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1969-4

At a meeting of the Council of Ministers on 31 October 1967 the Six expressed their intention of taking vigorous action to revive and encourage scientific and technical research and industrial innovation. It was decided to investigate the opportunities for cooperation in the following fields, considered to be of prior importance: information science and telecommunications, development of new means of transport, oceanography, metallurgy, abatement of nuisances, and meteorology.

How is it that one of the first active steps undertaken was a forward study on telecommunications, of which the main findings are reported in this issue?

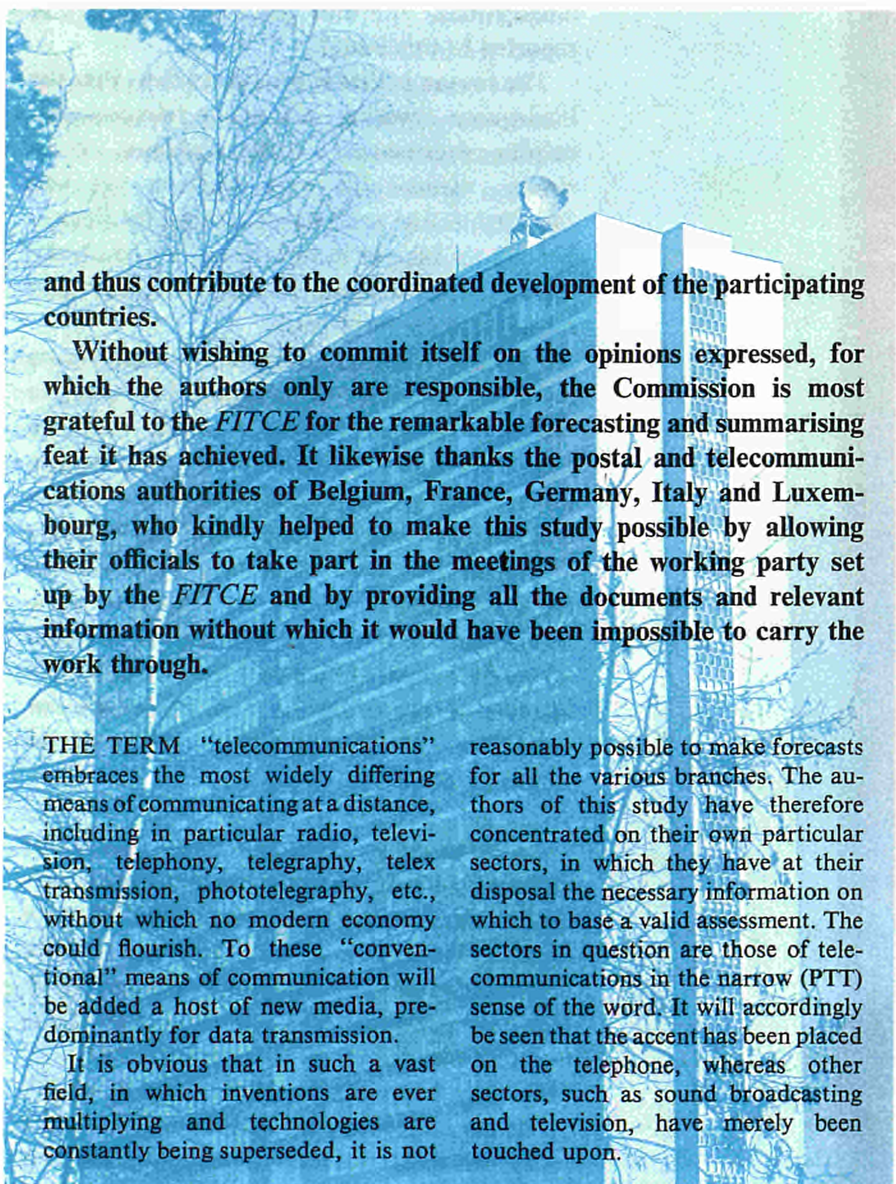
The reason is that it became evident that the inadequate covering of certain telecommunications requirements—with telephones, for instance, witness the long wait to get one installed, or the overloaded state of the lines—is due to a lag not in technology but in investment in a sector where demand is increasing at a well-nigh explosive rate.

An easy way out would be to keep up as nearly as possible with demand by trying to release enough resources to cope with the rapid spread of requirements. For the purposes of the forward study a different viewpoint was deliberately chosen, namely that the pressure of immediate needs must not be allowed to delay the introduction of certain innovations. Otherwise we risk perpetuating a situation where the supply of services follows the demand instead of preceding it, and thus does not contribute as fully as possible to economic and social progress.

Thus the report summarised here is the first step in a forward-ranging exploration of telecommunications requirements, with 1985 as its horizon. It was drawn up at the request of the Commission of the European Communities by the *Federation of Telecommunications Engineers of the European Community (FITCE)*. One may hope that a joint analysis of the problems stated by the authors of the report will lead to the working out of joint solutions

Telecommunications in the year 1985

The report summarised in this article will be published shortly under the title "Telecommunications development and research—A forward survey up to 1985".



and thus contribute to the coordinated development of the participating countries.

Without wishing to commit itself on the opinions expressed, for which the authors only are responsible, the Commission is most grateful to the *FITCE* for the remarkable forecasting and summarising feat it has achieved. It likewise thanks the postal and telecommunications authorities of Belgium, France, Germany, Italy and Luxembourg, who kindly helped to make this study possible by allowing their officials to take part in the meetings of the working party set up by the *FITCE* and by providing all the documents and relevant information without which it would have been impossible to carry the work through.

THE TERM "telecommunications" embraces the most widely differing means of communicating at a distance, including in particular radio, television, telephony, telegraphy, telex transmission, phototelegraphy, etc., without which no modern economy could flourish. To these "conventional" means of communication will be added a host of new media, predominantly for data transmission.

It is obvious that in such a vast field, in which inventions are ever multiplying and technologies are constantly being superseded, it is not reasonably possible to make forecasts for all the various branches. The authors of this study have therefore concentrated on their own particular sectors, in which they have at their disposal the necessary information on which to base a valid assessment. The sectors in question are those of telecommunications in the narrow (PTT) sense of the word. It will accordingly be seen that the accent has been placed on the telephone, whereas other sectors, such as sound broadcasting and television, have merely been touched upon.

It will also be observed that the official departments are not greatly concerned with telecommunication terminals, a field which is very often reserved to private enterprise. In view of the rapid evolution of data transmission systems, which call for operation at various rates and with different codes, selected according to a very wide range of applications, it is desirable to place at the users' disposal so-called "transparent" networks by means of which many different kinds of data can be transmitted. This remark acquires its full significance when, as was done for the purposes of this study, the situation is projected to 1985, by which time the telecommunications authorities will be concerned far less with the nature of the messages transmitted and the terminals which produce them than with the interconnecting networks.

Telecommunications and research

Before embarking on a study of telecommunications as defined above, it is of interest to point out some general notions which can usefully be borne in mind during perusal of the following chapters.

The great expansion that information science has undergone as a result of the new solid state technology is a stimulus to the application of the same techniques to telecommunications networks, in which the switchgear is based almost entirely on electromechanical systems, with an occasional admixture of electronic components. There is a temptation to apply to switching systems methods that have proved themselves in data processing, in the hope of obtaining equally brilliant results. We tend to forget that in the course of their long history the conventional switching systems have become so highly perfected that they can give satisfaction not only

Figure 1: The European Community's "Kirchberg Centre" in Luxembourg. On the upper platform can be seen the parabolic antenna of the radio link between Luxembourg and Esch-sur-Alzette, which has a capacity of 960 telephone channels.

to users of the traditional telephone and of the telex but also to operators of data transmission units.

Another extremely important factor that must not be lost sight of is the cost of telecommunication installations (still in the PTT sense of the word) and also their service life. Today in 1969, the combined telephone network of the five countries that participated in the study, namely Belgium, Germany, France, Italy and Luxembourg, has 17,900,000 subscribers. If the cost of a subscriber's line, including the switching systems, local and trunk connections, etc., can be estimated at 1,000 units of account (1 u.a. = 1 US dollar), the capital invested in the telephone network, which represents about 90% of the total capital, amounts to some 18,000 million u.a. for these five countries as a whole. It will be appreciated that the replacement of the electromechanical systems cannot be effected at very short notice but will have to be spread over a large number of years. Moreover, it is known that the conventional equipment has a service life of 20-30 years, which means that the electromechanical apparatus that is still being installed today will certainly still be in service in 1989 and even considerably later.

It is in the light of these considerations that the importance of the choices to be made in 1969 is measured, since the official departments or private companies responsible will be committed by these choices for a period of 20-30 years. It will also be realised that the research to be conducted in order to determine the configuration of future networks is essentially of an economic nature. With present-day techniques it is possible to do anything, or, more exactly, to provide any service required, albeit sometimes at a prohibitive cost. Now that we are preparing to abandon the conventional electromechanical channels and to take up electronic systems, which though highly promising are fraught with numerous dangers, it is no doubt just as well to bear in mind these few simple but extremely important considerations.

Services to be provided

The earliest means of telecommunication was the *telegraph*, which was the first network to employ the digital technique. Its spread was limited by the comparatively clumsy mode of operation, with the result that its importance began to decline as soon as other, more powerful and flexible, means of communication appeared.

After the telegraph came the *telephone*, which is analogue in character. Its simplicity of use and the fact that it fulfilled the desire of a great many people to be able to hold a direct two-way conversation ensured it of considerable success. It will thus be noted that all the networks currently in operation are modelled on the transmission of speech and are used only to a minor extent for transmitting non-analogue information.

The sole disadvantage of the telephone, namely that it leaves no written trace, led to the creation of the *telex network* which has, so to speak, taken the place of the telegraph. Like the telephone, the telex enables a dialogue to be held. We find that in practice the telex network is closely related to that of the telephone in respect of both the apparatus and the basic concept. This is readily understandable when we consider that, as regards the investment required, the number of subscribers, the volume of traffic, etc., the

Figure 2: Push-button telephone set.
The use of a keyboard instead of a dial has the following advantages:
—easier, quicker handling,
—at the exchange, reduction in the number of parts that are used only during "dialling",
—lower rate of "dialling" errors,
—possibility, once the connection is made, of using the keys to communicate with a computer, for instance.

Figure 3: The Paris-Meudon radio-frequency tower.
All communications on radio frequencies from Paris pass via the aerials mounted on the various platforms of this tower. The connection to the amplification station, located in Paris, is by coaxial cables at present; it will shortly be effected by circular wave guide.

telex network represents at the most only a few per cent of the figures for the telephone network. In particular, no advantage results from the fact that the telex transmission is digital in nature. Account is merely taken of its lesser requirements with regard to the frequency band to be used. The telephony band is accordingly divided up into a number of sub-bands which are reserved for telex use. The transmission speed of 50 bauds[1], which is equivalent to 6 2/3 characters per second, corresponds to the performance of a good typist.

As regards *radio and television transmissions* (e.g. between the studio and the transmitters), the techniques employed are closely related to those of telephony. Radio, of course, which has to satisfy a more exacting clientele as far as the quality of the sound is concerned, calls for a wider frequency band, which is obtained chiefly by allocating several adjacent telephony bands to a radio circuit. Microware radio links, which can transmit a large number of telephone channels (usually 960 or 1,800, according to the norms laid down), are also suitable for transmitting a television programme with sound. The only difference as compared with telephony is that the same information is routed from a studio to a number of transmitters and occupies wide-band links which could be more usefully employed for the transmission of several streams of information. Hence the interest in finding a new means of transmission and recovering the existing network. This idea, attractive though it is, is brought up short by the scarcity of the frequency bands available, for example, for the routing of television programmes via satellites.

1. Data are transmitted by means of a series of elementary signals (binary digits, or bits). If T is the duration of a signal in seconds, the modulation rate can be designated by a quantity 1/T which is expressed in *bauds*.

Among the *other conventional services* to be provided, mention can be made of *phototelegraphy* and *facsimile*. Since these services are of no more than secondary importance, use is made of the existing telephone network and, in particular, of the telephony band. This results in an extremely low transmission speed, the time required to transmit an average-sized document being a quarter of an hour.

Among the *new services* to be supplied, special attention must be drawn to *data transmission systems*, the present annual growth rate of which in certain countries is 100% and which are likely in future to disrupt the well-established telecommunication networks. In order to be profitable, large data-processing installations must be constantly in use. Very often, therefore, such an installation can only be economically viable if it is at the disposal of a large number of users scattered over a very wide area; another factor is the desirability of being able to have access to a central data bank or data index from a large number of terminals; hence the advent of teleprocessing, one of the essential characteristics of which is that the transmission no longer takes place between human beings but between human beings and machines or even entirely between machines. Here it is obvious that the rate of 50 bauds or 6 2/3 characters per second, which is based on the speed of a typist, is no longer sufficient in a great many applications. This is one of the fundamental problems that the telecommunications authorities will have to face in the years to come.

The *videophone* will constitute a natural complement to the telephone. Unfortunately, it will hardly be possible to transmit the image via the existing networks unless a rather mediocre quality is considered acceptable.

Quantitative study of the services

We have seen that the role of the telephone is absolutely essential and that the investments assigned to this sector greatly exceed those allocated to all the other services put together. It remains to be seen whether this will continue to be the case in the years to come.

Study of the evolution of telephone density in the past and comparison with the most advanced countries (USA, Sweden, Switzerland) have shown that the density progresses in accordance with a "natural law"—a kind of s-curve. Many authors have endeavoured to find sophisticated formulae on the basis of logical hypotheses, the mathematical treatment of which has often proved difficult. For our part we prefer a much simpler formula which can be written $f(t) = A \frac{1 + at}{1 + e^{-bt}}$, where the zero point on the time coordinate coincides with the point of inflection of the curve. The parameter b represents the slope of the curve in the exponential part; A is the saturation; a is the time history of the saturation (linear in the first approximation). This last parameter takes particular account of the population growth (in the case where the formula expresses the absolute number of telephones) and the rise in per capita income. This formula also has the advantage that it can be adjusted as time goes by.

Another method that has been resorted to is based on the use of regressions and makes it possible to foresee the consequences of a policy consisting, for example, in modifying the telephone installation charges or in arranging that the average waiting time for installation of a telephone does not exceed a certain period.

The results of these calculations are set out in Tables I-III, from which it emerges in particular that the absolute number of subscribers in the five countries taking part in the study will rise from 17.9 million to 56 million, i.e. the number of main connections will have trebled by 1985. The subscriber density will increase from 10.3 to approximately 28%.

It is a good thing to bear in mind that the cost of a subscriber's main connection is in the region of 1,000 u.a., which means that the five countries concerned will have to invest some 40.000 million u.a. merely to meet the demand for telephones, that is to say an average of 2,500 million u.a. per annum. The investment is likely to be of the order of 4,000 million u.a. in 1985. To place these figures in perspective it is of interest to note that in the same five countries the revenue from telephone traffic in 1968 amounted to 2,500 million u.a. The investment figure quoted above takes no account of the replacement of obsolete equipment. This again reflects the magnitude of the economic problems presented by telecommunications, to which reference was made at the beginning of this article.

As regards telephone traffic it is generally agreed that the growth of local traffic will probably be about the same as that of the number of subscribers. The annual growth rate of toll traffic, at present about 15%, is likely to decline in the future to around 10%, which means that in 1985 the volume of toll traffic will be at least five times that of 1968. The growth of international traffic should be even more rapid than that of local traffic. So far as traffic routing is concerned, the agreed estimate of the various countries is that in 1985 the main cables required to have a capacity of more than 10,000 channels will probably represent, for the European Community as a whole, a length of several thousand or possibly a few tens

Table I: Telephones in service in 1969.

	Population (in millions)	Number of subscribers (in millions)	Subscriber density (%)
Belgium	9.6	1.27	13.2
France	50.2	3.68	7.2
Germany	59.8	7.3	12.2
Italy	54.0	5.58	10.36
Luxembourg	0.34	0.073	21.8
Total	173.9	17.90	10.3

For comparison purposes, subscriber density as at 31 December 1967: Sweden 38, New Zealand 28, United States 31, Switzerland 27.

Table II: Telephone estimates for 1985.

	Population (in millions)	Number of subscribers (in millions)	Subscriber density (%)
Belgium	10.4	2.7	25.8
France	60.6	15.5	25.5
Germany	66.4	21.0	31.1
Italy	59.4	17.0	28.7
Luxembourg	0.38	0.155	42.5
Total	197.2	56.35	28.6

Table III: Increase in number of telephones from 1969 to 1985 (%).

