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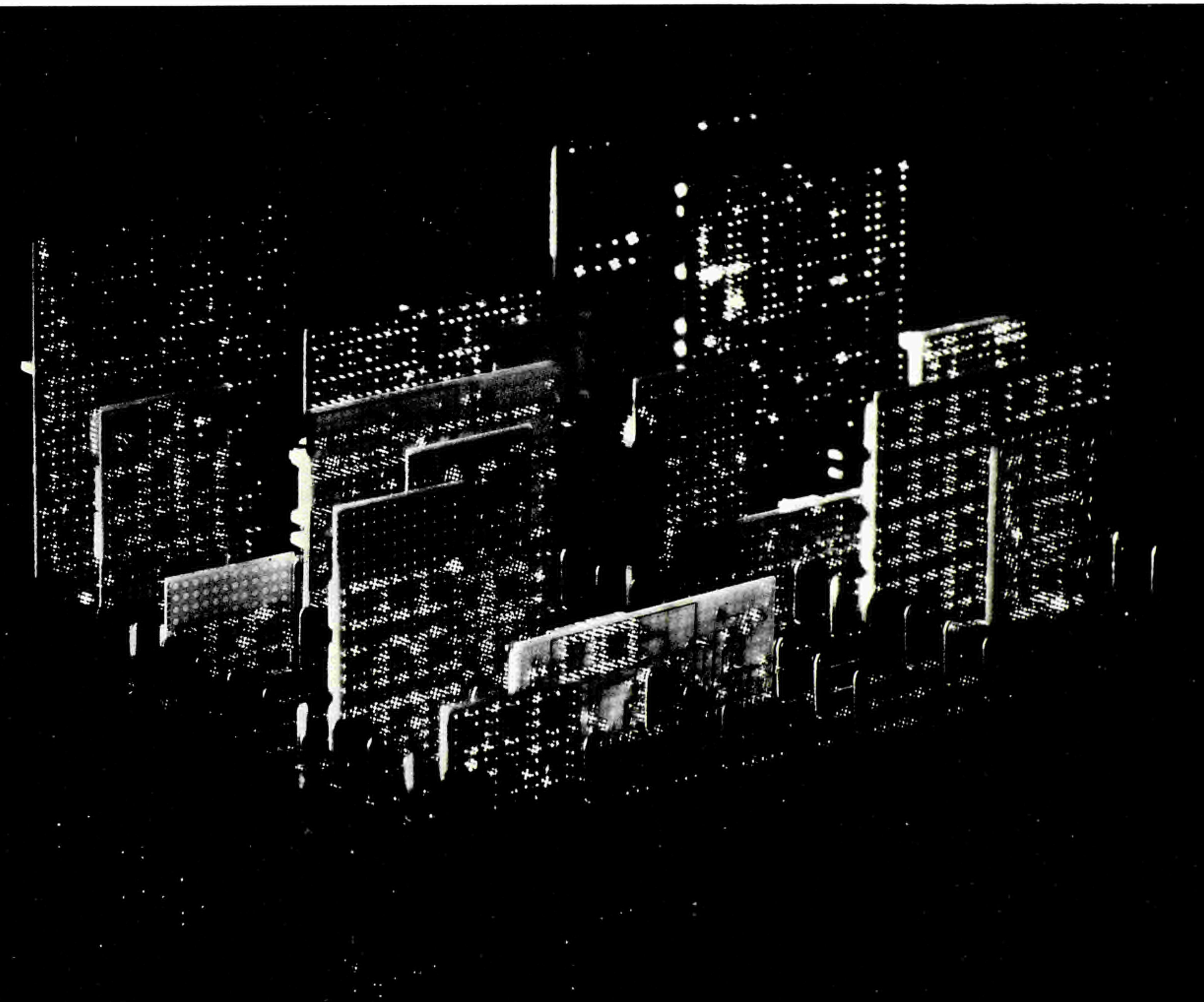

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Scientific and
Technical Review
of the European
Communities
(ex-Euratom-Review)

Very soon the geographical outline of the European Communities on our cover page will be extended to include Denmark, Ireland, Norway and the United Kingdom.

The ceremony in Brussels on 22 January of this year was an event of historical importance, a fact of which everyone from the political pundit to the man in the street is fully aware.

We would therefore regard it as superfluous to draw our readers' attention to it once again, especially since a great deal of ink has already been shed on the subject - perhaps even a little too much, but, in spite of this slight surfeit, History has emerged supreme. As always, the little incident merely added colouring to the background.

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The importance of Venture Capital as a Means of Financing Innovation

ARNO MORENZ

One of the decisive factors in innovation is the availability of "venture capital", and a series of articles on public and private financing of innovation will be published in our review.

The action of the "European Enterprises Development Co.", described in this contribution, is one of the most original in Europe, but not the only one.

ONLY CERTAIN ASPECTS of industrial innovation will be discussed in this article. Innovation in this context, means the whole sequence of events from the dawning of an idea to the launching of a new product, process or service on the consumer or capital-goods market. Our interest will focus mainly on "technological innovations" in the widest sense, i.e. not merely novel products and processes of a purely technical nature. Innovation is the business of large corporations and public research institutes, as well as of small and medium-sized firms and newly-established ones. Here we shall confine our attention to the two last-mentioned breeding grounds of innovation, though the importance of the others must not be underestimated.

ARNO MORENZ is an expert of an important European Venture Capital Company.

Innovation is imperative

Since Schumpeter's day innovation has been recognised as the cradle of progress and entrepreneurial action generally. During the last few decades innovation, in the broadest sense, has undoubtedly been the wellspring of economic and social progress, reflected in higher productivity and a better standard of living for the broad masses in the industrialised countries. The removal of customs barriers, the constantly diminishing life-cycle of new products and more severe competition between larger trading units, together with other features of our modern economy, have made innovative capacity an important factor in the economic survival of individual firms and whole economies. The success or failure of a nation's efforts at innovation ultimately show up in its balance on visible and invisible trade, particularly in the form of a surplus or deficit on licensing transactions. The fact that the licensing balances of European countries are in deficit and are tending to slip even further into the red must be taken as a danger sign.

Problems in the financing of innovation

The process of innovation is both protracted and expensive. It covers the whole period from the dawning of the idea, through the research and development phases (including market research), the prototype stage and the setting up of a new firm or restructuring of an existing one, up to the launching of the end product on the market.

The differing requirements of these successive phases in the evolution of an idea up to the production, in marketable form, of a new business project, must be met from appropriate sources of finance. To simplify matters somewhat, and to take the case of a new enterprise, this evolution can be divided into six distinct stages, namely research, development, actual establishment of the firm, break-neck growth, consolidated growth, maturity.

Research and development demand research capital, which can be supplied first and foremost by large industrial companies (out of their own resources) and by Government bodies (in the form of subsidies). Establishment and rapid growth call for risk capital, since in most cases financing with borrowed funds cannot yet be considered. Ultimately, development capital is needed for financing consolidated growth and the mature firm, and to an increasing extent this is being obtained in the form of capital borrowings from banks or, in the final stage, even equity capital raised on the stock exchange.

In the European economy, private research capital has to be provided through self-financing, hence the well-known problems of tightness in its supply. Financing problems in this area contrast with the relatively satisfactory supply position in the last two phases, even though, unfortunately, Continental stock exchanges only provide finance for firms capable of issuing their own securities.

