thin specimen, particularly those intended for examination under the electron microscope.

Both sides of the specimen are polished in one operation and the process can be visually monitored with great ease owing to the use of through lighting. Explosive or dangerous electrolytes can also be used without risk.



The electrolyte is housed in a receptacle with double walls through which a coolant circulates. The upper portion of the receptacle is tapered and provided with an opening at the top which is used as the bearing for a cylinder immersed in the electrolyte. The cathode is mounted at the bottom of the cylinder, with an atomiser having two horizontally opposed nozzles, between which the specimen being treated is placed at the top. The electrolyte is pumped through passages in the cylinder and ejected via the atomiser by means of an agitator on the bottom of the receptacle.

At the same level as the atomiser there are horizontal passages through the receptacle and ports in the cylinder enable the specimen to be observed during polishing.

(Luxembourg patent 58,797.)

NEWS FROM THE EUROPEAN COMMUNITIES

A true European policy of scientific cooperation and technological development should be pursued. In a note to the Council in June 1970, the Commission presented the first practical guidelines for such a policy. According to the Commission, it is necessary: 1) to organise periodic consultations at Community level on major national research projects (see article on page 66); 2) to launch schemes in certain special sectors forthwith: the nuclear sector (European fast reactor prototype, European high-temperature gas-cooled reactor prototype, European uranium enrichment plant), data processing, space, environmental management; 3) to encourage the creation of a European system of scientific documentation and personnel training. The *main theme* of the note is that scientific research matters should be tackled by the Community *on a joint basis.*

THE "Four Wise Men" have drawn up an interim report which the Commission forwarded to the Council of Ministers at the beginning of June. This was a report by four well-known scientists, Mr H. Casimir, Mr P. Ailleret, Mr H. Maier-Leibnitz and Mr G. Ruffolo, on what the function of the *Joint Research Centre* should be in the development of scientific research in the Community. The "Four Wise Men" recommend the joint construction and operation at Ispra of the *SORA* pulsed reactor, which would have the advantage of providing Ispra once more with a major objective and would ultimately lead to contacts with the other research centres and the universities, the adaptation of the Ispra *ESSOR* pulsed reactor to other uses besides fuel testing for heavy-water reactors, and the creation of a materials research institute to make the best use of the available resources, which are generally lacking elsewhere in Europe. They feel, moreover, that public service activities (such as pollution control) are most in need of Community action. The function of the Ispra Computer Centre in the development of data processing should be carefully investigated. In addition, the decision to carry out work in the *Joint Research Centre* for outside customers should be taken without delay.

BIOLOGY and health protection are the subject of a proposal for a five-year research programme submitted by the Commission to the Council. The proposal envisages a total budget of 38.82 million u.a. for the period 1971-75 and is divided in two main parts. The first concerns radiation protection and covers the study of human and environmental contamination, improved knowledge of the effects of irradiation on man and other living organisms, a distinction being made between short-term, long-term and hereditary effects, and measuring and dosimetry problems. The second part concerns the development of nuclear techniques for application to agricultural and medical research.

CONTROLLED thermonuclear fusion has also been the subject of a proposal for a five-year research programme submitted by the Commission to the Council. The proposed programme embodies virtually all the research being conducted in the Community in this field and will involve the coordination of a total budget of about 170 million u.a. during the period 1971-75, approximately one-third being borne by the Community and the remainder by the Member States. It should be noted that the Community's share in the world research effort on controlled fusion has increased from 7.5% in 1959 to about 20% today. The programme covers research in five broad sectors: fundamental general physics and theoretical work, closed configurations, open configurations (magnetic mirrors), very high density plasmas with very short confinement times and technology.

THE reorganisation of the Community's electrical and mechanical engineering industries is recommended in a Commission memorandum to the Council of Ministers. A study has shown that today, if a group is to be fully competitive, it must have a minimum heavy production capacity of about 6,000 MWe a year. In the Community, the only group to achieve this capacity at present is the German Kraftwerk-Union. On this basis, and assuming the pooling of resources, there will be room in the Community in the next five years for only two or three companies, as against about ten now. Accordingly groupings at the purely national level are no longer feasible.

A draft statute for a European joint-stock company has been submitted by the Commission to the Council of Ministers. It is intended to assist integration in the Common Market by creating a trend towards a common legal form of company. According to the draft, joint-stock companies having their registered offices in different Member States can adopt the European joint-stock company statute when they engage in the following operations: an international merger, the establishment of holding companies or the establishment of joint subsidiaries.

IN the new Commission of the European Communities, which took office on 1 July 1970, **Mr Altiero Spinelli** has been given special responsibility for industrial affairs and research and technology.

THE dissemination of information is among the responsibilities of **Mr Albert Borschette.**

MR Wilhelm Haferkamp, now Vice-President of the Commission, retains responsibility for energy matters.

THE Council of Ministers of Technology of the European Community met on 23 July 1970. The Council decided to invite the nine European non-member countries (Britain, Ireland, Denmark, Norway, Austria, Spain, Portugal, Sweden and Switzerland), with which discussions on technological cooperation have already taken place (see *euro-spectra* Vol. IX (1970) No. 1, p. 29), to continue the work, under a coordinating committee of senior officials; the committee is to have a budget of 600,000 u.a. for carrying out the first studies required; a ministerial meeting of the Fifteen is to be held in principle by the end of the year to make definite decisions on the implementation of the programmes and projects adopted.