	Population	Number of subscribers	Subscriber density
Belgium	+12	+113	+ 96
France	+20	+320	+254
Germany	+11	+168	+155
Italy	+10	+205	+187
Luxembourg	+12	+133	+ 95
Total	+13	+215	+178

of thousands of miles at the most.

The development levels reached by the telex network within the Community differ considerably from country to country. These levels vary between one telex station to 100 telephone stations and one to 1,000. The growth rate, which is relatively high, is from 10 to 30%. It is generally accepted that a density of 10-50 telex stations per 1,000 inhabitants is close to saturation. Telex traffic could increase at the rate of 15% per annum. In view of the relative importance of the telex and the telephone and the possibility of splitting a telephone channel into 24 telegraph channels of 50 bauds, the routing of this traffic should not present any problems, even with a growth rate of 15%.

Whereas it has been possible to give fairly precise figures in respect of the conventional services, this is not the case as regards the new services, particularly data transmission. Difficulties arise as soon as one attempts to define the nature of the requirements, owing to the different interpretations given to such words as "terminal" and "connection". Moreover, it is difficult to extrapolate trends on the basis of scanty data.

It was physically impossible to make a sector-by-sector study of the number of potential customers. These figures can only be obtained as the result of a lengthy survey by the various authorities in the sectors concerned. Furthermore, we have seen that the authorities are not greatly concerned—and in future will be even less so—with the content of the data to be transmitted; it is enough if they know the importance that this service will assume in the course of the years and the transmission speeds employed. Depending on which country is making the forecast, the number of "terminals" in the Community as a whole in 1985 will be anything from 100,000 to several million, and the investment volume, referred to that of investment in the telephone network, will be anywhere between less than 1% and more than 10%. An appropriate survey would yield more precise figures. The only point on which the forecasts agree is that transmissions at low or medium speeds (up to 2,400 bauds) will form a very large majority of the connections (85-97% according to the estimates). Low-speed transmissions will account for the bulk.

The videophone, even more than data transmission, is the great unknown quantity in telecommunications, on the one hand because the structure, or rather the infrastructure, of the network will be disrupted by the introduction of this service and on the other hand because the authorities can, without unduly damaging the economy, advance or postpone the date of introduction, which is not the case with data transmission. A survey of the market prospects for the videophone has been carried out in one of the Community countries. One of the conclusions is that there will be no market for a videophone of mediocre quality whereas a high-quality instrument, even if expensive, will stand a good chance of being accepted by business firms. In view of the cost of the installation and of the appropriate means of transmission (as far as transmission is concerned the requirements of the videophone are 100 times those of the telephone), the videophone will long remain purely a business instrument. It is hardly likely to come into use by the general public before 1985 or even later.

The objection raised against the conventional facsimile was its slowness due to the limitations of the telephone frequency band. It is obviously pos-

Figure 4: Digital techniques: the principle of pulse-code modulation.
Pulse-code modulation of an analogue signal is based on three principal operations:
—sampling, *which consists in replacing the signal by a series of amplitude samples taken at regular intervals. (Sampling is based on the Shannon theorem, which states that a function $f(t)$ containing no frequency higher than f_m can be restored from the series of its samples taken at the frequency $2f_m$. Thus for a standardised telephone channel, within the boundary values 300-3,400 c/sec, the sampling frequency most commonly used is 8,000 c/sec);*
—quantisation: *the amplitude of each sample is replaced by the nearest of a discrete range of standard amplitudes, of "quantisation levels";*
—coding: *each quantisation level is identified by its value expressed in binary notation, i.e. by a stream of bits 0 or 1. By interposing, between two coded signals, time-phase displaced signals derived from the coding of other signals of the same type, a time division multiplex is formed.*

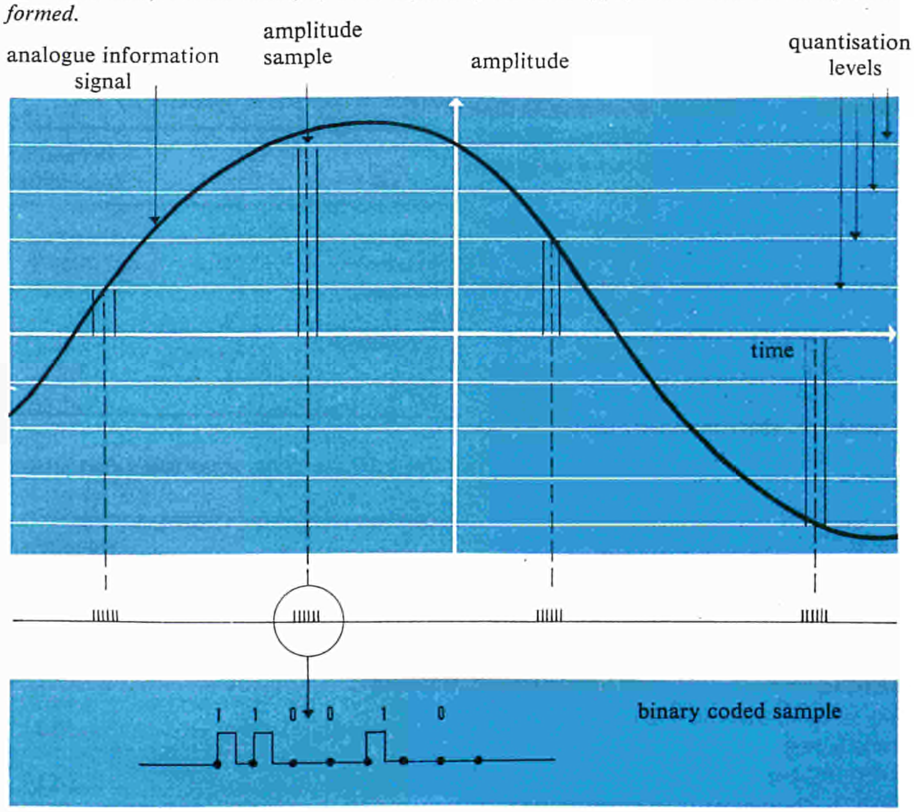


Figure 5: Night view of the "Hochzeitsturm" in Darmstadt. Between this tower and the telecommunications centre there is a two-mile-long experimental laser section. The photograph was taken in slightly hazy weather; in clear conditions the laser beam is invisible.

sible, even today, to envisage wider-band transmissions achieved, for example, by grouping several telephone channels together. The cost of these circuits, however, is such that applications are extremely rare. Only the general introduction of the videophone could completely alter the data of the problem by turning the facsimile into a by-product of the videophone. An ultra-fast service might compete with the post office for the routing of certain classes of mail.

Another service that could progress by leaps and bounds is that of telecommunications between mobile stations. Various solutions can be envisaged, ranging from the call-up system, which uses a small amount of bandwidth and is therefore feasible at the present time, to the system which provides for direct communication by radio, with the possibility of connection to the general telephone network. In this case the problems are still far from being solved.

As regards sound broadcasting and television there were only three points that could be considered.

The first is that the congestion of the ether as a result of the increased number of television programmes has favoured the installation of collective aerials with a cable distribution system. This makes is possible to bring into the homes of viewers who were previously at a disadvantage a large number of television programmes with excellent reception and often, in the case of frequency division, with simplified TV receivers.

Another point concerns transmissions between studios and transmitters, as well as closed-circuit television links. Even the increase in the number of programmes to be transmitted is not likely to alter the basic problem. In view of the cost of the circuits, moreover, it is doubtful whether closed-circuit TV will develop to any great extent. On the other hand, closed-circuit videophone links, the technique of which is somewhat different, could flourish as from the introduction of the videophone.

The last point is that cable distribution of programmes would enable frequency bands to be freed for other purposes, particularly for services with or between mobile stations.

Investigation of suitable technical means of meeting the demand

There is one important fact that can be deduced from the quantitative considerations set out in the foregoing. In 1985 the bulk of the demand in the telecommunications field will relate to the telephone. We have seen that the number of subscribers will treble between now and 1985. Since the density will then be 28 main stations per 100 inhabitants, we must even expect a further substantial increase after 1985, because the saturation density is estimated at between 40 and 50%. Stress has also been laid on the magnitude of the investments that will be required in order to be able to meet this demand: an average annual investment in the region of 2,500 million u.a. in the case of the five countries consulted. In principle, the demand can be met without difficulty by means of conventional electromechanical switching systems, but an attempt will obviously be made to take advantage of the new possibilities offered by solid state technology, as well as from the novel concepts born of data-processing[2].

One of the chief disadvantages of conventional switching systems is the delay in putting a call through, i.e. the time that elapses between the moment when the calling party decides to call and the moment when the called subscriber's instrument rings. This delay, which is usually expressed in tens of seconds, is due to the slowness of the dialling operations and, above all, to the slow response of the electromechanical mechanisms, aggravated in many cases by the non-availability of certain pieces of equipment.

These shortcomings led at a very early stage to attempts to develop switches operating wholly or partly on electronic principles. Thanks to the high speed of data-processing with electronic equipment it was possible for the logical functions—formerly split up—to be concentrated in a single control unit which more often than not is the only one in the entire exchange. It is only duplicated for reasons of reliability. This generation of switches is expected to offer the following advantages:

—*for subscribers*: shorter delay, thanks to the rapid setting up of the call, which allows full advantage to be taken of push-button selection; various service facilities such as automatic transfer of calls, recording of calls, three-party calls, etc.;

—*for the operating company*: easy modification of programmes, perfection of the charge-determination system, transmission of information concerning charges, trafficmonitoring, remote maintenance, smaller size, etc. There is, however, little likelihood that subscribers will make large-scale use of the new facilities, which in themselves are certainly not sufficient reason for the wide-spread installation of electronic switching systems.

Among the disadvantages of the new switches mention must be made of the following:

—the high cost of the electronic control units, which can only be used in a rational way in large urban centres, whereas there are also countless small rural centres to be served; if it is proposed to provide remote control for exchanges by means of data-transmission links,

2. In conventional telephone exchanges the connections are controlled by mechanical devices. In electronic exchanges the paths contain no moving parts and are controlled by solid state components. An exchange of this type in which mechanical contact points are nevertheless retained for the speech paths is known as a semi-electronic exchange.

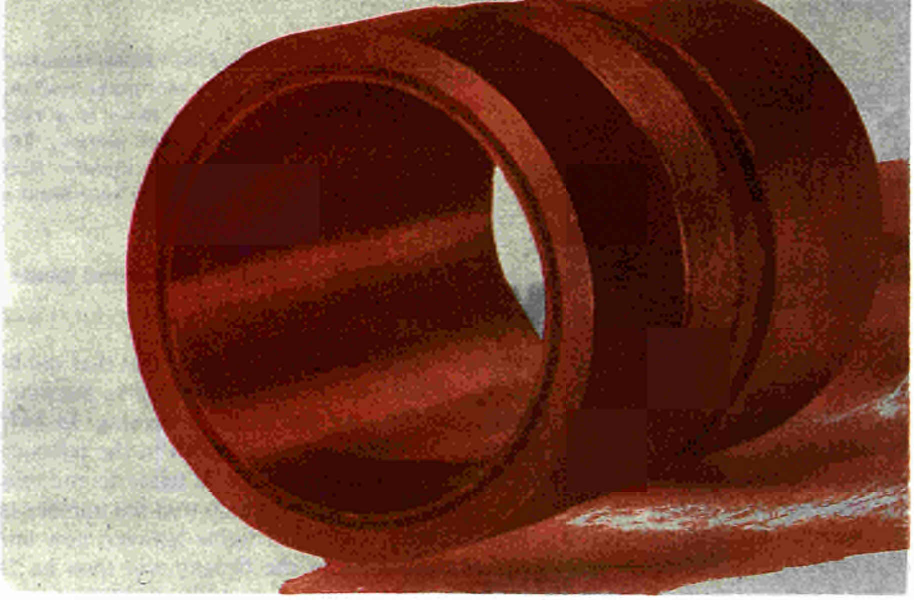


Figure 7: Circular wave guide.
Steel tube (5 cm dia) covered internally with a spiralwound copper wire. The mechanical tolerances are extremely close (10 microns), as are the radius of curvature requirements. Being far from cheap, the wave guide is only competitive with conventional systems where the capacity is upwards of some tens of thousands of telephone channels, but it does allow very economical routing of hundreds of thousands of telephone channels and dozens of television programmes.

there arises the question of reliability in the event of a fault in the network connecting the terminal exchange with the central switching station;
—the reliability of the new switching units: whereas with the conventional split-logic systems the failure of a switching mechanism affected only a limited number of subscribers or connections, there would now be a risk of total breakdowns if the remote-control link were cut;
—maintenance difficulties and problems of adapting and retraining personnel.

Various types of electronic switching systems have been developed:
—the semi-electronic exchange with electronic control and metallic contact points;
—the all-electronic exchange, which can itself be of two kinds, i.e. with space-switching, whereby a well-defined path is permanently assigned to a connection, or with time-switching, which necessitates sampling of the signal (see Fig. 4).

In view of the high cost of the electronic gate and the difficulties of cross-talk attenuation it is scarcely likely that all-electronic space-switching will eventually be adopted; consequently, the only competition will be between semi-electronic space-switching and all-electronic time-switching. Of these two systems semi-electronic space-switching is the more advanced, owing to the lesser difficulties to which this technique gives rise. Several exchanges of this type are in service in the public telephone network.

As regards the telex network it would, of course, be possible to develop a type of exchange similar to the semi-electronic telephone exchange with mechanical contact points, but it is far more probable that account will be taken of the numerical nature of the telex by incorporating it in a data transmission network of which it is merely a particular case.

Data transmission, which was born of data-processing is assured of tremendous expansion in the course of the next ten years. The question is whether a separate network will have to be set up in order to meet this demand or whether the data will continue to be routed via the telephone system, as at present. Since the latter was created for the transmission of speech and not of digital signals, it is not altogether suitable for data transmission. The solution adopted is to make use at the subscriber's end of adaptation networks, known as modulator-demodulators, whereby the d.c. digital signal is converted into a voice-frequency signal capable of being transmitted on the telephone network, which means that in effect the digital signal is transformed into an analogue signal. This seems, however, to be a makeshift solution in the absence of a network suited to these new requirements, so that it will be necessary to re-examine all the problems raised by this new means of transmission.

Having regard to the digital character of both telex transmission and data transmission it is theoretically already possible to envisage an all-electronic switch with time-division multiplexing, whereas in the case of the telephone network, as was mentioned above, the prevailing notion is that of semi-electronic space-switching.

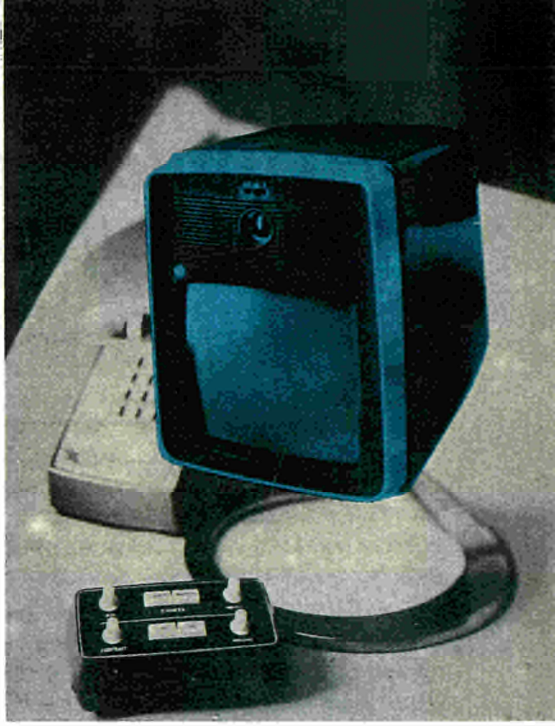
Since it is generally agreed that the solution of the (possibly distant) future is likely to be electronic time-switching, even for the telephone, one could consider the possibility of all telecommunications —be it the telex, data transmission, the telephone or even the videophone—being combined in a single network which could be called an "integrated network".

Such a network would possess undoubted attractions: each subscriber would be connected to the switching unit by an all-purpose loop on which he could transmit data, telephone conversations, telex messages, etc., as he wished. He would no longer be inconvenienced by the limited accessibility of the present separate networks.