There is a definite gap in the supply of risk capital for financing the establishment and the risk-laden early years of new enterprises based on innovative products and services. Governmental bodies concerned with the promotion of research usually consider that their brief does not extend this far. Traditional sources of finance such as the banks, large corporations and, of course, the stock exchange, cannot be approached at this early stage because the risks are still too great. In the past the backers most frequently resorted to at this stage were wealthy families and private bankers, specialising in this line of business. Over the last two decades this gap has increasingly been filled by the professional venture-capital companies. In the United States, for example, the general belief in the progress of science and technology has led to the formation of hundreds of venture-capital investment companies. A special form of these is the "small business investment company", which came into being under an American law for the promotion of small businesses. Although some merchant banks in the City of London have undertaken risk-capital financing for centuries, the concept of "professional" venture-capital is a comparatively new one on the Continent. The last ten years, however, have seen a number of attempts to set up venture-capital companies in Europe, largely as a result of American initiatives.

Prerequisites for the success of venture-capital in Europe

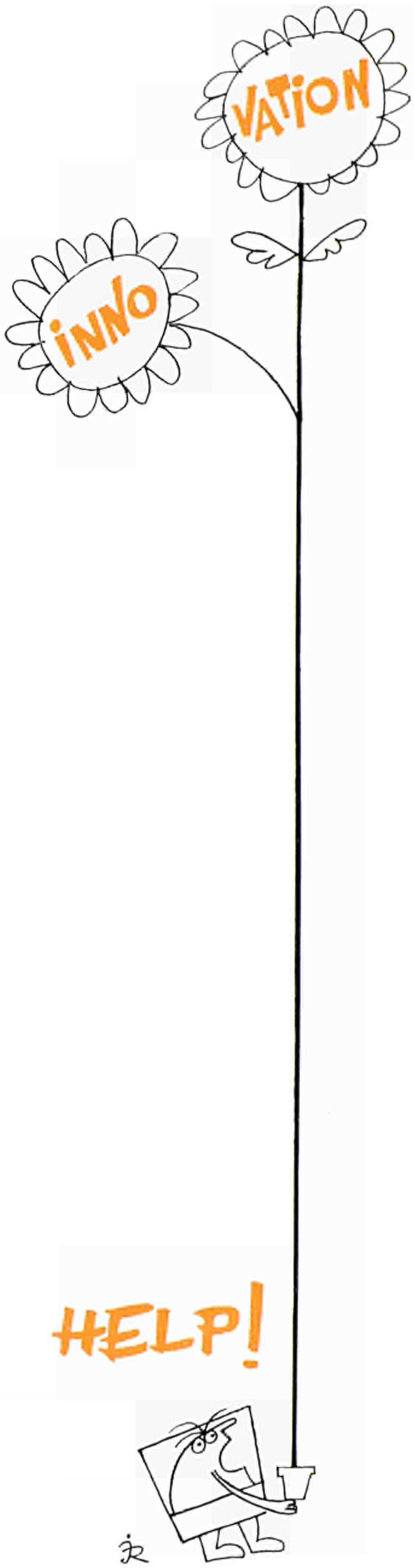
When the concept of venture-capital, American-style, reached Europe in the sixties, it was an innovation in itself, and it was not certain whether the conditions that had made venture-capital a success in the United States were also present in Europe.

(a) *Ideas.* One prerequisite is a constant stream of ideas from universities, laboratories, company research department, etc. The brain drain was regrettable but dramatic proof that Europe had the ideas.

Another prerequisite is a system for screening these ideas and channelling them towards the most-suitable application. Closely bound up with this is the question of how long it takes to develop an idea into a marketable product. In the course of history the time lag has grown shorter and shorter. It took 56 and 38 years respectively before the telephone and the laser became marketable propositions. In the case of television the same process took only 14 years, while for the transistor it was down to five. Any reduction in this "lead-time" is beneficial both to the economy at large and to the individual business enterprise, and any factor promoting it is to be welcomed.

In the last five years machinery has been set up in certain European countries for mating ideas with money and management, for example in the matter of patents. France, for instance, has set up *ANVAR* (*Agence Nationale de Valorisation de la Recherche*) for this purpose. Existing venture-capital companies can also be regarded as agents in this channelling process, so far as their professional discretion permits.

(b) *New-style businessmen.* The upsurge of technology-based industry in the United States during the fifties and sixties was due partly to the emergence of new types of businessmen, namely the "technological" or "academic" businessman. These terms are used to describe people who, in their capacity as scientists, engineers or technicians, develop new ideas up to the prototype stage and then take the bold step of going into business on their own account to launch their ideas on the market as new products or services. A prerequisite for success in such a case is a man's ability to combine scientific skills with qualities of leadership as a businessman. Although, broadly speaking, this combination is more common in the United States owing to the different education system there, this new type of businessman now seems to be emerging in certain European countries as well. Here again the key is a thorough-going entrepreneurial outlook, a willingness to take a risk and accept a challenge. This attitude is found in varying degrees in the various European countries. Whereas this type of dynamic businessman crops up in ever-increasing num-



bers among the young people of countries like Italy and Britain, the younger generation in certain other countries seem to have different priorities. They prefer, for example, the prestige of belonging to a large and highly regarded company, or the material security of salaried employment, to the status of independent businessman, which at the start often entails working seven days a week and "getting one's hands dirty".

In this connection it is often found that European scientists, in particular, are not interested in giving up their research work in order to set up in business, despite the lure of substantially higher personal incomes.

(c) *Mobility*. In order to determine the essential conditions for the success of venture-capital it is necessary to examine the actual roots of new entrepreneurial activity. In the main, there are two processes that lead to the establishment of new enterprises or the revitalisation of existing ones, namely, spin-off and the transfer of new technology.

Spin-off, in this context refers to the case of a successful man in the research department of a large concern who develops a new product in which, for various reasons, his employers are not interested. The inventor, however, wishes to exploit his own brainchild, so he leaves the firm and sets up his own company. Quite often the former employer acquires a stake in the new company with the intention of increasing it, if all goes well, by way of diversification. It is common knowledge that some American universities, and even firms, encourage their creative people to set up independent businesses based on an idea of their own. Still other firms have set up their own "think-tanks" to enable their creative staff to pursue the development of their ideas in greater freedom and with business responsibility of their own, without, however, losing these people for good in the process.

In the United States there are examples of fifth-generation spin-off, with the total turnover from the "descendants" exceeding that from the original idea.

Transfer, in this context, means the carry-over of a proven technology from a highly developed industry (e.g. space research) to a less highly developed one (e.g. construction). Exchange of technologies between equally advanced sectors can, however, also occur, resulting in cross-fertilisation. And cases frequently arise in which spin-off is combined with technology transfer.

(d) *Willingness to accept a partner*. Another prerequisite for the success of venture-capital is a readiness on the part of the fledgeling entrepreneur to accept a venture-capital investment company as a temporary partner in his firm. Here again, there are psychological obstacles to surmount. The founder often wishes to remain in sole charge and is horrified by the prospect of a partner who could possibly interfere. However, it is precisely the younger aspiring businessmen who are increasingly coming to recognise that half a large cake is better than a whole small one. Frequently, of course, this willingness to accept a partner is dictated by the need to expand at an above-average rate in order to remain in the race. But rapid growth, especially in international markets, requires more capital than these new entrepreneurs can usually raise by themselves.

Willingness to accept a partner also implies a readiness to make use of that partner's advice and industrial experience so that the firm may grow as rapidly as possible. For this reason, the *European Enterprises Development Company* (*EED*) S.A., to mention an example, insists on providing not only capital but also some measure of management assistance, since Europe's fledgeling businessmen with a scientific or technical background often lack the necessary management know-how.