THE industrial exploitation of the results of research is featured in a Commission reply to a question put by Miss Colette Flesch, a Luxembourg member of the European Parliament. In due course the Commission may propose to the Member States that they should either harmonise and coordinate existing ways and means of exploiting inventions and know-how resulting from research and development or set up a Community body with certain responsibilities concerning the transfer of technical know-how.

THE financing of research and development in the Community countries has been studied and analysed by statistical experts at the request of the Working Group on Scientific and Technical Research Policy (the Aigrain Group). The results of the study have been assembled in a report recently published in the new series "Research and Development" (copies of the report can be obtained on request from the Editor). The data are presented in a form permitting comparison of the research plans and budgets of the Community Member States and should enable any points of convergence and divergence, duplications and gaps to be pinpointed. As an example of the information given in the report, the appropriations for R&D in 1969 totalled around 1% of the Community's gross domestic product: France accounts for nearly half the public R&D expenditure, while Italy's share is less than 10% of the total; during the period 1967-69, the growth rates were very similar in the various countries, running at nearly 9% on average; except for France, almost half the appropriations go to the general furthering of knowledge, especially in universities, etc.

THE Commission has accepted an invitation by NASA for the *Joint Research Centre* to participate in the study of the moon rocks brought back by *Apollo* missions in the near future.

IRRADIATED foodstuffs were marketed for the first time in the Community in June 1970. They were mushrooms, irradiated under a research programme conducted jointly by Euratom and the *Instituut voor Toepassing van Atoomenergie in de Landbouw* (*ITAL*), and were offered for sale by a Netherlands chain store. The mushrooms were processed in a pilot plant at Wageningen (see *Euratom Bulletin* Vol. V (1966) No. 3, pp. 73-75).

THE Commission is to award a contract for a **study on metallurgical research laboratories** in Germany to the *Battelle Institute*, Frankfurt. Joint European research in the metallurgy sector, as desired by the Community countries, should be based on an accurate knowledge of what has been accomplished to date in each country. However, there is a total lack of such information in some countries, and the Commission has decided to start its overall study with West Germany, where the research effort in the field of materials is on a large scale and widely dispersed, with no central documentation system.

A **joint research programme** on the valorisation of fly ash and slag, to be conducted in West Germany and France, is to receive financial aid of 0.56 million u.a.

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from the Commission. The results of the research, which is not yet completed, are important in that they indicate new possibilities of putting these residues to good use.

TWO **research projects on the production of special coke** were conducted in 1970 with financial aid from the Commission worth 0.46 million u.a. The electrochemical and electrometallurgical industries are the leading consumers of special fuels.

THE major result of **two projects on anti-explosion** barriers (fire stoppings and other stoppings used below ground) is that they have demonstrated the practical application of water trough barriers. The Commission provided backing for these projects for a total of 0.03 million u.a.. This technique has proved very effective, so that it will now be possible to provide protection against coal dust explosions where the traditional type of stonedust barrier cannot be used.

A **new standard for neptunium-237** has been made at the *Central Bureau for Nuclear Measurements* in Geel, Belgium, and conditioned in a vacuum. Four standards for highly-enriched uranium have also been produced in a scintillation chamber; these have a mass occupation of 1 mg U/cm^2 on both sides of an aluminium foil (dimensions: $20 \times 20 \times 0.005$ cm) and are intended for neutron physics measurements.

A **list of particle accelerators** and associated equipment in the European Community has been published by the Commission. It can be obtained on request from the Editor.

INTERNATIONAL legislation on the irradiation of foodstuffs is the subject of a survey ordered by the Commission. The findings of this survey have been published in the Euratom report series under the number EUR 4466e. The report can be obtained in English from the European Communities Publications Office, 37 rue Glesener, Luxembourg.

CHRONIC respiratory disorders were the subject of a scientific colloquium organised by the Commission at Wiesbaden, Germany, in June and attended by about 100 experts.

OPERATION of the *AVR* and *Dragon* reactors was the main topic of an information meeting arranged by the Commission in Brussels in June. The officials responsible for these two high-temperature helium-cooled reactors spoke to some fifty representatives of industry, electricity producers and research centres.

NATURAL uranium producers in the Community Member States met at the *Joint Research Centre's* Ispra Establishment on 18 and 19 June 1970 at a conference organised by the Commission. While no shortage of uranium was noted for the time being, it seems unlikely that the deposits currently being worked will meet requirements in 1980. Measures to encourage uranium prospecting by Community firms need to be put in hand.

A **colloquium on radiation protection problems** posed by transuranium elements will be organised at Karlsruhe on 21-25 September 1970 by the Commission of the European Communities, in conjunction with the *European Nuclear Energy Agency*. Transuranium elements are becoming increasingly important in many research sectors as well as in industry, and they create special health and safety problems.

A **colloquium on the prevention of industrial accidents** in the coal and steel industries will be held by the Commission at Luxembourg on 21-23 October 1970.

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