Unfortunately, there are many problems to be solved and the integrated network would therefore seem to be a vision of a still distant future. Moreover, many telecommunications authorities are beginning to install semi-electronic telephone switching units, and in view of the long life of such equipment this means that in certain countries anxious to operate a single system the advent of integrated networks is likely to be delayed beyond 1990. Once again, therefore, we can see the importance of the choices to be made in 1969. The taking of different decisions by the various authorities would at all events greatly prejudice the setting up of uniform networks on a European scale.

Among the various existing and future transmission techniques mention must be made of balanced pairs, microwave systems, coaxial cables, waveguides,

Figure 8: The American Telephone and Telegraph Cy's "*Picturephone*". *This instrument, which is to be launched in the United States in 1970, enables the subscriber to see the person he is speaking to and possibly to question a computer. The image is not clear enough, in the present version, to enable a typed text to be read.*



lasers, satellites and undersea cables. It is interesting to note that present-day transmission techniques are capable of handling the telecommunications traffic in 1985. Only the widespread introduction of the videophone could completely alter the nature of the problem. We have seen, however, that the videophone is hardly likely to be in general use in 1985. Furthermore, it is considered that the use of waveguides will not be economically attractive until those routes whose capacity must be increased are already carrying some 10,000-30,000 channels. As far as satellites are concerned, the so-called stationary positions 22,400 miles above the equator are greatly in demand and the frequency bands allocated are somewhat limited, so that there is a risk of real congestion of the equator in the near future. It is furthermore noted that, despite the advent of satellites, undersea cables will continue to be of great importance.

Possible subjects of research

An analysis of the principal trends in telecommunications development reveals five major subjects of research.

The first important subject is *digitalisation of the network*. Reference has already been made to the great advantages that could be gained from a single integrated network using pulse-code modulation (PCM) and time-division switching. In Europe at any rate, pulse-code modulation is used solely in a few experimental telephone links. Since the switching equipment is of the conventional type, the analogue signal is sampled at the exchange output, coded, then transmitted on line before being converted back into an analogue signal at the terminating switching unit, possibly reconverted into a numerical signal for a second PCM transmission, and so on. Of course, this modulation process is only of minor interest as long as the switching itself is not of a time-type and the signals cannot be sent through the switching unit without demodulation. The PCM process is at present justified only for distances of approximately 5-20 miles (in some quarters it is held that the upper limit is about 30 miles). Below 5 miles, low-frequency transmission is more economic; above 20 (or 30) miles, carrier-current systems are best. The problems raised by digitalisation of the network are far from being solved. At what level should the analogue signal be converted into a digital one? Are there any grounds for developing a digital subscriber's terminal? Are the existing subscriber's loop wires capable of transmitting digital data on a large scale? How does one solve the problem of synchronising the various networks, etc?

The second subject for research is *time-switching*. Qualitatively, it is a question of expediting the breakthrough of a system which is considered by all the experts to be more attractive than the space-systems and of putting Europe in a good position to compete with the United States.

The third field for research is that of the *videophone* and its possible by-product, the *facsimile*. The principal difficulty to which widespread use of the videophone gives rise is the limitation of the bandwidth that can be transmitted on the subscribers' loops. Cross-talk studies have shown that this band cannot exceed 1 Mcs, which is considerably lower than the 5 Mcs required for an image comparable with a television picture. In order to obtain anything like an acceptable quality it will be necessary to reduce the size of the screen. A market study carried out in one of the Community countries has revealed that only a high-quality videophone would stand any chance of success. In view of the fact that 40% of the investment in telecommunications is intended for the outside plant which, moreover, have a service life of 40-50 years, it is difficult to see how the videophone can come into general use in the near future. Studies on data compression would undoubtedly be of very great value.

The fourth subject for research is *very-wide-band transmission* facilities. Even though the future requirements, at any rate up to 1985, can be met by conventional means, a reduction in the cost of future techniques (waveguides, lasers) as the result of research activity could open up important outlets which at present are still closed. The exploitation of these techniques will also depend on the fairly widespread use of the videophone and on the overall structure of the network indicated by operational research.

Operational research, which constitutes the fifth and last proposed subject of research, consists in the use of computers as an aid to the taking of technical decisions. These decisions can relate either to short-term objectives, such as traffic- and trunk-routing and the connection of subscribers, or to long-term ones, such as the choice of investments, the analysis of various network models in order to determine the optimum network, etc.

Conclusions

These reflections on the probable aspect of telecommunications in 1985, on the problems to be solved between now and then on the desirable guidelines for research make no pretence of being anything more than what they really are, namely an honest but certainly imperfect attempt to foresee what is in store. The authors have endeavoured to highlight trends and to suggest suitable guidelines for research, but they find it difficult to place each one of these in its proper perspective. Moreover, they would be only too happy to be proved wrong in the near future by some unexpected breakthrough. They will nevertheless feel that their efforts have not been in vain if they have helped to provide some enlightenment for those responsible for research policy both on a national and on a Community level.
EUSPA 8-14

Do cosmic phenomena influence the growth of living creatures?

GEORGES VERFAILLIE

The radiations reaching us from outer space have long formed part of that category of semi-occult phenomena on which it was tempting to lay the responsibility for all sorts of events, almost exclusively unpleasant, which could not be accounted for otherwise. Even in our time they have not lost all their mystery, especially as regards their effects on living creatures, but certain recent experiments, including the one described in this article, have thrown fresh light on their subject.
The fact that emerges very clearly from the results obtained by Mr. Verfaillie and the interpretation he proposes is that certain radiations of solar origin have a considerable adverse influence on the growth of plants.
It remains to be seen whether they affect all *living creatures to such a marked extent, and more particularly man. This is a question which it seems essential to answer, especially as there is today a widely-growing awareness of the problems posed by our environment.*

THE photograph on the opposite page (Fig. 1) shows two groups of rice seedlings, all of the same age, taken from the same batch of seed and grown under strictly identical controlled physical and chemical conditions. The only difference is that they were sown a week apart. Why are they so dissimilar?

The "P" chemical test

Over the last twenty years there has been a growing conviction that geophysical conditions of cosmic origin influence the speed of certain chemical reactions, particularly those that take place in colloidal states. It is further recognised that even a very thin copper screen modifies this influence by acting as a shield, just as a Faraday cage does against electric field disturbances.

The influence appears to operate by way of minute changes in the physicochemical state of water, a state which even today is still only imperfectly understood.

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The cosmic phenomena which might be responsible include geomagnetic disturbances, variations of the electric field, the hard and soft components of cosmic radiation and very low frequency electromagnetic waves. All these factors act simultaneously on the earth and, furthermore, they influence one another, so that it is very hard to discern which of them really do act on the kinetics of the chemical reactions mentioned above.

To get round these difficulties G. Piccardi, Professor of Physical Chemistry at the University of Florence, in 1954 worked out a chemical—and therefore objective and reproducible—test that would measure, not the "cosmic state", the nature of which is in fact unknown, but its physicochemical effects. His method consists in statistical measurements of the difference between the velocities of sedimentation of bismuth oxychloride in the open air and under a copper shield. The corresponding index, known as the P index, is the percentage of cases in which sedimentation is faster with the shield than without it. These indices, recorded three times a day, are published regularly by the *Centro Universitario per lo Studio dei Fenomeni Fluttuanti* in Florence. Numerous correlations have been observed between the fluctuations of the P indices and those of the intensity of various phenomena of solar origin, such as Wolf's R number denoting the frequency of sunspot appearances. Like the intensity of all geophysical phenomena of cosmic origin, Piccardi's P indices go through certain well-charted periodic fluctuations such as the diurnal, annual and secular variations and the approximately eleven-year solar cycle.

Since the colloidal medium is the one in which all living cells develop, it is not surprising that the same cosmic phenomena which influence the chemical test may also influence certain biological events. For ten years now investigations have been in progress on the velocities of blood coagulation and erythrocyte sedimentation and on the flocculation and fermenting capacity of *Saccharomyces Ellipsoideus*. An increasing volume of experiments has revealed the physiological effects of the electric and electromagnetic fields and of the ion content in the ambient air. All these researches come within the field of interest of the *International Society of Biometeorology*, which has been publishing the *International Journal of Biometeorology* since 1961 and recently (in September 1969) held its *Fifth International Congress* at Montreux, Switzerland.

A rice growth experiment

In 1966 evidence was obtained for the first time of a correlation between a phenomenon of extraterrestrial origin and the rate of growth of a higher living organism, namely rice, a chlorophyllous plant. We should mention that the experiments which yielded this evidence did so quite unintentionally; in fact the effect they revealed, unsuspected at the outset, brought about the failure of the research project. It is interesting to follow the chronological stages of the observations which led to the unexpected conclusions dealt with here.

In the spring of 1966, at the biology laboratories of the Joint Research Centre's Ispra Establishment, it was decided to grow some *Ballila* rice under controlled conditions in order to study this species' growth curve. As the seedlings were to be used for subsequent experiments, the only phenological and analytical criteria employed were such as could be applied *in vivo*, e.g. the total fresh weight and the length of the parts above the ground.

The scheme called for a batch of homogeneous starting material, namely 1,500 live seedlings fourteen days old with as little measurable difference among them as possible. As a wide degree of biological variability was inevitable, it was necessary to effect a preliminary random selection out of some ± 6,000 seedlings. With such a vast number of seeds to germinate and of seedlings to be selected and then picked out, there could be no question of doing the whole lot in a single sowing. It was therefore decided to stagger the sowings over a period of twenty days, leaving out the weekends.

Every day from the start of the experiment, seed-boxes containing 300 seeds were put at the rate of one a day into the same growing-room, with controlled conditions, and were taken out fourteen days later. The seedlings were then measured and selected. All the seeds came from the same batch and had been weighed individually to make sure that their weight fell within the distribution of a statistically homogeneous, normal population (i.e. along a Gaussian curve). Germination took place on washed white sand all soaked with the same feed solution. To obviate the influence of any local variation in the conditions inside the growing-room, the seedboxes were moved along daily in a cycle which took each batch through exactly the same route during its fourteen days' growth. In addition, each seedbox was turned round through an angle of 180° every day. In this way the only possible difference of treatment between one batch and the next was the shift of 24 calendar hours for a growth period of two weeks. Of these consecutive periods, thirteen days out of fourteen were common.

Apparent violation of the rules of statistics

The selection principles involved are based on statistics and can be briefly explained as follows.

If we classify the seedlings into fresh-weight groups we obtain a population distributed on either side of a mean, in a bell-shaped Gaussian curve (Fig. 2). The differences from the mean weight spread out on either side of it as a function of a standard deviation represented by s which, expressed as a percentage of the mean value, becomes the coefficient of variation represented by c. The higher the value of s or c, the more widely the weights are scattered around the mean M.

If we choose a selection range of $\pm e$ on either side of the mean M, the subjects selected will be increasingly uniform and close to M as the half-range e diminishes in relation to the standard deviation s. Statistical calculation shows us that a half-range equal to 0.3 s means that 75% of the subjects will be rejected as against 25% selected. That is why it was necessary to start with 6,000 germinations in order to obtain 1,500 sufficiently similar seedlings. Also, as the plants were to be grown in seedboxes of 300 at a time, it was desirable that the mean of the individual weights in each box should have every chance of remaining within the

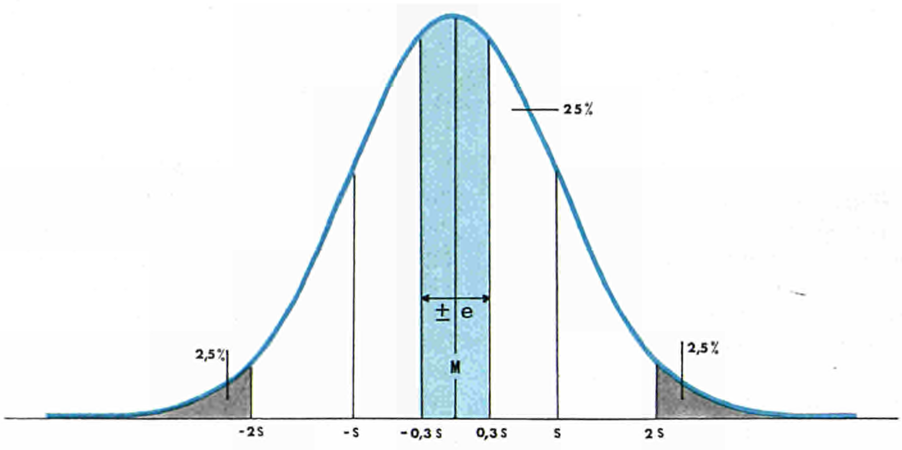


Figure 2: The Gaussian curve represents, in our case, the frequency distribution of the fresh weights of fourteen-day-old rice seedlings. These weights vary around a mean M. *The dispersion is characterised by the standard deviation* s. *If the seedlings are sorted and all the ones with a weight differing from the average by not more than* e = *0.3* s *are selected, only 25% of the total will be retained, but these seedlings will all be of very similar weight.*
M = *mean*
s = *standard*
e = *selection range*

limits of the selection range. Under the conditions chosen this probability stood at 500 million to one, or in other words amounted to a strict certainty.

Against all expectations, *the observations* yielded statistically unforeseeable results. If each seedbox is considered separately, the random distribution turns out to be entirely normal, confirming the sound basis of the selection principles adopted. But if the seedbox averages are compared with one another they completely cease to obey the rules of statistics. For instance, according to these rules, with a homogeneous population the averages of different groups cannot differ from one another more than about five times in a hundred by more than twice the standard deviation affecting those averages. Similarly, the deviation will be treble the standard deviation only once in a hundred times, quadruple once in a thousand times, and so on. But the differences found between the averages of two consecutive seed-boxes (Nos. 6 and 7) are *18 times* the standard deviation, and the biggest difference (Nos. 1 and 9) is *28 times* that deviation. This can *in no case* be due to chance (Fig. 3). The variations thus obtained over the course of time actually make it quite impossible to operate any selection amongst plants that are not grown concurrently.

Interpretation of the variations—the P index

These variations can only be *interpreted* as being due to imperceptible external causes which themselves vary with time. Furthermore, the variations are neither continuous nor random, but fluctuating. The scientist conducting the experiment, with memories of a geophysical station he had run in Antarctica, was struck by the resemblance of these fluctuations to those of the usual cosmic phenomena. It was then, and only then, that he had the idea of comparing the rice-growing results with the concomitant geophysical

Figure 3: Variations of rice-crop yield as a function solely of the period at which the rice is grown, all other factors being constant. In ordinate, the average fresh weight expressed in milligrams per seedling. In abscissa, the time interval between the sowings (one day normally, three days at weekends).
The big differences between the yields of two successive sowings cannot be explained by statistics and can in no case be a chance effect. They can only be the effect of a time-linked cause.

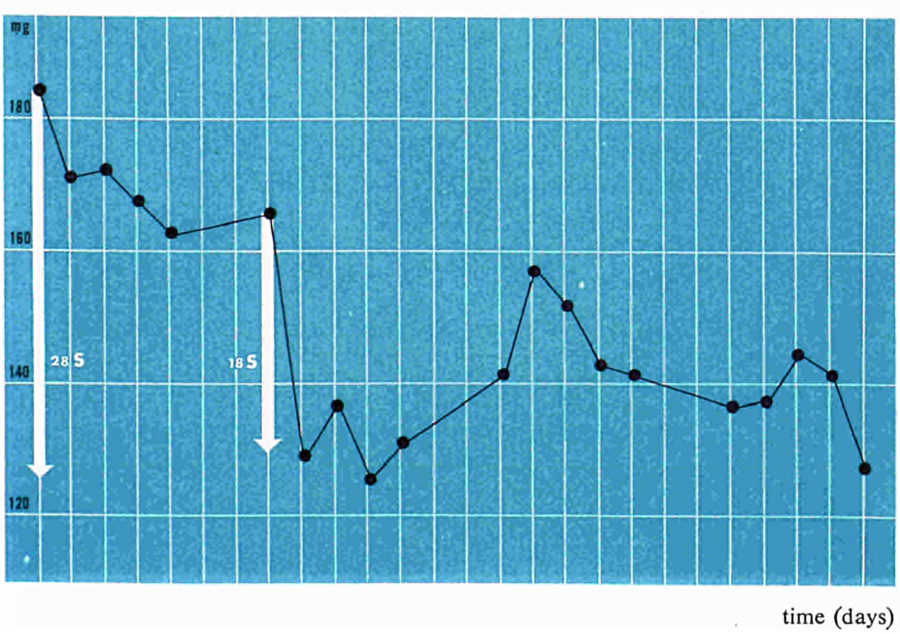
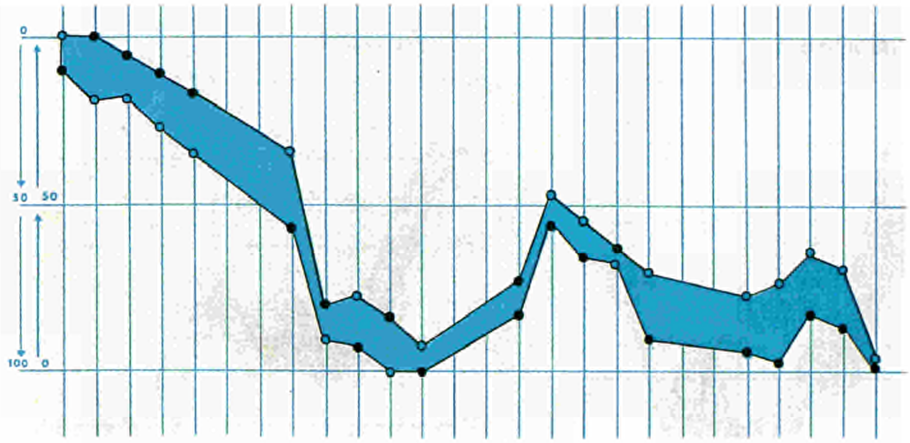


Figure 4: Parallelism of fluctuations with time of the seedlings' fresh weight yield *and of the* P *indices for* solar activity *(the intensity of both phenomena is sealed 0-100, with the* P *index scale intentionally inverted). The negative correlation signifies that the growth is greater when the* P *indices are smaller.*
The solar activity slows down growth!