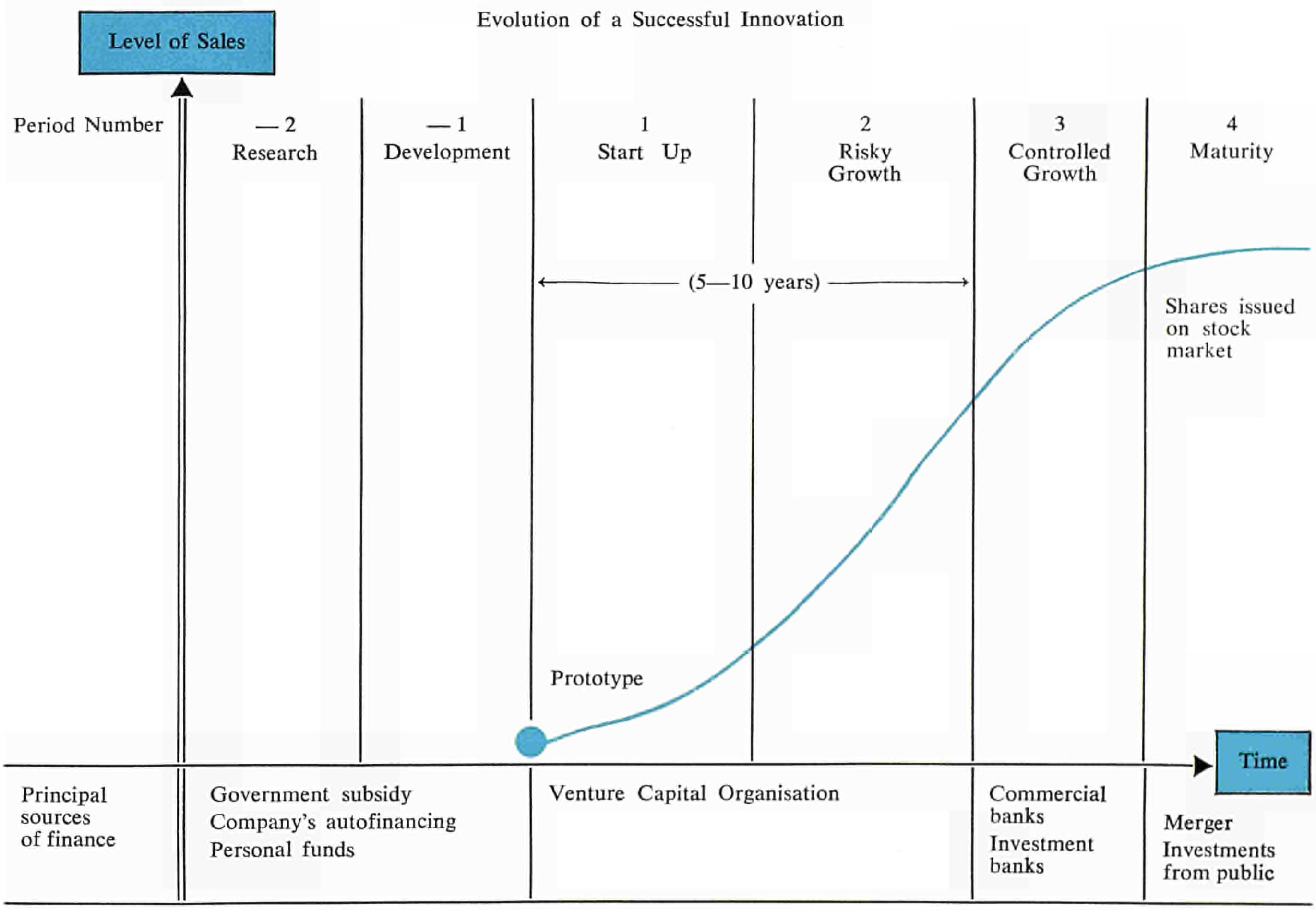
(e) *Disposability of holdings*. Since a venture-capital company regards itself as a temporary partner, it withdraws from the enterprise once traditional sources of finance can be tapped. As a rule this point is reached after five to eight years. Withdrawal will entail the disposal of the venture-capital company's holding, for which a buyer must be found. The ideal solution, and the usual practice in the United States during the sixties, especially, is for the venture-capital company to place its holding through an issue on the capital market. Initially, dealings are conducted "over the phone" (i.e., not on the floor of the stock exchange), and later a stock exchange quotation is obtained. In Europe, however, where the capital market operates differently, this method of withdrawal is ruled out. On the Continent, at least, there is no efficient system of telephone dealings for the securities of small and medium-sized companies. The requirements for admission to stock exchange trading are so stringent that only large concerns can meet them. All that can be contemplated at present is the disposal of such holdings to another industrial concern or their repurchase by the original founder of the firm in question.

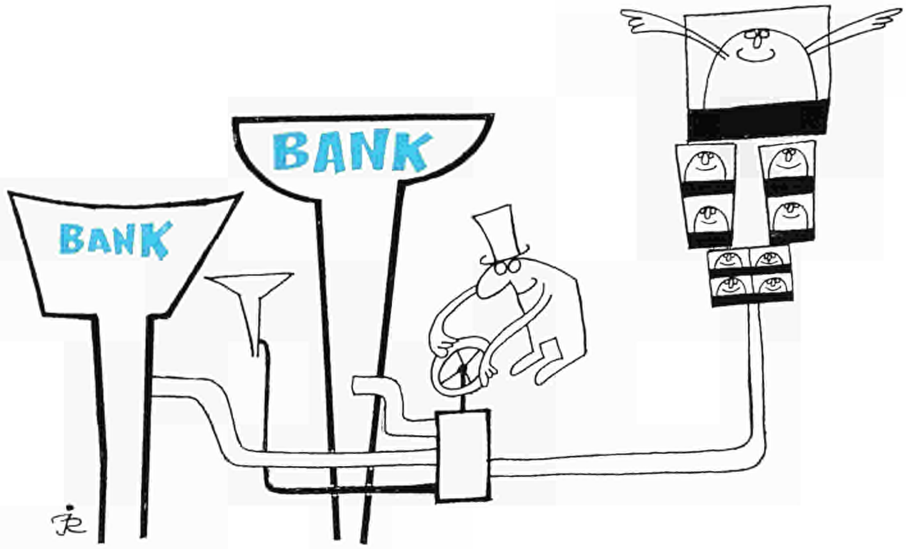
Venture-capital in action

The venture-capital system in Europe, as operated by the *European Enterprises Development Company (EED)* S.A., for example, involves the acquisition of a financial stake in new or existing firms, together with the provision of management assistance. A professional venture-capital company therefore looks for projects in which it might participate, analyses proposals and, lastly, administers the holdings it has acquired.

(a) *The search for projects*. Since Europe, unlike the United States, is still unfamiliar with the concept of venture-capital, a number of interesting projects do not progress beyond their originators' drawing boards because the requisite finance cannot be obtained. The venture-capital company's first job, therefore, is to publicise itself as a

Fig. 1: Venture-Capital.





source of finance. Above all, it must keep in touch with the appropriate universities and research laboratories and with major firms heavily committed to research. It must retain consultants and experts covering a wide range of scientific and technological disciplines. In addition, it must maintain contact with key figures in business and science to whom the initiators of new business projects may possibly turn for advice.

In propagating the concept of venture-capital the European Enterprises Development Company has gone to the length of producing a cartoon film and devising a computerised business game called "Venture". A business game used as a marketing aid for financial services is in itself an innovation, and this one simulates the establishment of new, technology-based enterprises the initiators of which have to obtain the necessary funds through negotiations with commercial banks, venture-capital companies, investment banks, etc.

(b) *Project analysis.* The first step is to sift the hundreds of proposals received and select those that really warrant a serious study. If the venture-capital company is prepared to spend time and money on an intensive study, the project is examined in the light of the following criteria:

—The proposal should relate to an innovation in the widest sense of the word, i.e. a product, process or service the novel character or superiority of which puts it ahead in its particular field. This may equally well be a product, an industrial process or a practice, for example a new sales technique or teaching method.

—The project should have reached an advanced stage. Wherever possible, a prototype should exist.

—There must be a substantial market for the new firm's product range. If possible, the original product should be capable of spawning a whole family of products. It must offer an adequate production life-span. It should be capable of being manufactured and marketed without undue dependence on suppliers and customers. The prospects for sales growth must be exceptional in order to justify the risks entailed.

—The founder and his team must have the capacity to run a business. They must be prepared to commit themselves to it totally. Lastly, it must be possible to collaborate with the management team on a partnership basis.

It has frequently been found in practice that the technology and the market can be gauged with fair accuracy, but the biggest risk for the venture-capital company lies in choosing the man who is behind the idea and around whom the new firm will be built. To appraise him accurately from the outset has proved extremely difficult. Moreover, the problem is aggravated by the fact that the man must frequently grow with his firm and assume new roles in the course of its rapid expansion.

(c) *Financial stake.* It is a basic principle that a stake is acquired in the nascent or existing firm. This is usually in the form of a minority holding in order that control may remain in the hands of the initiator. Venture-capital is put up as long-term, interest-free equity capital. The price paid for such a holding is largely a matter for negotiation, since at this early stage there is usually no proper basis for a proper valuation of the firm. Unlike, for example, the German investment company Kapitalbeteiligungsgesellschaft system, venture-capital arrangements do not include a repurchase clause which is agreed on from the outset, is binding on the head of the firm and lays down the principles governing valuation. Those in the venture-capital business take the view that the business vitality of fledgeling firms is so great that no such shackles should be imposed. Sometimes the initiator and head of the firm is given options to increase his holding at specified preferential prices if operation is successful as measured by certain criteria, which may be based on profits as well as turnover.

The minority holding is often supplemented by the granting of loans partly on terms better than those obtainable in the market, and sometimes in convertible form. Since the "book" value of the firm is frequently low when the venture-capital company acquires its stake, the financial commitment in the form of loans is sometimes greater than the actual holding. This can be a particular incentive to bring in a venture-capital company as partner, because the firm is not yet considered credit-worthy by the traditional banks.

Moreover, the fact that a venture-capital company is participating financially in a new or fledgeling company often clears the way to obtaining additional loans from the banks: credit-worthiness is enhanced firstly by the improved capital structure and secondly by the confidence which the involvement of a venture-capital partner generates as regards the management of the business. The greater "leverage", or "gearing", thus obtained is also important to the venture-capital company, which is intent on increasing the efficiency of every invested dollar by means of additional, borrowed, dollars.

(d) *Management assistance.* In order to ensure the maximum growth for its protégé, the venture-capital company backs it with advice on how to run the business. In most cases the venture-capital company is represented on the firm's Board of Directors or Management Committee. In intensive working meetings the experts from the venture-capital company try to pass on their wide and varied industrial experience to the management of the partly-owned firm.

It it in this connection that a venture-financing company, especially one organised on European lines, can give valuable help with the internationalisation of the recently founded enterprise. The output of specialised products from technology-based fledgeling firms often cannot be absorbed by a single national market, so that these firms are compelled from the outset to export if they are to grow to an economic size. *EED*, for example, specialises in this form of advice and sees itself as a partner for industry and an expert on rapid growth. In proof of this it points to the fact that exports account for 65% of the total output of the thirty or so companies in which it has a stake.

In exceptional cases the venture-capital company may second a member of its staff to an associated firm for an extended period in order to help it over a crisis. The subjects on which advice is given are usually long-range planning, marketing, information systems and financing.

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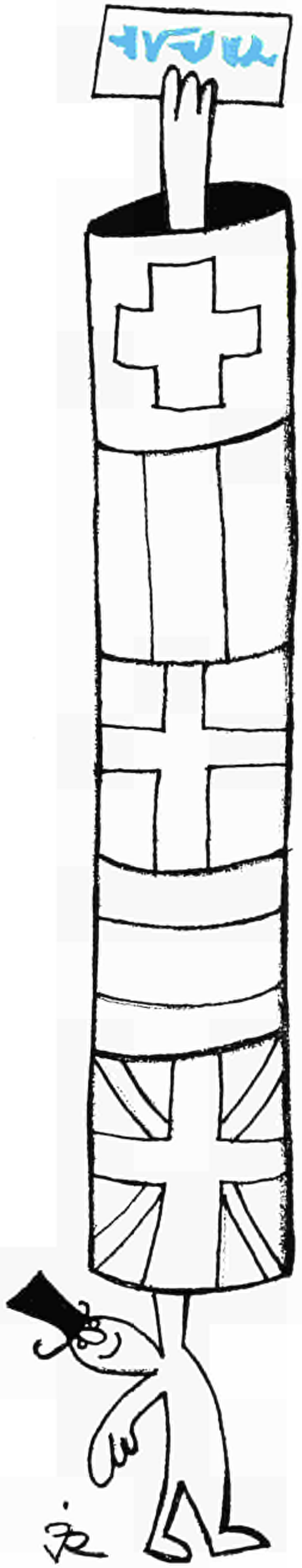


The war on pollution

Desulphurization of fuels and fuel gases

PIERRE LEMOINE

POLLUTION due to the presence of sulphur in domestic or industrial effluents raises serious problems—more serious, it is asserted, than those due to traffic in towns.

Each year more than 90 million tons of sulphur are discharged into the atmosphere in urban and industrial areas, of which it is estimated that 60 % are due to coal and 40 % to oil products. With the growth in energy consumption and the relative decline of coal, the percentage of sulphur from oil products is rapidly increasing.

The two processes generally used at present to reduce the ground-level sulphur content of discharges are (a) the dispersion of smoke by high stacks, and (b) the use of fuels with a low sulphur content.

These are, of course, palliatives and not solutions. They are note desulphurization methods in the strict sense.

Dispersion is not practicable for emissions from domestic heating installations or from business premises in towns. The only solution here is to use fuels with as low a sulphur content as possible.

For example, in the centre of New York domestic heating plants may only burn fuel with a sulphur content of 0.3 %. For other cities the maximum rate is 1 %, while in thinly populated areas it varies from 2 to 3 %. In Europe, where the problem is not so serious, the sulphur content of heating oils averages about 2.5 %.

PIERRE LEMOINE is a member of the Directorate-General for Social Affairs of the Commission of the European Communities.

The dispersion of major sources of sulphurous gas by means of high stacks is becoming increasingly expensive and also leads to protests from neighbouring countries. Moreover, there is much we still do not know about the behaviour of sulphurous gases discharged into the atmosphere and about their chemical or physicochemical evolution.

On the other hand, the search for coal and oil fuels with a low sulphur content, is liable to cause serious imbalances in the production and use of natural resources.

The following methods may be used to reduce sulphur emissions during combustion:

—reduction of the sulphur contents of the fuels, i.e. fuel oils (particularly heavy residues) and coal;

—alteration of the energy production cycle by initial gasification of the fuel; a rich gas can then be desulphurized before use in a turbine-boiler system;

—desulphurization of the combustion gases and sulphurous gas emissions by the dry or a wet route.

All these techniques are still under development, and hardly any has yet been extensively used. The available data are therefore inexact from both the technical and the cost standpoint.

Desulphurization of heavy residual fuel oils

The traditional method of refining oil is to concentrate the sulphur in the crude oil in the heavy fractions and to remove it almost entirely from the light fractions. It is the heavy fuel oil, with its high sulphur content, which is burned in power plants and large industrial and commercial concerns.

The cheapest method of producing heavy fuel oil with a low sulphur content is to use a crude oil which itself has a low content. However, since heavy residual fuel oil is the cheapest product, many countries produce as little of it as possible. Consequently only small quantities of heavy fuel oil are produced from crude oil with a low sulphur content.