∘ fresh weight
• P indices

time (days)

data that could be obtained a posteriori. Of these data, the cosmic neutron and meson radiation intensity, the geomagnetic K indices and the Wolf R numbers only yielded doubtful correlations with the growth rate of the rice. Piccardi's indices, however, recognised by their author as being most likely to interpret the fluctuating biological phenomena, showed an astonishing negative correlation both with the seedlings' growth rate (Fig. 4) and with the coefficient of variation affecting that rate (Fig. 5). As the causes affecting variability can make themselves felt from the very first day of germination, it is the sum of the P indices covering the whole fourteen days' growth that has been chosen in Fig. 5 as the variable representing the cosmic state. In Fig. 4, on the other hand, that variable is represented by the sum of the indices covering only the last six days' growth, because it is during those six days that over 90% of the fresh weight of a fortnight-old seedling is acquired.

It may appear startling, we agree, that such an ordinary event of life as the growth of a plant can be closely dependent on imperceptible if not mysterious causes. Yet the degree of significance of the correlations, as calculated by the usual methods, is so high that in the case in question it exceeds that of the correlation between the weight and height of the plants. Who would dream of questioning the evidence of such a correlation? Incidentally we should mention that the laboratories which were observing on the one hand the rice plant growth and on the other hand the chemical tests were virtually unaware of each other's existence at the time of the experiments and were, moreover, nearly two hundred miles apart.

In order to check the authenticity of the cosmic interpretation, a second experiment was undertaken immediately. If cosmic effects are the root cause of growth fluctuations, their action on two concurrent series of sowings must be parallel. So for ten consecutive days not one but two identical seedboxes were treated simultaneously under conditions similar to those of the first experiment. As the choice of a single criterion—weight of fresh matter—was open to criticism, the measurements this time were extended to include the dried matter and ash weights; there was nothing to prevent this since the seedlings were no longer being grown for transplanting and could be destroyed. As the figures (6 and 7) show, the parallelism obtained is beyond all doubt.

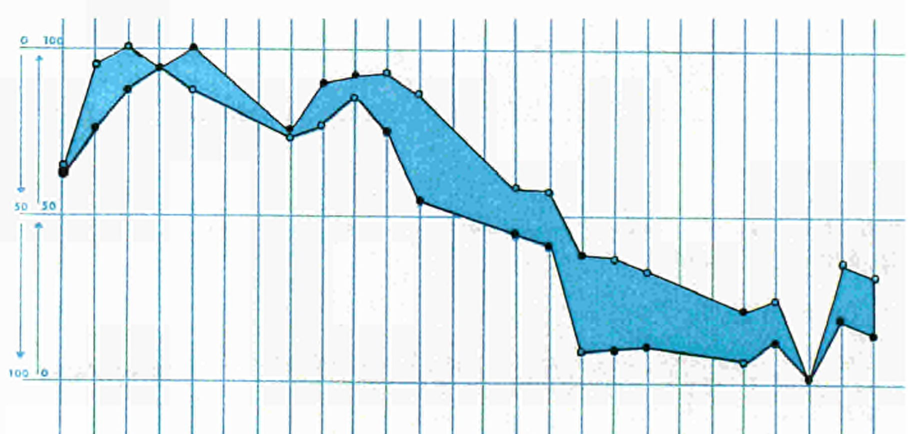
A solar hypothesis, the likelihood of which has been confirmed over recent years, interprets the time-linked biological variations as effects of the sun's chromospheric eruptions. These eruptions are believed to act through radiations which are emitted by them and intercepted by the earth. The radiations are of two kinds, electromagnetic and corpuscular (Fig. 8).

Both types of radiation are emitted simultaneously. The first, electromagnetic, travels uniformly at the speed of light, impinges on the earth in a solid mass after about eight minutes and passes right through the atmosphere, producing in it short-term effects generally lasting less than an hour.

The other, corpuscular radiation, is a great deal slower. Its particles, under the pressure of electromagnetic radiations, leave the sun at speeds ranging down from 2,000 to 600 km/sec, the liberation velocity on the sun. As the sun's gravity slows down the particles, the first corpuscular front does not reach the earth until about a day after the electromagnet-

Figure 5: There is a similar correlation with the coefficient of variation c *which affects the growth rate.* Solar activity reduces the uniformity of a crop!

∘ variability values
• P indices



time (days)

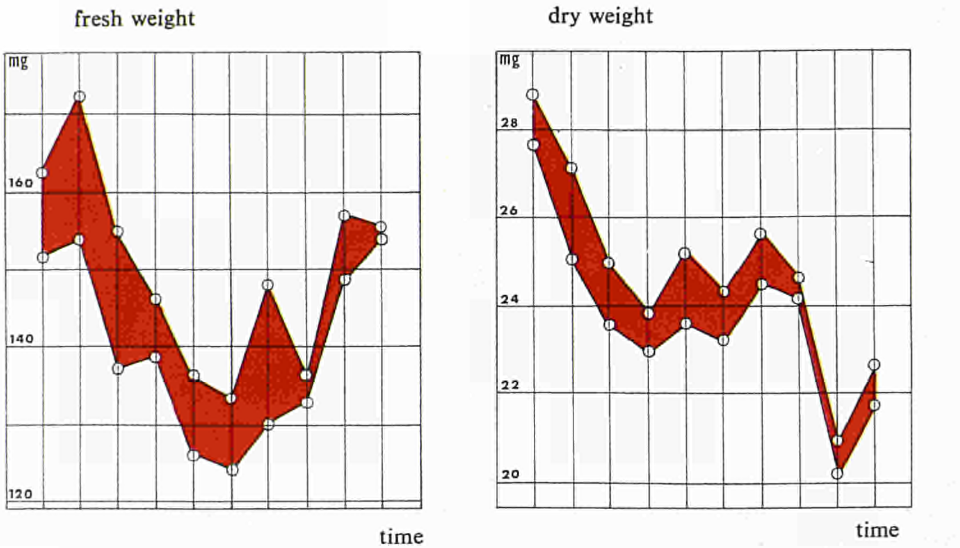


Figure 6: The yields of two concurrent sowings fluctuate in parallel with time. Time is a biological factor *which has to be taken into account*

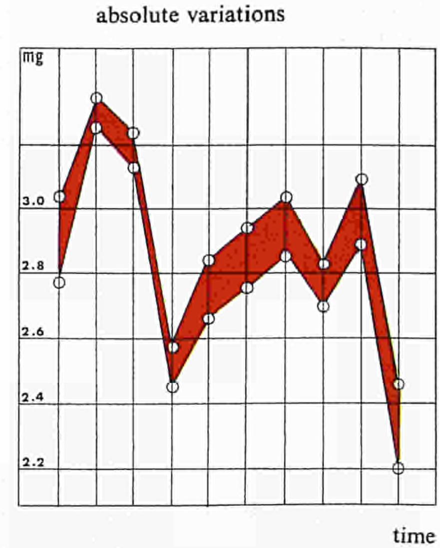


Figure 7: Parallelism of fluctuations through time in the uniformity of the yield given by two concurrent sowings.

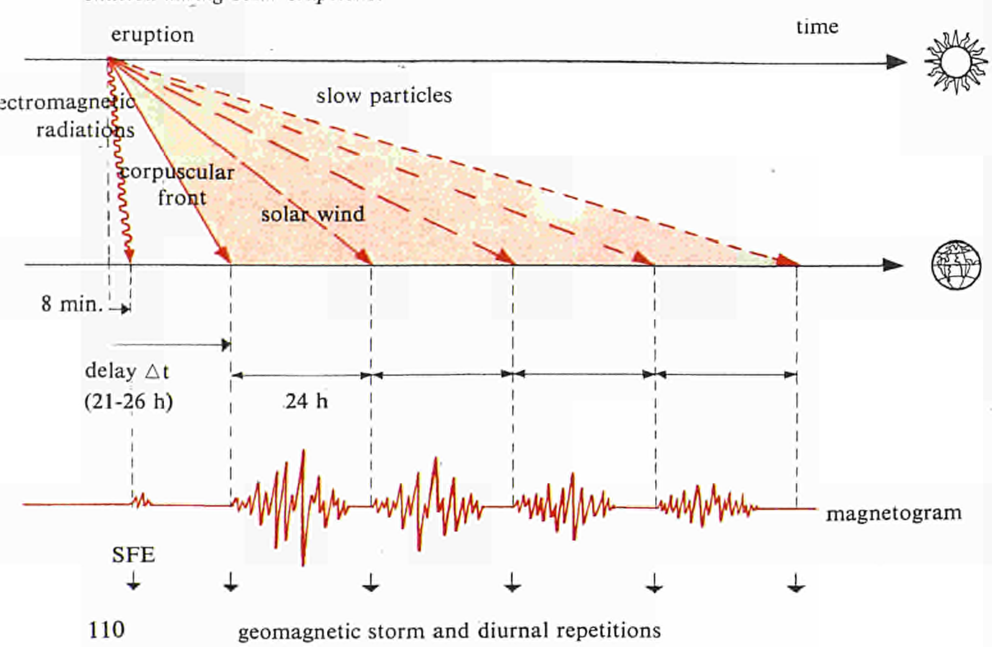
ic radiations. The slower particles arrive at intervals covering a period of several days. The particles are arrested by the earth's ionosphere in which they set up disturbances detectable in the guise of geomagnetic storms, polar auroras and fading in radio broadcasts. The disturbances may last several days, diminishing in intensity and following a daily cycle due to the earth's rotation.

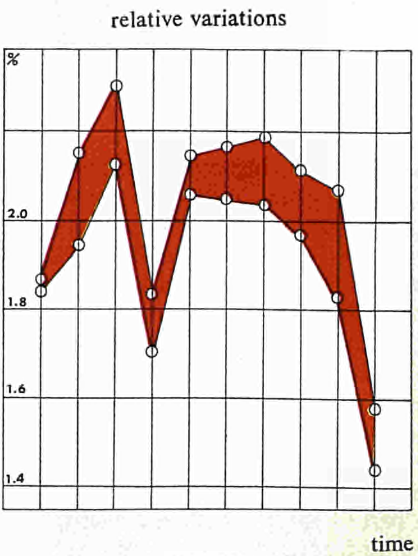
This being so, it seemed worth while to find out whether the rice growth was influenced by the same type of radiation as Piccardi's chemical test, with which a close correlation had been found. If the two phenomena depend on the same type of solar radiation, the correlation will be greatest when the correlated data are concurrent (Fig. 9). If not, the maximum correlation should be found with pairs of data with a time shift of the order of one day between them.

We calculated all the mathematical correlations existing in respect of time shifts between data ranging from minus four to plus five days at the rate of three increments a day. Fig. 10 shows the findings. The value of the time shift Δt of the chemical data (Piccardi's P test) in relation to the biological data (rice growth rate) is shown in abscissa. The ordinate t (Student value for 18 degrees of freedom) is a function representing the likelihood of the correlation.

The clarity of the results obtained is astounding. Not only do we find a very sharp peak corresponding to a time shift of +21 hours but, something quite unexpected, there are the four first daily

Figure 8: Diagram of solar emissions during a chromospheric eruption. Below, the effects of these emissions as recorded at geophysical stations in the form of geomagnetic storms. SFE *(Sun Flare Effect) is a sharp, short disturbance due to the electromagnetic radiation emitted during solar eruptions.*





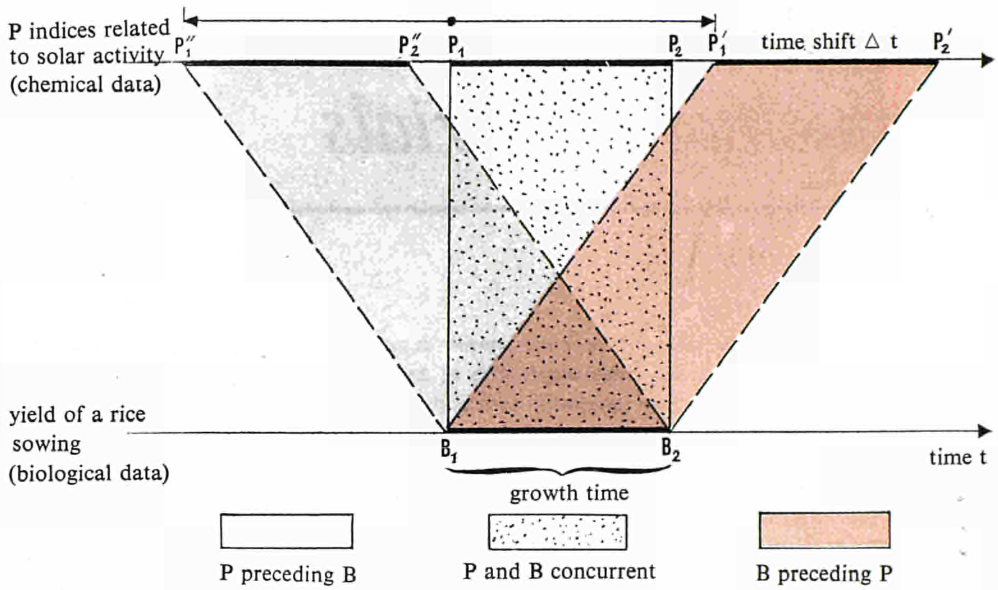


Figure 9: Diagram explaining the principle of the analysis of the mathematical correlation between the P indices (chemical test connected with solar activity) and biological effects (growth of rice). The problem: is the optimum calculated correlation obtained when the chemical and biological data are concurrent (P_1P_2-B_1B_2) or when there is a time shift △t between them? In the latter case, which time shift will give the optimum correlation?

repetitions of decreasing intensity mentioned earlier on. This suggests that the rice growth must be directly influenced by the electromagnetic radiations of chromospheric origin, whilst Piccardi's chemical test must be sensitive to the corpuscular emissions from the same source, or at any rate to the secondary effects produced by them in the earth's ionosphere.
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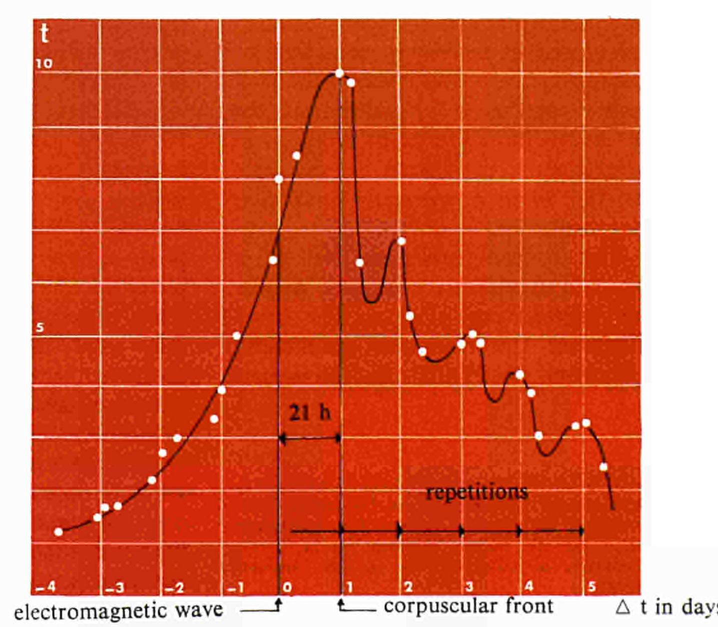
Figure 10: The optimum mathematical correlation is obtained when the Piccardi chemical test data are 21 hours behind the biological data. This time-lag is precisely the lag at earth level of corpuscular radiation, also called the solar wind, behind electromagnetic radiation. The diurnal repetitions of the correlation peak can be accounted for by the earth's rotation in the corpuscular flow of the solar wind. (t is a statistical function reflecting the probability of the correlation).