Another method is to mix high-sulphur oils with fractions with a lower content. The very large quantities of fuel oil containing 1 % sulphur (and less) which will be required nonetheless make it necessary to desulphurize the fuel oil. Desulphurization of the *light fractions* by treatment with hydrogen is in commercial use. Processes have recently been developed for the desulphurization of the *heavy fractions*. Several plants are now in operation, and some large-scale plants are being built.

The methods used to remove the sulphur are generally based on the principle of *hydrodesulphurization*, there being several variants.

Many factors affect the cost of processing, the most important being the following:

1) type and quality of the oil;
2) type and quality of the product desired;
3) availability and cost of hydrogen;
4) cost of the fuel and electrical energy;
5) catalyst cost and lifetime;
6) quantity and value of the sulphur as a by-product;
7) size of the plant.

In view of the large number of variables it is not surprising that the cost estimates quoted are many and various. A report by the National Research Council [1] estimates these costs at 50-80 cents per barrel when

[1] Abatement of Sulphur Oxides from Stationary Combustion Sources, National Research Council, Washington DC, 1970.

the sulphur extraction ranges between 1 and 2.6 %, corresponding to 210-300 dollars per ton of sulphur extracted. The limited industrial experience available does not at present permit a more exact estimate.

If the content is reduced below 1 %, the costs rise rapidly, particularly if a content of 0.3 % is desired. The intensive treatment necessary to obtain these low contents leads to the production of a greater quantity of light products.

Research fields: The aim is to obtain better catalysts, with higher efficiency and a longer service life. Production capacity could then be stepped up and operating temperatures or pressures lowered. Their greater specificity for the sulphur would enable the volume of hydrogen used to be reduced or the lifetime of the catalyst increased. It would also be desirable to reduce the cost of the hydrogen, which is a major factor in the total cost.

Reduction of the sulphur content in coal

Up to the present research on the purification of coal has been directed mainly to the removal of the deads, which generate ash; the problem of the elimination of the pyrites in order to prevent atmospheric pollution is a relatively recent one.

The traditional methods of washing coal (removal of the schists and pyrites) are based on differences in density. However, in order to separate the pyrites the coal must be crushed very fine in order to release the impurities in small particles. Some of the (organic) sulphur nonetheless remains bound to the coal. The methods most widely tested up to the present thus combine the processes of crushing and elutriation.

The methods of *flotation* and *centrifugal separation* are being tested on very fine grain coals. The finely crushed pyritic coal is treated in a centrifugal dust-extractor with an updraft of air. The heavier pyrites particles being very heavy are deposited, while the lighter coal particles are removed. The experiments conducted hitherto have resulted in the extraction of up to 38 % of the pyrites contained in the coal, and up to 55 % of the ash content.

Other techniques are under study or planned, these being based on the difference in the magnetic properties, in the hardness, or the electrostatic charges which can be induced in coal and in pyrites.

Gasification of coal and mineral oil followed by desulphurization of the obtained gas

One efficient way of removing the sulphur from fuels (coal or fuel oils) is to desulphurize the gases resulting from their gasification. Several new systems of coal gasification are under study, especially in the United States [2].

[2] Consult "Recherche sur la valorisation et l'utilisation du charbon aux Etats-Unis d'Amérique". (Report on a visit by a delegation of the European Coal and Steel Community, by C.J.A. Berding and K.G. Beck, Brussels 1970.)

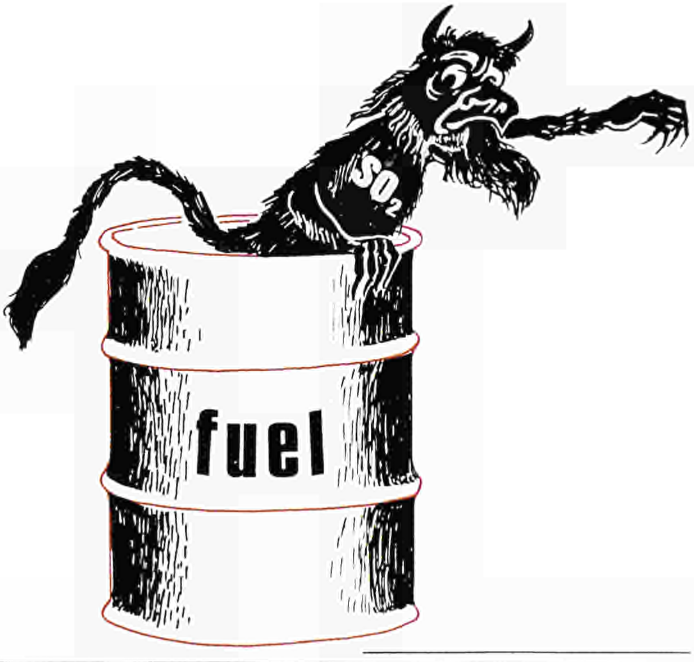
Gasification using gas turbines suggests a possible technique for the production of electricity. It could prove more efficient than the traditional energy conversion process, the cost of which would be pushed up by the additional desulphurization of the fumes.

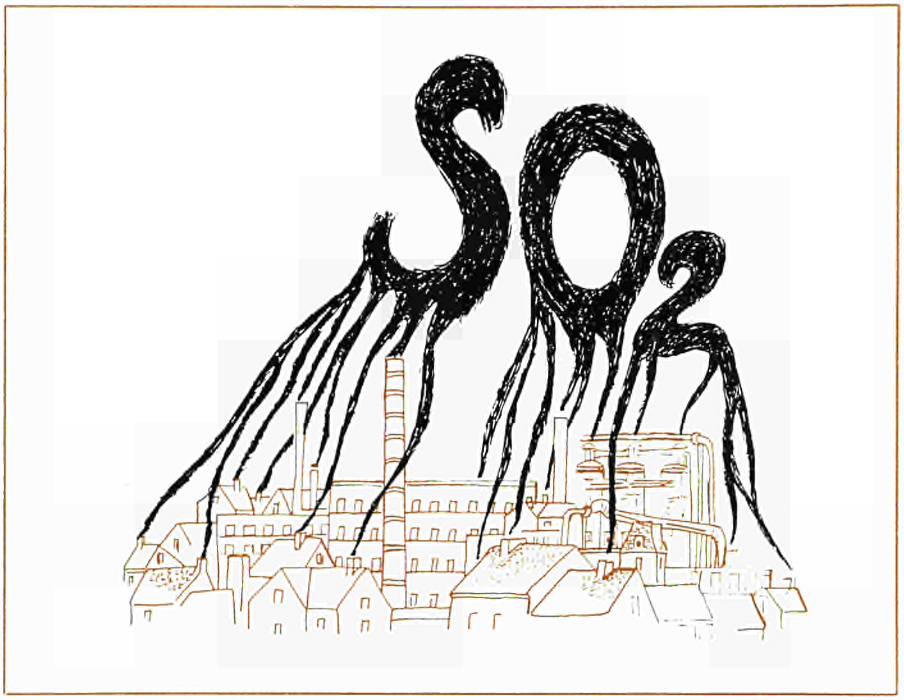
The improvement of the efficiency of the turbine/boiler cycle depends on increasing gas temperatures at the turbine, and consequently on improving the ability of metals to withstand high temperatures.

Desulphurization must also be carried out without cooling the gases. It can be done during combustion in a fluidized bed, by the addition of basic substances such as lime, dolomite, etc.