Safeguard and control techniques for nuclear materials

UGO MIRANDA

The Euratom safeguards and controls system is designed to discourage, on the territory of the Community, the misappropriation of fissile materials for purposes other than those for which they were originally intended, but is nonetheless not a policing system.

What is the aim of safeguards and controls?

BEFORE reviewing the techniques currently employed or being developed for the safeguarding and control of fissile materials, more particularly in the European Community, it is desirable to define the actual aim of the safeguards for this can determine the choice of the methods to be used.

In Chapter VII, Article 77, of the Euratom Treaty it is laid down that "the Commission shall ensure that the materials subject to control are not used for purposes other than those declared by the users".

This definition shows that in the case of the Community the aim of safeguards and controls is a fairly wide one and is not centred exclusively on considerations relating to the peaceful use of the materials. Nevertheless it is indisputable that by far the most important aspect of the safeguards is to prevent the misappropriation of fissile materials for military purposes.

This concern manifests itself in all bilateral agreements concluded between the United States, Canada, the United Kingdom, the European Community (Euratom), the *OECD*, the *International Atomic Energy Agency* and other countries, in which agreements it is linked with the clauses governing the supply of these materials. More recently it constituted the primary objective of the nuclear non-proliferation treaty.

As regards the Euratom system in particular, it is noteworthy that this is the only instance of multinational safeguards to which six countries have submitted—spontaneously and independently of all international commitments—, over ten years ago.

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What materials are subject to supervision?

The materials subject to supervision are normally those which can be of considerable interest from the point of view of their military application. In the case of Euratom the supervision extends to "special fissile materials", i.e. plutonium 239 and mixtures thereof with other isotopes, uranium 233 and uranium enriched in U^{235} or U^{233}; it also extends to "raw materials", which comprise natural uranium, or uranium depleted in U^{235}, and thorium; finally, to these materials must be added heavy water and tritium, as well as reactor equipment should the supplying countries so require.

Moreover, Euratom supervision is essentially of a territorial nature, that is to say it is exercised over all the above-mentioned materials merely by virtue of the fact that they are "on the territory of the Member States".

The materials subject to supervision may be in the course of dispatch, production, processing or use, or they may be still in storage. This means that these materials can be present in many different forms, e.g. as ores, nitrates, various salts, oxides, carbides, hexafluorides, pure metals or alloys, in the form of fuel elements, powders, solutions, scrap, etc.

In practice nearly all the fissile materials find their peaceful use as energy sources in nuclear reactors, hence all plants which form part of the fuel cycle are included in the field of application of the safeguards (see Fig. 1).

To these installations must be added the research centres, which may likewise contain large quantities of fissile materials and other plants not related to the fuel cycle.

To give an idea of the scope of Euratom's control activity, the number of installations of various types on Community territory as at 31 December 1968 was as follows:

—research installations	57
—industrial plants (from ore concentration to fuel element fabrication)	37
—processing plants	10
—reactors	133
	237

On the same date the approximate quantities of fissile materials in these plants were:

—natural and depleted uranium	11,000,000 kg
—enriched uranium	480,000 kg
—plutonium	700 kg

What are the means of control?

In order to provide a system of safeguards it is necessary to set up appropriate structures and mechanisms, which may differ according to the concepts that are adopted from both the legal and the technical point of view. There are various ways of defining the relationships between the supervising and the supervised parties, and choices have to be made as regards the means of supervision to be used and the points at which the checks must be applied.

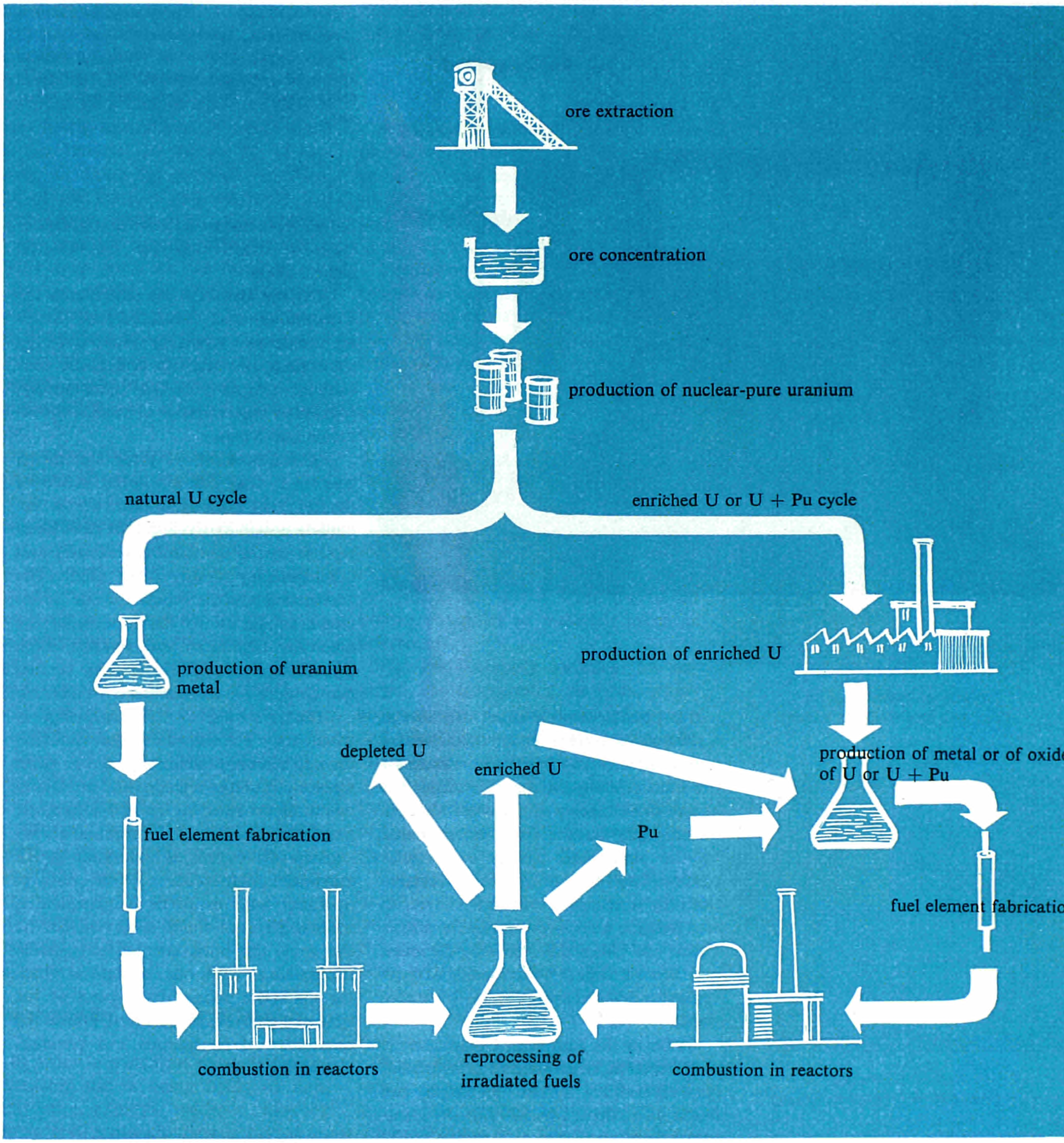


Figure 1: Flow scheme of the fuel cycle (for the sake of simplicity the thorium/uranium 233 cycle is omitted).

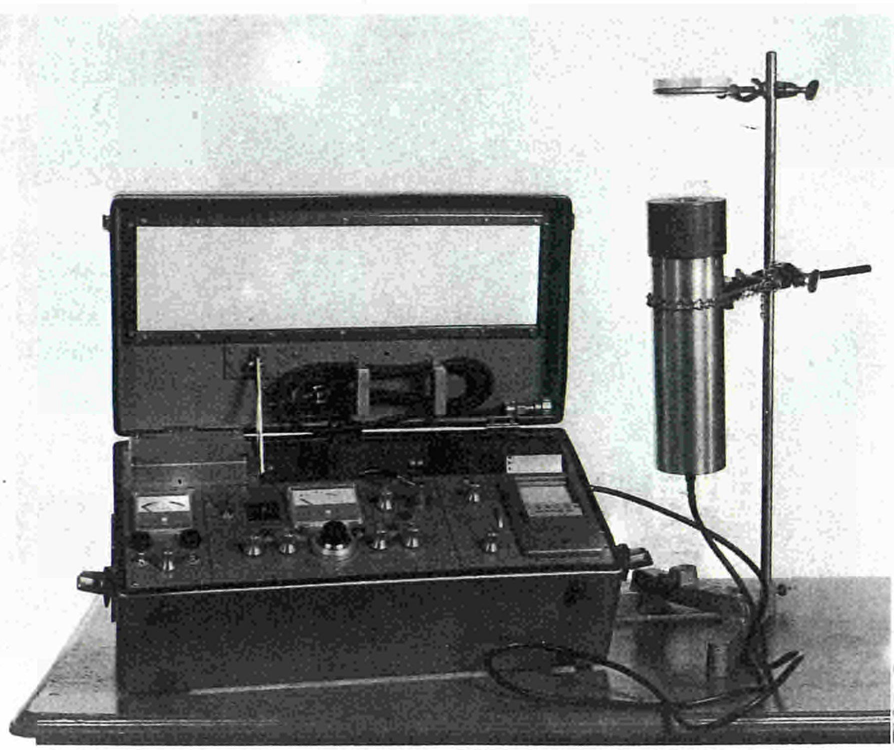


Figure 2: One of the portable gamma-spectrometers, with crystal and sample holder, which have been used for several years by Euratom inspectors (measurable energy range 5 keV-5MeV; automatic print-out).

It is possible, for example, to envisage a safeguards system which functions by noting directly and by its own means all the data relating to the materials, just as one can conceive of a system which is based solely on the declarations made by the supervised parties and which confines itself to checking those declarations by accounting methods. One can also imagine a system whereby the supervisors are given the role of policemen and are furnished with means of preventing any misappropriation of materials.

As far as the European Community is concerned the structure and principles of the supervisory system employed are based on Articles 78 and 79 of the Euratom Treaty, as well as on Article 81. The plants are required to keep accounts of the materials subject to safeguards and to submit systematic and regular statements to the Commission (Article 79). The Euratom inspectors verify the accuracy of these statements on the spot by means of accounting methods and physical checks (Article 81). In other words, the authors of the statements are responsible for them and the Commission checks them.

On the basis of these statements the Commission has instituted and keeps up to date an accounting system covering the ores, raw materials and fissile substances present in the Community, together with a balance of stocks, movements and losses.

The examination of these statements paves the way for an initial series of purely book-keeping checks which are made possible by the fact that each plant reports to the Commission directly and independently of any other plant. The accounting system based on the statements submitted by the holders of the materials facilitates and renders more significant the physical checks carried out directly on the materials concerned.

Clearly, owing to the processing to which they are subjected, the materials do not remain indefinitely in the same place but undergo changes and pass from one plant to another. The book-keeping situation as declared represents an inventory of the changes undergone by the material in the course of time, both in quantity and in form. Consequently, when a physical check is carried out on the spot, the book-keeping data make it possible to work out the state in which the materials should have been at the time of a previous verification. Hence the possibility of continuous and constant checking.

What are the physical checks?

By far the trickiest and most complex part of the supervisory procedure is the on-the-spot checks, the object of which is to verify that the situation as declared is in fact the true one.

The difficulties stem chiefly from the fact that the materials are present in many different physical and chemical forms, from their dispersion in certain installations and from their degree of accessibility. By way of example, mention need only be made of the fuel element fabrication plants, in which much of the material is present in various forms all along the production chains, and of the reactors and irradiated fuel reprocessing plants, where direct access to the material is practically impossible owing to its very high radioactivity.

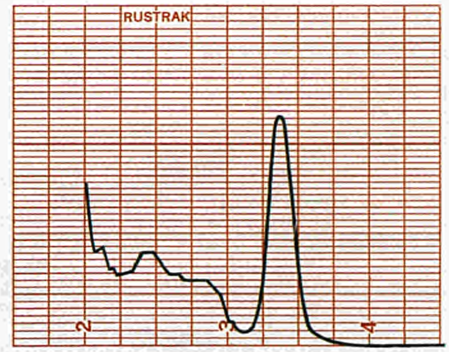
In the course of their on-the-spot checks the inspectors often take samples, which are sent to approved laboratories for analysis. The analyses most frequently required relate to uranium or plutonium concentration and to isotopic composition.

In cases where the material is directly accessible (for active solutions, of course, special techniques must be adopted) and representative samples can be taken from it, conventional methods of analysis are employed. These methods are often limited in their use by their cost, the frequently long time needed to obtain the result and, lastly, by the very fact of having to resort to sampling at all. Indeed, samples constitute a difficulty inasmuch as their cost is always high (in the case of highly enriched uranium the cost is about \$12/g and in that of plutonium about \$43/g) and because the sampling must be confined to materials which are in solution, in powder form or not in their final state, in order not to add to the cost of the material itself that of fabrication, which in the case of fuel elements, for example, can amount to several thousand dollars.

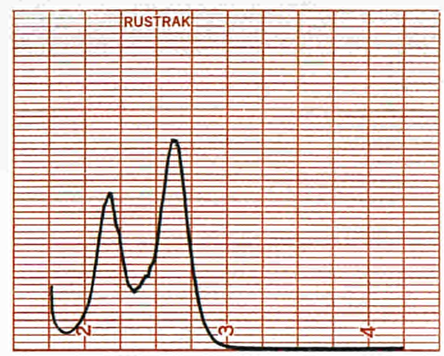
Non-destructive measuring techniques

In order to overcome these difficulties increasing use is being made of non-destructive analysis methods whereby the material is examined directly, in whatever state it is in, without recourse to sampling. This is a necessity whenever sampling is difficult either because the material is non-homogeneous or because it has undergone a particular treatment in order to be transformed into, say, finished fuel elements, the sampling of which would result in their destruction.

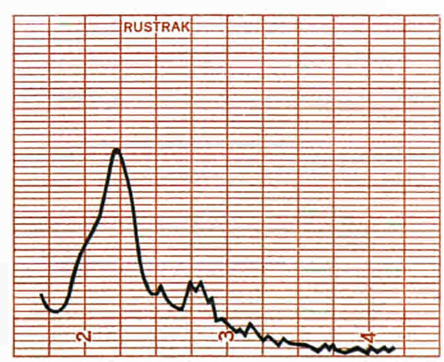
Figure 3: Spectra obtained with the gamma-spectrometer illustrated in Fig. 2.



caesium-137
(peak at 0.66 MeV)



93 %-enriched uranium
(peaks at 93-95 and 184 keV)



depleted uranium
(peaks at 93-95 and 194 keV)

A particular feature of non-destructive measuring techniques is that in some cases they can be carried out by means of portable apparatus, with the advantage that the result of the determination is quickly known.

Furthermore, their use facilitates the checks carried out on the same materials at different times and makes for more effective checking when non-destructive methods cannot be employed.

It is necessary with the aid of these methods to be able not only to detect the presence of fissile materials but also to determine the quantity; in addition, they must enable the degree of enrichment to be ascertained.

There are both absolute methods, which do not call for standards of comparison, and relative methods, by which the results are given with respect to known quantities of materials taken as references.

The first category includes, for example, the calorimetric methods, which are particularly suitable for plutonium and which serve to determine the heat quantity released instead of the weight of material present. Application of this technique requires an exact knowledge of the plutonium's isotopic composition and the americium-241 content.

The second category embraces methods based on gamma-spectrometry, neutron counting, etc., for which it is necessary to have a reference element of the same type as those on which the measurements are to be performed and of which the composition and enrichment are known.

The methods can be further subdivided into "passive" and "active" ones according to whether they are based on the measurement of X-rays, neutrons, gamma-rays, etc., spontaneously emitted by the material to be analysed, or whether the emission is brought about by bombardment with a neutron beam.

The "passive" methods suffer from a limitation insofar as neutrons and gamma-radiation are emitted only by certain materials, and in many cases the

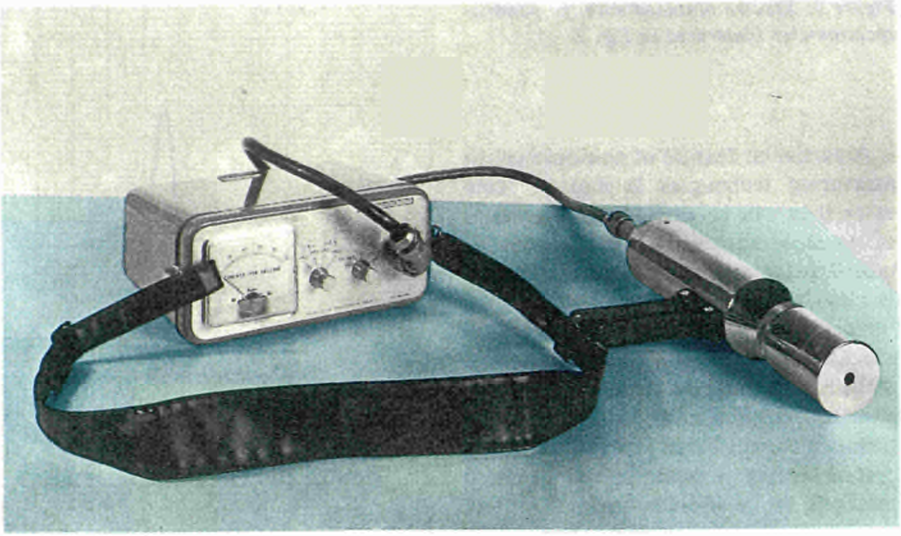
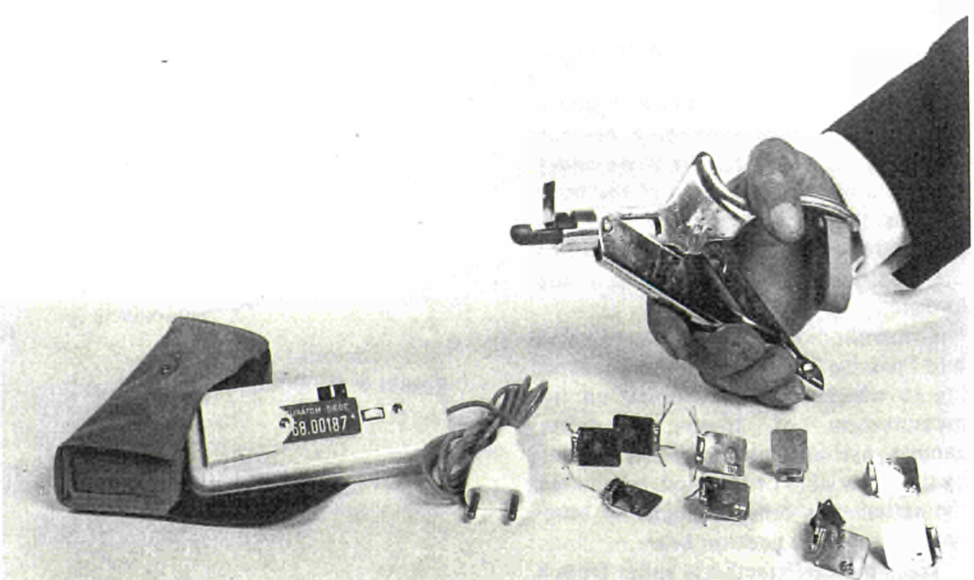


Figure 4: Portable gamma-ratemeter for rapid measurement, during inspections, of the 384 keV peak characteristic of Pu^{239}.

Figure 5: Personal monitors; tongs and seals used during inspections.



gamma-rays characteristic of a particular material are of such low energy that they are not even able to pass through the emitting medium. These difficulties are avoided by the use of "active" methods.

Table I summarises the methods that can be employed and indicates the conditions under which the measurements can be carried out, as well as the accuracy that can be expected.

In conclusion, the requirements with which the physical techniques must comply are as follows: they must be sufficiently accurate, provide a quick answer and operate as far as possible without the need for destruction of the material.

It must, however, be pointed out that it is not yet possible to use non-destructive measuring techniques on all the materials and in whatever form they occur; although several of the techniques mentioned are in an advanced state of application, others are still in the design stage.

Where should the checks be carried out?

Another interesting aspect of the implementation of physical supervision is the choice of the points at which the checks must be carried out. Physical checks can be performed either at every stage in the fuel cycle or only at certain points which can be regarded as compulsory transit points. Similarly, during physical checks it is possible to choose between confining the measurements to certain points in the plant and carrying out the determinations wherever the materials are present.

In some cases the points at which material checks can be performed are already determined by the nature of the operations to which the material is subjected. In fuel reprocessing plants it is technically possible to carry out the material measurements only at certain points for which provision was made at the design stage.

Other safeguards methods

A research team at the GfK[1], Karlsruhe, has commenced studies aimed at

1. Gfk = Gesellschaft für Kernforschung.

limiting the checks in the plants solely to those points which in recent terminology are known as "strategic" and are situated outside the zones where operations are carried out on the basis of processes which, for commercial reasons, must be protected.

The research relates to the identification of such points, for each type of plant, which fulfil the condition of being necessary and sufficient for a determination of the material balance. This surveillance is based on the measurement of the materials flow and provides, among other things, for the installation of devices which would "seal off" the plant using the materials. According to this concept it should be possible to ensure that the materials always enter or leave the plant at the same points and it is at these points that the measurements would be effected. Certain plants such as reactors are already "sealed off" in this sense and have a clearly defined route for incoming and outgoing materials; in the case of other installations studies are still in hand on possible surveillance techniques.

It should be noted in this connection that the surveillance of the materials flow relates solely to the quantities in circulation; as no provision is made for access to the installations, it is impossible to check on what use is made of the materials during their presence in the various parts of the plant.

In short, the Euratom safeguards system is not a police system, but it is designed to detect any violations and hence to discourage any misappropriation of materials. To this end there is provision for sanctions, which are directly applied by the Commission.

Other methods, based on different legal and technical concepts, could be brought in as a means of exercising safeguards but at present they exist only as studies or proposals and have yet to be put to the test.

Moreover, it must be pointed out that surveillance techniques are continually evolving. Euratom's safeguards system is benefiting greatly from this thanks to research and development programmes conducted by specialised personnel of the Joint Research Centre.

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Figure 6: Portable Geiger counter as used by Euratom inspectors.

Literature: (1) Euratom Treaty, Regulation No. 7 of 18.2.59 and No. 8 of 12.3.59. (2) U. MIRANDA: Euratom – Ten years of experience in safeguards. *Paper presented at the meeting of I.N.M.M.*, Washington D.C., June 1967. (3) Report of the *Panel on safeguards techniques, I.A.E.A., Vienna, 21-25.8.1967.* (4) Report of the *Panel on safeguards methods for conversion plants and fuel fabrication plants, I.A.E.A., Vienna, 14-18.4.1969.*

Figure 7: Equipment used for gamma-spectrometry measurements: 2″ × 2″ NaI (Tl) crystal and photomultiplier; lead collimators.

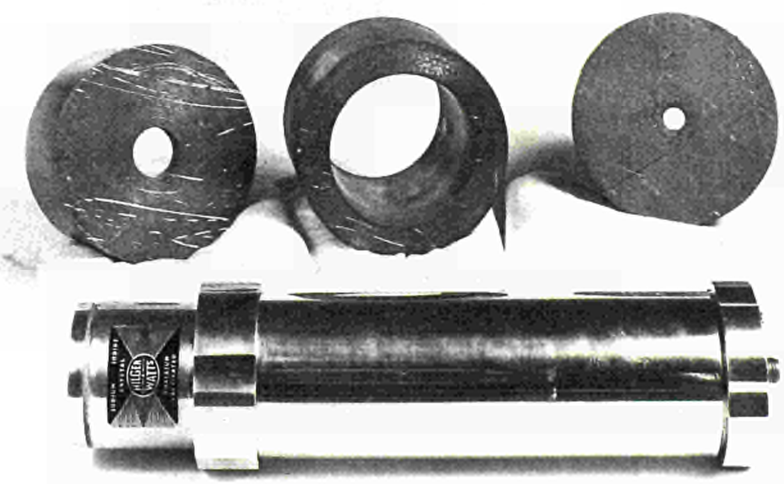

Table I: Principal methods of inspection.

Material to be inspected	Form	Determination	Method	Error	Remarks
uranium	metal, alloy, salts, oxides, carbides, etc.		*destructive analyses*		*a representative sample of the material to be measured is required*
	fuel elements (MTR plates, assemblies, pellets, etc.)	U content	gravimetry, coulometry, spectrophotometry, etc.	0,2-0,5 %	
		enrichment	mass spectrography	0,5 %	
			non-destructive analyses		*the measurement has to be carried out with respect to standards*
		U content and enrichment	spectrometry (emission + absorption)	0,5-2 %	measurement of the gamma-emission from U-235; absorption measurement with gamma-source (Cr-51, etc.).
		fissile U content	delayed neutrons		use of a neutron source
		fissile U content	reactivity variation		subcritical or critical assembly is required
plutonium	metal, alloy, salts, oxides, etc.		*destructive analyses*		*a representative sample of the material to be measured is required*
	fuel elements.	Pu content	coulometry, etc.	0,2-0,5 %	
		isotopic distribution	mass spectrography	0,5 %	
			non-destructive analyses		
		Pu content	calorimetry + delayed neutron and gamma-counting	0,5-1 %	it is necessary for calorimetry to know the isotopic distribution of the Pu and the Am-241 content
		fissile Pu content	counting of spontaneous fission neutrons	0,5-1 %	for delayed neutrons or gamma-counting the counts must be carried out with respect to standards
		fissile Pu content	reactivity variation		need for a subcritical or critical assembly

The anatomy of biological research in the Community - part 2

HEINRICH GEORG EBERT

An enquiry pointing up the weaknesses and strong points of biological research in the European Community and indicating the sectors on which future efforts should be concentrated.

AN ENQUIRY conducted by the Commission of the European Communities over the years 1966 and 1967 yielded interesting data on the state of research in biology, medicine and agriculture in the Common Market countries. A first article ("The anatomy of biological research in the Community, *Euratom Review*, Vol. VII (1968) No. 4 pp. 114-116) summarised the results of the statistical part of the enquiry, which dealt with the manpower and appropriations available to research institutes in the fields covered. The other part of the enquiry consisted mainly in obtaining replies to the following three questions:
a) "In which fields of your discipline do you consider the European Community to be behind or ahead of non-member countries?"
b) "What fields of research do you consider as promising or particularly important, having regard to possible consequences of a practical nature?"
c) "What new measures would you recommend?"

Our intention in the present article is to outline the chief ideas which emerged from some 750 detailed replies, taking first the biomedical and then the agricultural sector.

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Research in biology and medicine, . . .

Many institutes engaged in biological research, basic medical research and experimental medicine replied at considerable length. On the other hand, only marginal attention was given to clinical medicine, so that it is impossible to assess the situation fully in this sector, important though it is.

From the replies received it is difficult to arrive at an overall appraisal of the level attained by biomedical research in the Community, with opinions ranging from "Community ahead of everyone else" to "Lagging behind hopelessly". What does emerge clearly, however, is that the position is much the same in all the member countries.

. . . its focal points . . .

The results of the enquiry have revealed a number of focal points in biomedical research. Repeatedly quoted disciplines were the experimental study of the cell, virology, immunology, molecular biology, radiobiology and cancerology, all of which offer considerable potential, especially as regards practical applications.

In the field of *cell study*, the main problems are those of normal and disturbed growth and of cell differentiation, with the accent naturally on the cell recovery mechanisms. The aim must be to elucidate the mechanisms regulating these phenomena. Study of the problems in question will undoubtedly be a worthwhile basis for rational gerontological research, which is frequently regarded as having especial significance for the future.

The results of this general experimental study of the cell should give a new boost to cancer research, as regards both etiology and therapy. Cancer research is in turn closely linked, by reason of the oncogenic viruses, to the second main focus, namely, *virology*, which is considered as being of major importance but also as virtually undeveloped in the Community countries.

Immunology, together with all its ramifications such as immunological biology, immunopathology, immunological chemistry, immunosuppression and cancerological immunity, also occupies a central position. Its practical value is mainly in connection with the grafting of tissues and organs.

During recent years, research in the field of immunology has progressed satisfactorily in the Community countries. According to some, it is more or less on the same footing as in the United States and the United Kingdom; according to others, it still falls short of the standard achieved in the United States.

Whenever, as is often the case in the three fields just referred to, the emphasis is on the elucidation of fundamental phenomena, thinking and working methods must be directed to *molecular biology*. While this field was quoted with remarkable frequency in the replies, one is in many cases left with the impression that the expression has been used rather as a slogan. When the problems are described in more concrete terms, very important areas are listed, such as:

—the molecular mechanisms governing the effect of active compounds at the physiological and pharmacological levels (hormones, carcinogenic factors, drugs, etc);

—molecular genetics;

—molecular neurophysiology;

—biophysics and biochemistry of cell membranes.

All the focal points are, of course, closely linked with *radiation research and radiobiology*.

In this connection, attention is drawn to the necessity for studying the following problems:

—late-developing radiation damage, particularly after the incorporation of radionuclides;

—widening of knowledge of human radiobiology by studying as thoroughly as possible the long-term effects of radium-224 and thorotrast treatment;

—radiation damage resulting from minor radiation doses;

—study of radiotoxicity and, in particular, of bone-seeking isotopes;

—study of compound lesions;

—biochemical radiation protection.

Genetics continue to arouse a substantial degree of interest. The Community's advance on non-member countries is not very clear-cut; in some cases, indeed, there is a considerable leeway to make up. According to some replies, there are scarcely any laboratories whose performances are well above the average; however, some are to be found in France (micro-organism genetics), Italy (human genetics and general genetics) and the Netherlands (human genetics).

Particular significance, both theoretical and practical, attaches to molecular genetics, experimental evolution, gene regulation, recombination biochemistry, extrachromosomal heredity and, in the field of human genetics, prognoses relating to pathological anomalies. Also mentioned as subjects of interest for the future are the study of the fine structure of human chromosomes, the study of new diseases, the study of biochemical actions and the study of chromosomes in cases of neoplasia.

There are many who regard *cancerology* as one of the major research problems for the years ahead, and more particularly cancerological biochemistry, cancerological virology and cancer immunology. Needless to say, the problems inherent in cell growth and differentiation are intimately bound up with cancer research. The main call in this field is for a detailed study of experimental carcinogenesis; other areas indicated are cancer immunotherapy and chemotherapy and research on cytostatics. A sector of cancer research which many feel should have priority is the study of oncogenic viruses.

The United States is ahead of everyone else in cancerology. The Community has no institutes on the scale of the NIH, Bethesda, and the *Sloan-Kettering Institutes*, New York, where a large number of specialised clinical units cooperate closely with those of the major research institutes which are engaged entirely in cancer research. In Europe, the *Chester Beatty Research Institute* is the nearest equivalent to the US organisations but is in no way comparable with them as regards size. In a field of this kind, it is not sufficient to promote intensive collaboration between individual groups of research scientists; it would be more appropriate to set up a European form of the *NIH*.

. . .and some other problems with a bearing on the future

In *pharmacology and toxicology*, there is a certain lag vis-à-vis the United States, one of the chief causes being that efforts are in many cases confined to conventional toxicology. This also accounts for the frequently voiced desire for more intensive use of molecular biochemistry and pharmacology. There is an obvious need to set about studying the metabolism of drugs and pesticides, with particular emphasis on their teratological effects.

Figure 1: Average staff per institute specialising in biological, medical or agricultural research in European Community countries. White is used for university institutes; black for research institutes.