Examples:

1) a plant using fuel oil containing 4 % sulphur is operating in Holland. Costs of 140 dollars for 200 MW and per ton of sulphur are obtained. It is estimated that for 600 MW the costs would fall to 101 dollars. The efficiency is lower than that of a conventional plant;





2) the *STEAG* (*Steinkohlen Elektrizität AG*) estimates that this type of power plant requires 15 % less capital investment than a conventional plant;

3) tests carried out under the auspices of the *NAPCA* (*National Air Pollution Control Administration*) by the *United Aircraft Research Laboratories* suggest that this technique could become competitive about 1980;

4) project of the *Institute of High Temperatures of the Academy of Sciences of the USSR*, in conjunction with the Institute for Scientific Research on the Treatment of Mineral Oil and the Institute for Research on the Purification of Gases. It is planned to desulphurize high-sulphur fuel oils by preliminary oxidizing gasification under pressure, followed by wet purification of the gas;

5) *Shell* project for a 200 MW power plant. Estimated efficiency 37.5 % (as compared with 39.5 % for a conventional power plant). It is estimated that the capital investment will be 20 % greater than for a conventional power plant of the same output. Extraction of 90 % of the sulphur present in the fuel;

6) in Czechoslovakia the gasification of coal and lignite permits sulphur removal rates of up to 59 %.

Desulphurization of fumes

The difficulty of removing the SO_2 from combustion gases in electrical power plants lies mainly in the fact that it is necessary to treat large volumes (millions of m^3 per hour) containing a low proportion of sulphur oxides (0.1-0.5 %). These gases are under low pressure and become highly corrosive, particularly in the presence of moisture.

This results in a need for cumbersome and costly equipment in order to remove or reduce the quantity of sulphur oxides emitted. These installations are not economic in themselves; they tend to increase costs and this acts as a brake on the construction of such units.

In addition, these costs have so far been difficult to estimate. Many processes have scarcely passed the experimental stage while some are undergoing small-scale testing.

The estimated revenue from the sale of recovery products are sometimes included in attempts to assess costs. But some of these products are difficult to sell (low-density sulphuric acid, low-value fertilizers, etc.). Their production is also liable to alter the balance of the market for a product, e.g. that for sulphur.

It would be impossible here to mention all the methods which have been devised for reducing the sulphur content of flue gases, but the following can be given as examples:

A. DRY PROCESSES

a) *Injection of calcium carbonate or dolomite.* Lime can be used in three ways to extract the sulphur dioxide from combustion gases: it can be added in the dry and crushed state to the fuels before combustion, it can be added in dry state in the boiler or it can be diluded with water. Dry injection and purification with water can be combined.

Drawback: low efficiency (35 %), even with excess of $CaCO_3$.

The process is being tested for the *NAPCA* by the *Tennessee Valley Authority* (Shawnee Power Plant—180 MW).

b) *Dry injection, wet purification.* This process is similar to a), but includes a wash-purification stage. It forms part of the purchase contract for a 480 MW power plant of the *Kansas Power and Light Combustion Engineering Co.*

Planned rate of SO_2 removal: 85 %.

This process raises the problem of the removal of wet sludge. In addition, like all the wet processes, it makes effective dispersion of flue gases more difficult.

c) *Dry process with manganese oxide (Mitsubishi).* This has been tested in a pilot plant on a gas flow of 150 000 m^3/h. The sulphur removal rate was 90 %.

This method is difficult to apply, since it necessitates the use of a toxic solvent which can be discharged into the atmosphere. In addition, ammonium sulphate is obtained as a by-product, for which there is a very little market.

d) *Bergbau-Forschung process with active carbon and thermal regeneration.* Active carbon has the property of fixing SO_2. The sulphur-carrying carbon is continuously evacuated and passed into a vessel, where it is regenerated by contact with every hot sand in an inert atmosphere.

e) *Bergbau-Forschung process with active carbon and wet regeneration.* This process is also known by the name of *Lurgi Sulfacid.* The sulphur-carrying carbon is passed through a washing column in countercurrent in order to remove the sulphuric acid.

The process is technically promising, but the removal of the low-concentration sulphuric acid raises a problem which is not yet solved.

f) *Adsorption by sodium aluminate* (alkalized alumina—Na AlO_2). SO_2 in the combustion gas is fixed by highly reactive sodium aluminate. This process has the advantage of obviating the need to cooling the combustion gases before or during the treatment. However. the regeneration of the solvent entails heavy operating expenses.

B. WET PROCESSES

a) *Purification by potassium sulphite.* This process is known under the name of *Wellman-Lord.* Potassium sulphite is used as the washing solution. It can reduce the SO_2 content in fumes to less than 0.5 %.

The study is being carried out by the *Potomac Electric Power Co.* Baltimore, Maryland.

b) *Addition of ammonia followed by purification.* This process has been developed by *Electricité de France;* it consists in the injection of ammonia into the gases, followed by purification. The ammonia is recovered following a treatment with calcium carbonate.

Tests are being carried out at the Saint-Ouen pilot plant.

c) *Production of sulphuric acid by catalytic oxidation.* This process is known by the name of *Monsanto Cat. Ox.* It is being tested at the Portland, Pa., power plant of the *Metropolitan Edison Company.*

The gases are passed over a vanadium catalyst maintained at 480° C, and the SO_2 is oxidized into SO_3 by oxygen present in the gas. SO_3 is converted into H_2SO_4 by the action of the water vapour and condensed at a lower temperature. At least 99.5 % of the dust must be removed in an electrostatic precipitator operating at 500° C.

According to Monsanto, the capital costs for a 1 000 MW power plant are 20-30 dollars per installed kW. The operating costs depend among other things on the revenue obtained from the sulphuric acid.

d) *Absorption by hydrated compounds of magnesium oxide and manganese dioxide.* MgO and MnO_2 are easily hydrated and react rapidly in contact with acid gases. The absorbent is regenerated by mixing with a reducing agent followed by calcination.

This process has the advantage of producing concentrated sulphuric acid of commercial grade.

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Light-water nuclear plants in the Community: the present position and development prospects

Some of the electricity that we now consume comes from nuclear power stations. In addition to those already in service, more are under construction or in the planning stage: what is the present status of light-water nuclear plants in the Community and what are their development prospects?

LUIGI BARAZZONI, ARMAND COLLING, JOACHIM EHRENTREICH, HUBERT NACFAIRE and MANFRED SIEBKER

All the co-authors are employed by the Commission of the European Communities. LUIGI BARAZZONI is on the staff of the Directorate-General for Energy, ARMAND COLLING is with the Joint Research Centre and JOACHIM EHRENTREICH, HUBERT NACFAIRE and MANFRED SIEBKER are on the staff of the Directorate-Generale for Industrial, Technological and Scientific Affairs.

LIGHT-WATER REACTORS, both of boiling-water *(BWR)* and pressurised-water design *(PWR)* have now attained a considerable degree of commercial application.

In the United States alone, after a boom year in 1967, when a total of 25 800 MWe was ordered, 133 light-water nuclear plants were on order, in service or under construction on 1 January 1972 - a capacity of approximately 113 000 MWe.

In the Community, a similar expansion in the number of light-water plants is under way, though on a smaller scale: as of 31 December 1971, gas/graphite and light-water plants each made up 50% of the installed nuclear power, but by the end of 1975 over 80% will be accounted for by the light-water plants under construction. A total of 28 light-water plants, with a capacity of approximately 16 000 MWe, were on order, in service or under construction in the Community on 1 January 1972.

Furthermore, it is reasonable to believe at the present time that advanced high-temperature reactors and fast breeders will have little impact on the growth of nuclear power before 1980. It is herefore foreseeable that until then virtually all plants ordered will be of the light-water type.

On the basis of the foreseeable growth in the number of nuclear power plants in the Community, and assuming a lead time of five years between ordering and commissioning, an average of five to eight orders for units in the 800-1200 MWe range can be expected annually over the period 1971-75, and between six and nine orders for the 1200-2000 MWe range over the 1976-80 period (these forecasts are mean values, disregarding possible exports and the enlargement of the Community).