Nor is the situation in the field of *physiology* deemed very favourable. Even so, the development of certain sectors, such as electrophysiology and endocrinology, is as advanced as in other countries.

Broadly speaking, the *biochemical disciplines* (such as general and medical biochemistry, molecular biology, cell biology, etc.) are of especial importance to the future of most if not all disciplines. The Community has a number of front-rank biochemical laboratories. The overall situation, however, is unsatisfactory compared with the United States. Mod-

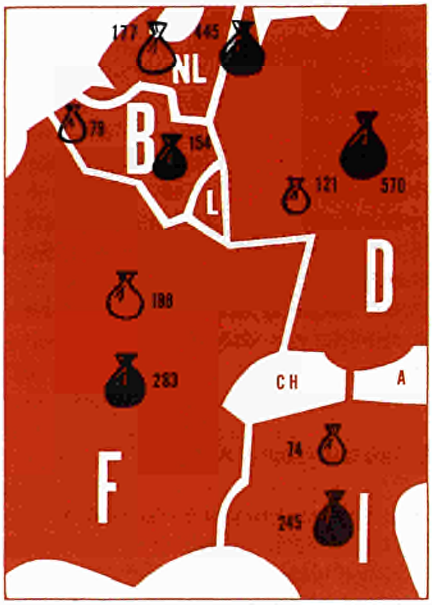


Figure 2: Average expenditure per institute in thousands of u.a. (= US dollar). White is used for university institutes; black for research institutes.

ern biochemistry is insufficiently represented at university level and nearly all the progress achieved has come from the major research institutes. The chief drawback in this state of affairs is that the universities, and in particular their clinical departments, find themselves cut off from new biochemical methods and from new discoveries in biochemical research. Hence the chorus in favour of biochemistry.

In some parts of the Community, *transplant medicine* has been developed considerably, and a certain amount of progress is seen to have been achieved in the field of incompatible transplants, such as bone-marrow grafting and transplant immunology.

In *biophysics, medical physics, radiation measurements, electrocardiac therapy and nuclear medicine*, there are many cases of dependence on the United States as regards new instruments and the latest techniques. No clear picture of the situation emerges. The importance of these disciplines lies partly in their being fundamental (in the case of microdosimetry and cybernetics, for example) to biology and medicine and partly in their auxiliary function. The application of nuclear medicine methods to haematology and cardiology has enabled the Community to forge ahead in these fields. Great promise is held out by the application of the results of nuclear medicine to metabolism kinetics and cell kinetics and by the use of the data thus acquired for experimental or therapeutic action on metabolic processes.

Agricultural research, . . .

In the opinion of a number of the institutes which cooperated in the enquiry, agricultural research in the Community Member States is slightly ahead of other countries if it is considered as a whole. However, the degree of development is not the same in the various Member States.

. . . the situation in certain special fields . . .

It is agreed that the Community has a certain lead in some particularly important sectors, such as genetics, zootechnics, plant improvement, plant diseases, parasite control and soil science. To these research sectors may be added others which are concentrated in one or more of the Member States, namely rice cultivation, oenology, tobacco research and problems affecting olive groves.

In *applied genetics*, Belgium and Italy are seen to be lagging behind the Netherlands, Western Germany and, to some extent, France; this is attributable to the inadequate numbers of research scientists working in this field.

Zootechnics and the genetics of domestic animals are fields the development of which varies widely from country to country in the Community, depending on the proportion accounted for by stockbreeding in income from agriculture. Thus in Italy scarcely any attention is given to applied genetics in agricultural colleges even though the work accomplished in zootechnics has been appreciable.

A Dutch institute states that in future it will be necessary for research on *plant improvement* to embrace cytogenetics, biometrics, physiology, phytopathology and biochemistry if such research is to maintain over the long term the progress it has achieved. Due weight will have to be accorded to this factor and it will accordingly be essential, on the one hand, for existing research institutes to introduce specialisation by their biogenetic researchers in certain particular fields and, on the other hand, to ensure, at both national and international level, close cooperation or, where appropriate, division of work.

In the field of *plant diseases*, the specialised sectors of mycology, bacteriology and physiology are regarded as having attained a satisfactory level of development. Virology, haematology and general microbiology, on the other hand, have a considerable leeway. In the view of certain institutes, the excellent performance in the Netherlands is particularly worthy of mention.

Where *veterinary science* is concerned, the Community has a distinct lead in preventive medicine and in control and analysis processes. It is true that harmonisation is seen to be necessary in this sector. The accent is laid on the importance of research in the field of domestic animals and zoology, which has been particularly neglected.

In *marine biology*, there is a long way to go before catching up on the United States, the USSR and Japan.

A problem frequently referred to is that of *technological resources*. Some institutes feel that the situation is satisfactory as regards research on the application of rational cultivation techniques and on mechanisation.

Just as in biology and medicine the use of computers for recording, simulation, operation and administration is considered urgent and essential. Emphasis is laid on the usefulness for research of modern computing methods. The lag, compared with the United States in particular, as regards computers and other technical aids is a matter for concern.

. . . and research of especial significance for the future

Many institutes devote particular attention to the use of research results for raising living standards and have stressed the significance of certain fields in this respect, mentioning in particular *mutagenesis*, from both a theoretical and a practical standpoint.

For work of this kind, researchers from the various disciplines concerned should be brought together in new institutes.

Fields mentioned in particular are mutation research and the improvement of genetic material, notably when exposed to irradiation, and the improvement of the efficiency of phytosynthesis of proteins by plants.

Another serious problem from an agricultural research standpoint is *pollution of the environment*, which engaged the attention of numerous participants in the enquiry, although not solely with reference to possible radioactive contamination. Research on pesticides, insecticides and fungicides and its practical consequences is regarded as a field of interest in the years ahead. Many institutes are of the opinion that there is still insufficient knowledge of the effect which pesticides have on biological systems, the way in which they build up in plants and animals, and the pattern of their development in the food chain. The same applies to the use of hormones and antibiotics in stockbreeding.

A corollary to this problem is the need to carry out research into food additives and their toxicological effects, with particular attention to food preservation by irradiation. At all events, food biochemistry is marked out for a role of capital significance.

Parasite control is highlighted by the problem of environmental pollution. In this context, it is proposed that a searching study be conducted into the behaviour of useful and harmful insects, as well as on the host-parasite relation, parasitism physiology, radiation sterilisation of monogamous harmful insects, etc.

Noteworthy aspects of *soil science* include the use of chemical fertilisers, organic and mineral metabolism, the movement and equilibrium of oligoelements in the soil and their relation with plant food, and biological and microbiological activity in the soil. Soil hydrology, especially in arid areas, would lend itself particularly well to cooperation at Community level.

In the context of environmental pollution, ecology is also regarded as important.

The role of basic research

A problem frequently accorded considerable weight, whether in medical or in agricultural research, is that inherent in the transfer to applied research of the results, methods and ideas deriving from basic research. There are many who criticise the lack of coordination between these two types of research. Hence the need for cooperation within the various disciplines and in many cases beyond national frontiers, better coordination of the work, and the setting-up of a form of organisation aimed at securing optimum use of the joint effort.

Cooperation in the Community

The promotion of cooperation at international, and in particular Community, level is considered by the majority of the institutes concerned with this question as a factor of prime importance. Contacts with American scientists are closer than contacts with scientists in other Member States.

In order to step up cooperation within the Community, it is proposed that:

—the work involved be jointly planned and apportioned;

—joint key programmes be drawn up;

—joint working groups and Community laboratories be set up and given assistance;

—funds be made available for travelling;

—grants be set up;

—seminars and colloquia be organised.

It is surprising to note how frequently replies from the Member States show the Community as being the natural and obvious level for the planning and coordination of research programmes and joint key projects.

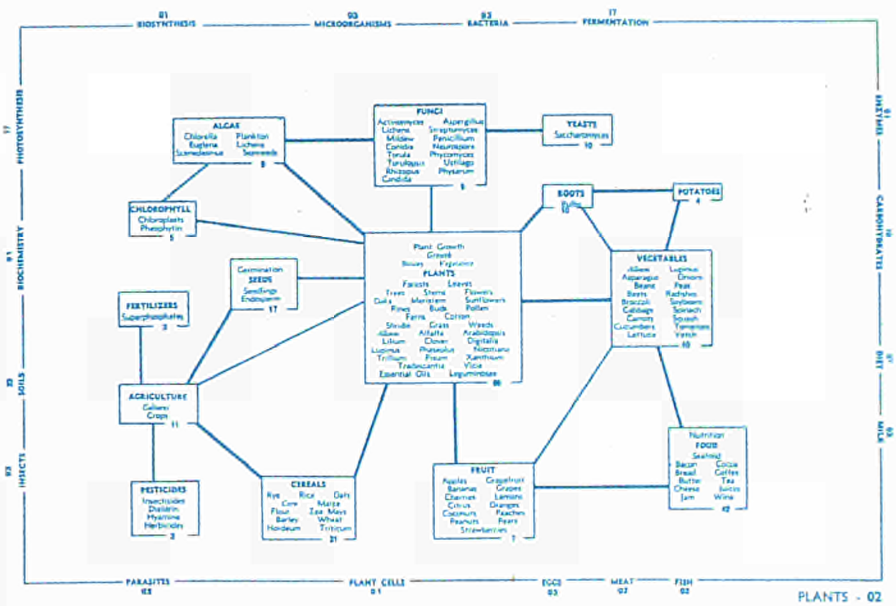
Organisation of research

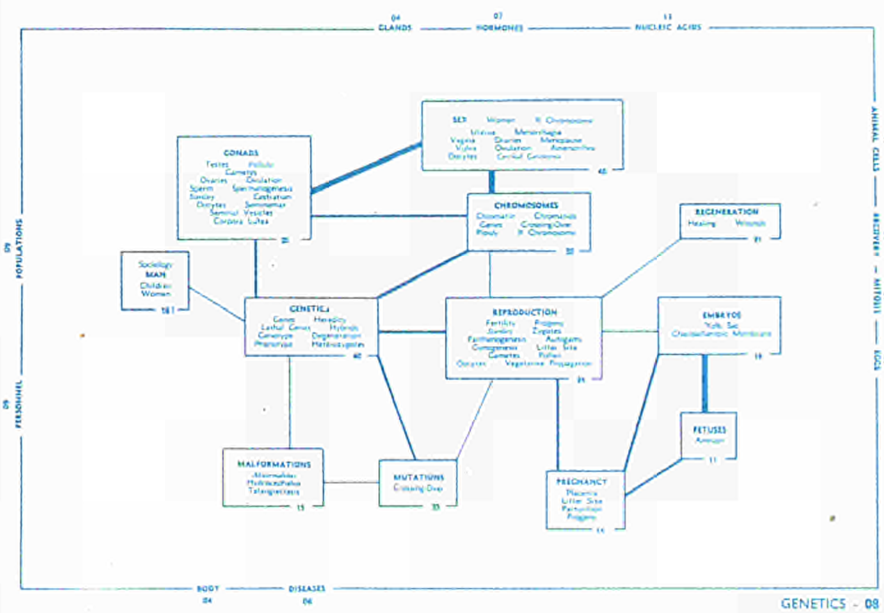
The proposals aimed at setting up modern laboratories recommend, in addition to interdisciplinary cooperation (considered as an obvious condition), collaboration between scientists from different fields (such as biology, medicine, chemistry and physics) and with different specialisations.

Top-grade interdisciplinary working groups should be set up on an international basis. In most cases, such teams can only be formed within the wider Community framework, for in a smaller one it is impossible to find the highly qualified researchers required for a rational and efficient team. It is also necessary to increase researcher mobility in the Community and to ensure that researchers are really able to move freely between the Member States, by affording opportunities for careers of the same level and removing any obstacles of an administrative and legal nature.

The "research gap" in the Community, whether in the construction of up-to-date Community-scale laboratories, the structure of the institutes concerned or the absence of sound scientific management, is often ascribed to the lack of organisation. Finance is not always the main difficulty with which researchers have to cope.

It is frequently pointed out that the social and professional status of the scientist in the Member States leaves something to be desired. The rigid pyramid of authority in the universities, the repeatedly quoted structural crisis, the unsatisfactory career opportunities, especially outside the university sphere, all give rise to problems. In the event of increased mobility, a career must no longer (as has happened so often in the past) be totally disrupted through employment in another Member State, with the researcher himself taking the risk involved.





Figures 3 and 4: Two "terminology charts" used for indexing purposes in Euratom's nuclear documentation system (see report EUR 500e 2nd edition, Part II).

Power reactors in operation, under construction (*) or planned (**) in the Community
(*Status as at 24 October, 1969.*—NB. As compared with the situation shown in *euro-spectra* Vol. VIII (1969) No. 1 pp. 29-30, the total power reactor capacity in service, under construction or at the planning stage in the Community has increased by 3,500 MWe in spite of the provisional removal from the list of the French Fessenheim project (2 × 650 MWe). This advance stems exclusively from the projects announced by the German producers and distributors, which relate to very large nuclear power plants. In view of the present status of the construction work and the declarations of intention known to date, the Community can expect to have 15,000-16,000 MWe of nuclear power available towards 1975.)

1. The total net electric capacity of the nuclear power plants in operation, under construction or planned is 16,618 MWe, broken down as follows:

a) Proven-type reactors		
Gas/graphite		
Chinon 1 (EDF 1)	F	70
Chinon 2 (EDF 2)	F	200
Chinon 3 (EDF 3)	F	480
St. Laurent 1 (EDF 4)	F	480
St. Laurent 2	F	515*
Bugey 1 (St. Vulbas)	F	540*
G 2 Marcoule	F	40
G 3 Marcoule	F	40
ENEL (Latina)	I	200
Boiling water		
KRB (Gundremmingen)	D	237
KWL (Lingen)[1]	D	155
VAK (Kahl)	D	15
ENEL (Garigliano)	I	150
GKN (Doodewaard)	N	52
KWW (Wurgassen, Weser)	D	640*
HEW/NWK (Brunsbüttelkoog)	D	750**
Pressurised-water		
KWO (Obrigheim)	D	283
SENA (Chooz)[2]	F	266
ENEL (Trino Vercellese)	I	257
BR 3 (Mol)	B	10
KKS (Stadersand Elbe)	D	630*
S.E.M.O. (Tihange s/Meuse)[3]	B	750**
Centr. Nucl. de Doel (Doel s/Escaut)	B	780**
PZEM (Borssele)	N	400*
RWE (Biblis/Rhein)	D	1.150**
b) Advanced converters		
Heavy-water		
MZFR (Karlsruhe)	D	50
KKN (Niederaichbach)	D	100*
EL 4 (Monts d'Arrée)	F	70
CIRENE (Latina)	I	32**
High-temperature		
HKG (Schmehausen)	D	300**
AVR (Jülich)	D	13
KSH Geesthacht 2 (Schl. Holstein)	D	22*
Sodium/zirconium hydride		
KNK (Karlsruhe)	D	19*
Nuclear-superheat		
HDR (Grosswelzheim)	D	22
c) Fast-breeders		
Phenix (Marcoule)	F	250*
SNR (Weisweiler)[4]	D	300**
d) Type not yet decided		
Kernkraftwerk Neckar (Lauffen)[5]	D	750**
BASF (Ludwigshafen)[6]	D	1.200**
ENEL 4 (Isola Serafini – Lomb.)	I	650**
ENEL 5 (. . .)	I	650**
E.V. + Badenwerk (Oberhausen)	D	600**
Chem. Werke HULS + VEW (Marl)	D	600**
Fessenheim 1	F	p.m**
Fessenheim 2	F	p.m**
KKW Schmehausen (Westfalen)	D	600**
GKM + Badenwerk (Kirschgarthausen)	D	700**
Bayernwerk + Isaramperwerke	D	600**

2. Percentage breakdown of the reactors in operation and under construction, according to type

Gas/graphite	2,565 MWe	41 %
Boiling-water	1,249 MWe	20 %
Pressurised-water	1,846 MWe	30 %
Heavy water	220 MWe	4 %
Other advanced converters	76 MWe	1 %
Fast breeders	250 MWe	4 %
	6,206 MWe	100 %

3. **Breakdown according to state of completion and by country**

	Germany	France	Italy	Netherlands	Belgium	Community
Reactors in operation	775	1,646	607	52	10	3,090
Reactors under construction	1,411	1,305	—	400	—	3,116
	2,186	2,951	607	452	10	6,206
Reactors planned	7,550	—	1,332	—	1,530	10,412
TOTAL	9,736	2,951	1,939	452	1,540	16,618

1. Excluding conventional superheat 2. Franco-Belgian power plant (50/50) 3. With French participation (EDF) of 50% 4. Breakdown of participation: Germany 70%, Netherlands 15% and Belgium 15% 5. Participation and commissioning date not yet settled 6. Including 400 MWe for steam supply.

Meeting of Council of Ministers for Science

On 28 October 1969 the Ministers for Science of the six Community countries met at Luxembourg to examine the situation of Euratom and the outlook for European scientific cooperation in non-nuclear sectors.

They decided to send the four countries seeking membership of the Community (United Kingdom, Ireland, Denmark and Norway), together with Austria, Portugal, Spain, Sweden and Switzerland (and perhaps other non-member European countries later on), a memorandum proposing cooperation on the basis of the report by the Community Working Party on Scientific and Technical Research Policy (Aigrain Group).

In the seven fields given priority at a previous meeting of the Ministers, namely information science, telecommunications, new means of transport, nuisances, meteorology, oceanography and metallurgy, the memorandum to be sent to those countries mentions the courses of action that have received substantial approval among the Community countries. This does not mean, of course, that any of the countries consulted cannot propose other action that they consider particularly worthwhile.

Thus a start has been made on the procedure already laid down of consultation with non-member countries with a view to European cooperative action in the field of science and technology.

As regards Euratom (promoting of a common nuclear industry policy, common research programme, the question of a European uranium enrichment plant), no decision has been taken, except to allow further time for thought. The file will perhaps be brought up at the meeting of the Heads of State or of Government to be held at The Hague in December 1969, and in any case will be the subject of a fresh meeting of the Community Council of Ministers.

Review of work on plutonium recycling

Under a number of Euratom research contracts a thorough study of the problems of plutonium recycling in thermal reactors has been carried out during recent years. In the case of two of these contracts, signed with the French *Commissariat à l'énergie atomique (CEA)* and the *CEN-BelgoNucléaire Association* respectively, the work was completed a few months ago. Another contract, with the Italian *ENEL*, is still in progress, but an important milestone was passed with the loading of twelve plutonium elements into the Garigliano reactor (see *Euratom Review* Vol. VII (1968) No. 4 pp. 126-127) and, very recently, the order placed with three Community firms (*Alkem*, *Belgo-Nucléaire* and *Combustibili Nucleari*) for four prototype plutonium elements to be used in the same reactor.

In order to let interested Community circles know the results of this work as quickly as possible, the Commission organised an information meeting on 13 and 14 October, in Brussels and at the Mol Research Centre, followed up by a series of visits to the *CEN* and *Belgo-Nucléaire* plutonium laboratories.

This meeting was also used for reviewing the work carried out in the entire Community during the last ten years, it being found that as regards both the physics of plutonium-containing lattices and the manufacture of plutonium fuel, the experience accumulated in the Community is broadly comparable with that of the Anglo-Saxon countries.

Exchange of experience between nuclear power plant operators

As part of the scheme run by the Commission of the European Communities to promote the exchange of experience between nuclear power plant operators, some 90 specialists, including the representatives of 25 Community electricity utilities, met in Brussels on 23 and 24 October 1969.

This was the third event of this kind, the first having taken place in Amsterdam in November 1966 and the second in Paris in November 1967 (see *Euratom Bulletin* Vol. VI (1967) No. 1 p. 27 and *Euratom Review* Vol. VII (1968) No. 1 p. 30).

The agenda included reports of experience acquired during 1968 and 1969. Discussion centred particularly on incidents during operation. Their causes, countermeasures to be taken and the lessons to be drawn from them for future power plants were described and discussed thoroughly and with considerable candour. It should be emphasised that the success of this project, in which the Community's nuclear plant operators are participating on a voluntary basis, depends on the frankness with which experience is exchanged.

One of the thorniest subjects raised was the damage suffered by the internals of two pressurised water reactors, the subsequent intense investigations carried out into the vibrational behaviour of the affected components and the modifications that had to be made to the plants.

Steam turbines were another major point on which attention was focused, for since 1963 seven operators have reported turbine defects and the number of incidents totals 18. This would suggest that the special problems arising because these turbines run on saturated steam have been underestimated. Blade failures are generally attributed to vibrational phenomena which have since been thoroughly investigated.

From a general discussion held at the end of the meeting on future work to be carried out under this scheme it emerged that it would be beneficial to extend the exchange of experience henceforth to non-Community countries such as Britain, the United States, Switzerland, Spain and the Scandinavian countries and to tackle not only purely technical problems but also topics such as the training of nuclear plant operating staff.

Symposium on fuels for high temperature reactors

A symposium held in Bournemouth, England, from 4 to 7 November 1969 was attended by 260 representatives of 35 industrial organisations and research centres from the 12 countries which signed the *Dragon* Agreement. The main aim of the conference was to review research and development work on fuels for high temperature gas-cooled reactors.

The discussion covered all aspects of fuel production, from the fabrication of the kernels and their coating (see *Euratom Review* Vol. VII (1968) No. 2 pp. 46-51) to their compacting in cartridge form and the assembly of the fuel elements. The main difficulty at present is to go over from fabrication in the laboratory to industrial-scale production.

Studies carried out jointly by the *Dragon* Project and the Ispra Establishment of the *Joint Research Centre* and based partly on data provided by industry show that the capital cost of a twin power plant with a capacity of 1,320 MWe would be in the region of $145/kWe, the cost price of the electricity produced being approximately 3.8 mills/kWh.

Concerning the design of fuel elements, the *Dragon* Project wishes to encourage industry to adopt the "teledial" type (the configuration of which does in fact resemble a telephone dial), which enables the maximum temperature of the coated particles to be limited to 1,250°C.

Ground pressures and supports in mines

The Commission of the European Communities devoted two factfinding days, 13 and 14 November 1969, to one of the most important aspects of its programme for the promotion of research in the coal industry, namely, ground pressures and supports in mines. This sector has absorbed approximately 17% of the funds made available by the Commission (and its predecessor the High Authority of the *ECSC*) for the entire programme.

The 270 participants included experts from ten other countries besides the six Community Member States.

The research reported on during these two days comes under the general heading of the Community's energy policy, the main aims of which are long-term security of supply and favourable and stable prices; the technical results of the research, insofar as they are passed on to and turned to account by operators, help to reduce costs.

In European mines, ground pressures are very considerable on account of the depth of the workings and the low resistance of the rocks as a result of dislocation of the deposits.

If we can achieve a better understanding of the "ground pressures" phenomenon, and if we can acquire more accurate knowledge of the forces at work and their interaction, we shall be better able to develop sophisticated extraction processes and support equipment. It will then be possible to speed up technical improvement of collieries, to reduce the risk of accidents and to increase the mechanisation and automation of production through which heavy manual work can be replaced by control and supervision operations.

The research effort in this sector is therefore of social as well as of economic importance.

Fact-finding meeting on prestressed concrete reactor vessels

More than 350 experts met in Brussels between 18 and 20 November 1969 to exchange ideas and experience on prestressed concrete reactor vessels and their thermal insulation.

This was the second meeting on this subject to be sponsored by the Commission of the European Communities, the first having been held in November 1967 (see *Euratom Review* Vol. VII (1968) No. 1 pp. 18-23). However, unlike the first occasion, when participation was limited to the Community Member States, the meeting just concluded was thrown open to countries outside the Community, being attended by representatives from 14 countries in all.

It emerged clearly that within the space of a few years, as a result of an ever-increasing number of tests and the availability of more powerful computers, substantial progress had been achieved in the technology of prestressed concrete reactor vessels. In particular, computers have made it possible to ascertain the behaviour of containments subjected to a pattern of complex triaxial stresses, and consequently to reduce superfluous precautions due to the ignorance factor.

Originally developed for proven and then for advanced gas reactors, the application of this vessel design is now being extended to boiling-water reactors. The studies reported pointed to the belief that the prestressed concrete vessel, enabling as it does the technological frontiers to be pushed back and being easier to use and quicker to build, may well become a serious rival to steel vessels.

The second theme of the meeting was thermal insulation of pressure vessels, which is, moreover, inseparable from their construction, as the solutions adopted are conditioned by the solutions chosen for their thermal shielding. It is gratifying to note that in this field, too, considerable progress has been achieved during the last few years by dint of searching basic studies which have made it possible to clarify the convection phenomena responsible for heat transfer in insulating media.

A handbook on radioactive pollution of water

The Commission recently published a handbook under the title "Principles and general methods for determining the maximum radiological capacity of a hydrobiological network". This book, which is a summary of the talks and discussions held between the Commission and experts from numerous fields, should help the health authorities of the Community States to align their methods of dealing with the problem of liquid radioactive waste.

The chief difference between these effluents and conventional waste lies in the persistence of radioactivity and in the way it travels through the various ecological systems before reaching the human organism. It would be unreasonable, however – and this idea stands out very clearly in the handbook – not to allow discharges of radioactive effluents whose behaviour, dilution and dispersion have been studied beforehand, if their biological effects meet basic radiation protection standards (see *Euratom Review* Vol. VII (1968) No. 3 pp. 66-73).

A chart of radionuclides used in medicine

Prof. A. S. Simon, Professor of Radiology at the Free University of Brussels, has been entrusted by the Commission of the European Communities with the task of drawing up a chart of radionuclides used in medicine and biology.

This guide will commend itself particularly to industrial physicians and to radiological protection officers. For each radionuclide it lists the physical and chemical characteristics and biological behaviour, the dosage in cases of medical use, the irradiation doses and the necessary protection and decontamination measurements.

Thulium-170 generator operating at Ispra

Since 19 September, a generator in which approximately four watts are generated by a radioisotope source has been in operation at the Ispra Research Establishment. The source consists of 14 thulium-filled tubes in which the isotope thulium-

170 (a beta-emitter with a half-life of 127 days) is produced by irradiation in the *BR* 2 reactor at Mol. The heat generated in the tubes is converted into electrical energy by means of germanium-silicon thermocouples.

This experiment is the result of studies carried out at Ispra, on a very limited budget, with a view to obtaining technological knowhow in the field of radioisotope generators for space travel purposes in Europe. Valuable experience was acquired, especially as regards the solution of heat insulation problems, thus leading to high conversion efficiencies and the installation of powerful radioisotope sources in generators. Their use in satellites would, however, necessitate further optimisation studies on generator measurements and radiation shielding.

The following are some technical data. On 19 September 1969, the source supplied a thermal power of 92.2 watts for a radioactivity of about 41,000 curies. The power measured at the consumer resistance was 4.14 watts, which corresponds to a thermal efficiency of 4.5%. With minor improvements in design the efficiency might be raised above 5%. The temperatures on the hot side of the couples were 835°C and on the cold radiation-cooled side 390°C.

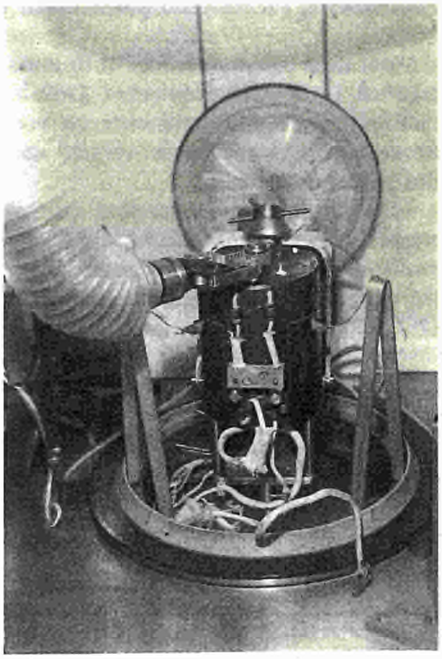


Figure: The generator being set up in a shielded cell with the aid of a remote handling device (taken through a 25 cm thick lead glass window).

Technical novelties

In its "Technical Notes" series the Commission of the European Communities recently published information on the following devices and processes, which were developed under the Euratom research programme:

- —Programmer for automation of chemical and radiochemical separation processes.
- —Smoke detector.
- —Reactivity computer.
- —Pneumatic exchanger for gamma spectrometry.
- —A simplified method for determining the BET surface.
- —Device for heat treatment in a vacuum.
- —Rapid sealing device for tubes.
- —Device for securing finned tubes to measuring benches in a vertical position without deformation.
- —Automatic X-ray apparatus for fuel element welds.
- —Pneumatic device for transporting irradiation capsules in a nuclear reactor.

Enquiries for further details on these devices and processes, with a view to their application, should be addressed to the Commission of the European Communities, D.G. XIII, Direction A, 29 rue Aldringer, Luxembourg.

European conference on radiation and isotope techniques in the building industry

The Bureau *Eurisotop* is to hold a European conference in July 1970 on "Radiation and isotope techniques in the building industry". It will be concerned in particular with developments or applications which have already reached industrial maturity and with the latest results of applied research.

The conference programme will be drawn up in conjunction with the trade associations in the relevant fields, e.g. building, plastics, metallurgy, concrete, paints and varnishes, and wood.

Organisations and individuals in a position to present papers on the conference subject are asked to submit their proposals to: Bureau EURISOTOP, Commission of the European Communities, 200 rue de la Loi, Brussels 4 (Belgium).

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Just published

The Commission has just published a booklet entitled "Research and Technology and the European Community". This booklet can be obtained free of charge from the Scientific and Technological Information Service, Commission of the European Communities, 200 rue de la Loi, Brussels 4.

A strategy for the European electronics industry

The gap between Europe and the United States in the electronics sector has its roots not only in research but rather, and in particular, in the structure of the industry and its markets. If each of the Community countries wishes to develop its industry along purely national lines, American firms will inevitably take over complete control of Europe's electronics industry sooner or later.

This pessimistic forecast was made by a group of three research teams (French, German and Italian) which the Commission of the European Communities asked to carry out a study, the results of which will be published shortly. The report analyses and compares the structure of the electronics industries in the Community and certain non-member countries, stressing the R and D aspect and drawing conclusions as to possible strategies.

A comparison of the turnovers of the different companies reveals the absolute predominance of the American industry over its rivals, be they the European Community countries (5 to 1), British (11 to 1) or Japanese (13 to 1) and points up a revival of the consumer durables sector in the United States since the introduction of colour television, a trend that has not yet appeared in the other countries, where the market represented by the general public is far from saturated.

Another finding is that the degree of concentration in the electronics industry is inversely proportional to the size of the market. Thus, in 1965 the four largest groups in the United States accounted for only 25% of output, compared with more than 40% in the Community and almost 60% in Japan.

It was also found that, within the electronics field, only small American firms had a highly specialised product range, but these "small" firms had a turnover eight to ten times that of their counterparts in the different countries of Europe. In fact, specialisation is only possible if the market is large enough.

Outlets, and particularly orders for hardware placed by public bodies, are therefore seen to be the dominant factor. This being the case, and since the Community countries cannot resort to artificial methods such as the United States' military and space programmes, an agreement should be reached between governments to give preference to European manufacturers in the placing of orders by public bodies for equipment which is at present imported.

The part played by public funding is even more significant when it comes to research and development. The proportion of research and development carried out in the private sector of the electronics industry is 73% in the Community and 81% in the United States, but the proportion financed by public funds is 16 and 66% respectively.

As a result American firms can afford to spend a relatively smaller proportion of their turnover on research and development than their European competitors (3.5 compared with 7.1%). Here again, however, the effects of size are felt and the amount of money put up by American firms exceeds the combined total for private firms and public authorities in the Community ($ 750 million compared with $ 542.5 million).

Proceeding from this analysis the study goes on to consider the various strategies open to European firms. Having rejected the development of foreign techniques—the "Japanese" approach—which is politically dangerous, and the policy of "market gaps", which tends to concentrate efforts on a particular area while abandoning others, the report finds that most large European firms have adopted what is known as the "controlled gap" policy and strive, with the aid of multidisciplinary research centres, to keep up with technological progress.

While this strategy prevents the gap from widening, however, it can hardly close it. Herein lies the explanation for governments tending increasingly to intervene directly in the industrial sector. What happened in the particularly sensitive field of data processing is now being extended to the components field. However, while rationalisation moves leading to the establishment of publicly-backed national groups may enable heavy research costs to be borne, such an approach may also seriously hamper the formulation of a common policy by the Member States which would ultimately result in the reorganisation of the Community's electronics industry.

In the absence of such a common policy the Community countries would with the passage of time be condemned to allow the complete control of an industry which is universally recognised as being of fundamental importance to pass into American hands.

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