In view of the major commercial impetus imparted to this reactor family by the American and European nuclear industries, it can be estimated, as of now, that by 1980 the total capacity of light-water plants will exceed 150 000 in the United States and be of about 45 000 MWe in the Community.

DEVELOPMENT OF DESIGN UP TO THE PRESENT, AND FUTURE PROSPECTS

In view of widespread commercial use of light-water nuclear power stations throughout the world, it is interesting to analyse the chief technical advances marking this development and to attempt to predict the chief advances in the coming years.

Size and standardisation. Since entering commercial service, both boiling-water and pressurised-water plants have followed roughly parallel trends in size growth; the main stages of this are shown in Fig. 1, plotted against the year of ordering. The process of size growth can be divided into two periods. The first, up to 1966, saw the commercial development of light-water reactor plants, as a result of which they managed to achieve economic competitiveness.

Since 1966 there has been a certain slow-down in the rate of increase in plant size, particularly owing to problems relating to the development of power-grids. The commissioning of new assembly shops by the manufacturers, and the introduction of new methods of on-site assembly for major plant items (pressure vessels, steam generators, turbine-generators) might make it possible to envisage the ordering, from 1975 onwards, of 1 600 MWe, even 2 000-3 000 MWe units, for service in the eighties. The latter, however, cannot be built until new techniques for the manufacture of turbine generators have been perfected. This trend might also be hampered by the increase in construction lead time due to the rise in plant sizes, particularly in view of the high cost of interest during construction.

Another point worth noting is that the growing number of orders for plants has resulted in an increasing degree of component standardisation.

Performance. Since the first light-water nuclear plants were built their performance has been enhanced through a number of substantial technical advances.

The key parameters affecting plant and fuel cycle costs are:

a) the power per unit weight of uranium;

b) the power per unit of core volume;

c) the power extracted per unit of coolant volume;

d) the fuel burn-up;

e) the specific coolant flow rate;

f) in the case of *BWRs*, the steam quality at the core outlet.

The changes in these key parameters, in respect of United States and Community plants, is shown in Tables I and II.

The rise in specific power, in particular, has resulted from:

—improved understanding of heat transfer relationship;

—a reduction in margins of uncertainty;

—the optimisation of fuelling schedules;

—the use of different fuel element enrichment level to reduce the power peak factors;

—in the case of *PWRs*, the use of chemical shim control and the adoption of cluster-type control rods.

In the coming years, a further rise of 15-20% in specific power ratings can be expected, without the need to resort to new techniques.

The coolant inventory per unit of power extracted from the core has been considerably reduced through the adoption:

a) in *BWRs*, of:

—water/steam separating equipment mounted inside the reactor vessel;

—a single steam cycle;

—pumps integrated in the vessel (jet pumps by *General Electric Co.*, and axial-flow pumps by *AEG*);

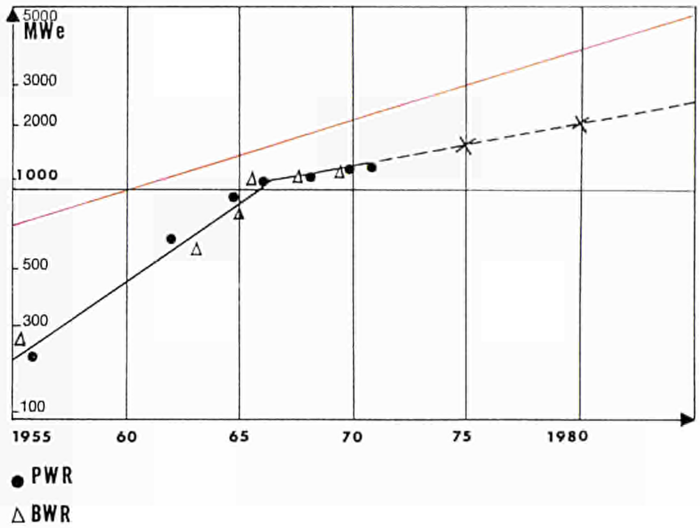


Fig. 1 : *The chief stages in the growth of the maximum size (power in MWe) of light-water plants, plotted against the year of ordering. Forecasts are shown by a dotted line. The coloured curve shows how power doubles every ten years.*

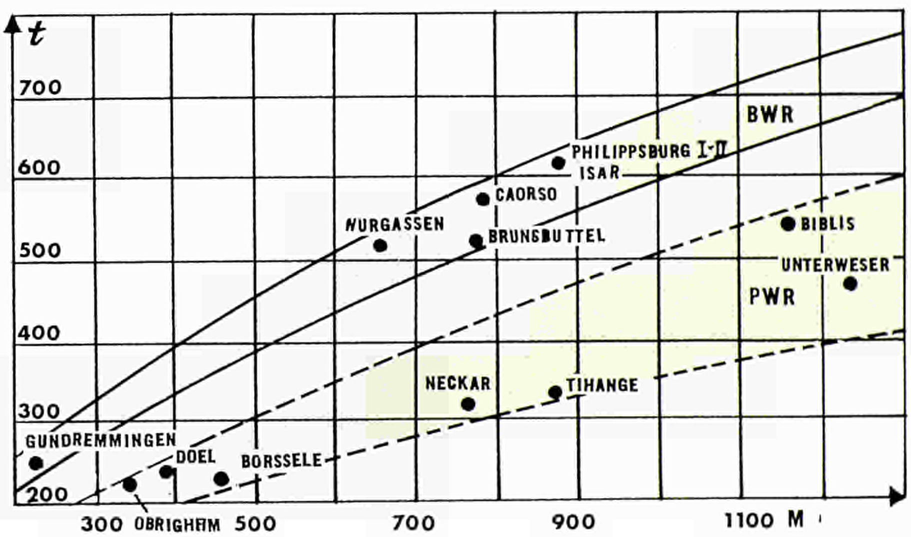


Fig. 2 : *The increase in the weight (metric tons) vs power of* BWR *and* PWR *pressure vessels.*

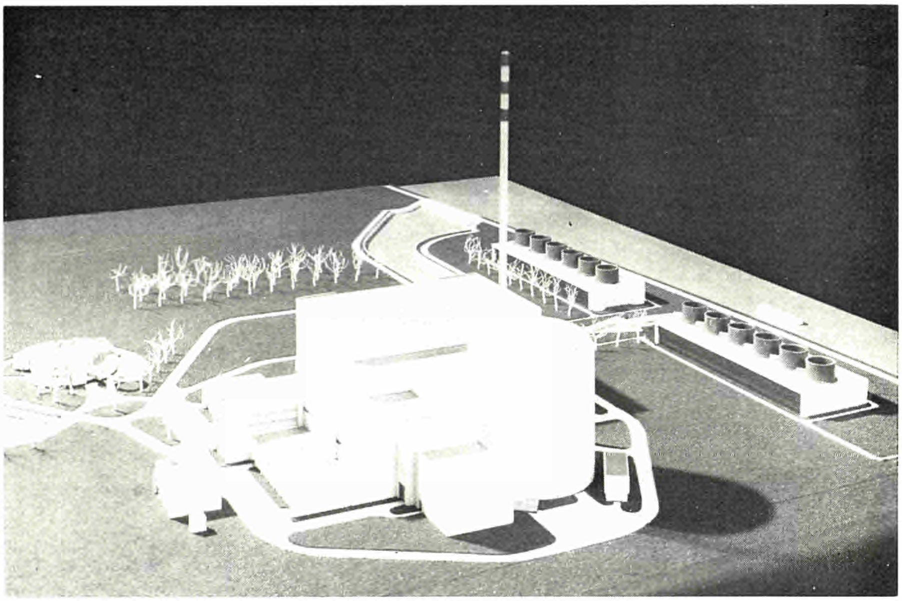
b) in *PWRs*, of:

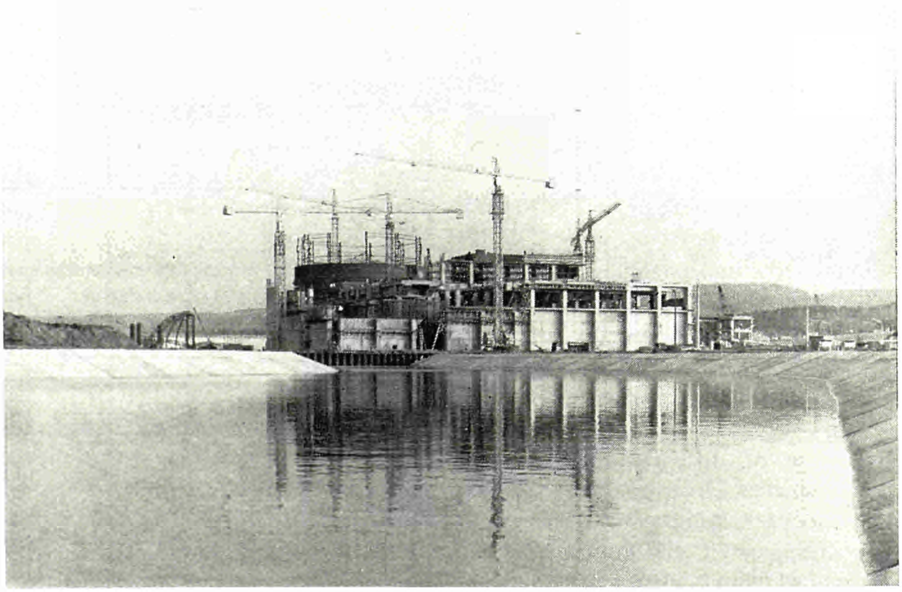
—cluster-type control rods, dispensing with followers;

—a high-temperature difference across the reactor, cutting the heat-exchange surfaces in the steam generators and resulting in an appreciable reduction in containment volumes and pump sizes.

The rise in the average *fuel burn-up* from 11 000 to more than 30 000

Tihange nuclear power plant. The plant is sited by the Meuse; the cooling towers along the bank and the plant buildings can be seen in the model. The second picture shows the progress of construction work at the end of 1971.





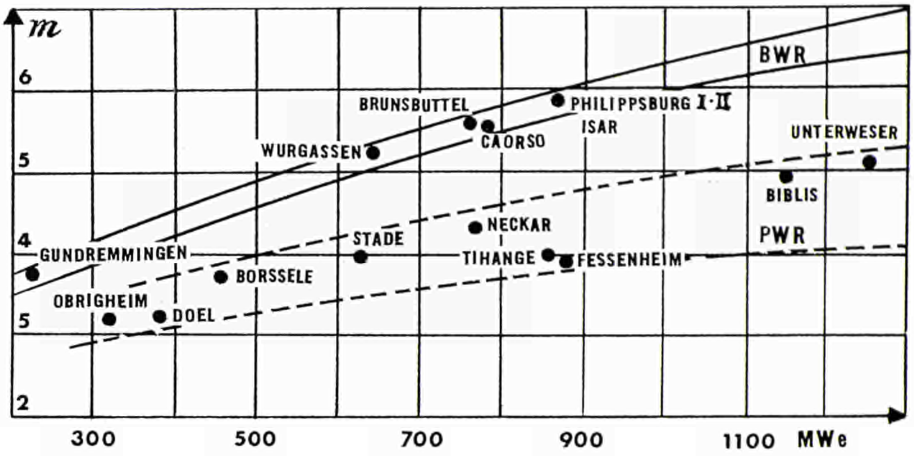


Fig. 3 : *The increase in the inside diameter (in metres) vs power of* BWR *and* PWR *pressure vessels.*

MWd/t has cut fuel cycle costs sharply, at its current level of 27 500-33 000 MW, however, burn-up has reached an economic optimum, making further spectacular gains unlikely in the years to come.

Tables I and II also give estimates of the chief characteristics of future generations of water reactors.

Design. Concurrently with the raising of light-water reactor performance, station design has improved, substantially in some respects. The chief advances have been:

1 — *Reactivity control:* The design of reactivity control system in boiling-water reactors has remained virtually unchanged, although the number of control rods per MWe has fallen from 0.50 to 0.17 in present-day plants. In certain plants now under construction, however, it is planned to use burnable poisons as an additional means of reactivity control.

Greater advances have been made in reactivity control in pressurised-water reactors: a new concept, the cluster-type control rod, has been evolved. With this new concept, power density peaks due to water gaps are eliminated and control-rod followers can be dispensed with, resulting in a considerable reduction in the overall height of the pressure vessel. In addition, the development of chemical shim control has led to a big decrease in the number of control rods needed, and pressurized-water reactors. The average fuel burn-up owing to the better power distribution in the core.

2 — *Primary circuits:* advances have stemmed chiefly from:

—the adoption of more efficient controlled-leakage pumps which need less maintenance than submerged-rotor pumps;

—the elimination of isolation valves in circulating loops;

—in the case of *PWRs*, the increase in power extracted per loop;

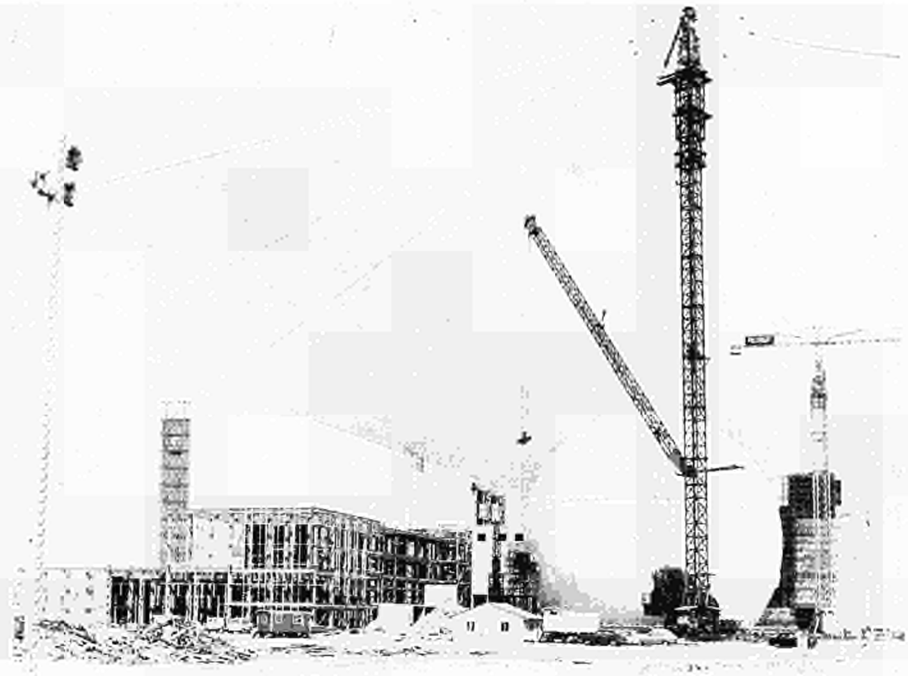
—in BWRs, the use of jet or axial-flow pumps mounted inside the pressure vessel. This layout has enabled the circulating loops to be reduced in number or entirely eliminated. Hence, a modern *BWR* rated at about 1 000 MWe needs no more than two external loops. *AEG* has developed an axial-flow controlled leakage pump to be housed in the bottom portion of the pressure vessel, enabling external circulating loops to be dispensed with.

BWRs have larger pressure vessels than *PWRs*, owing to their lower power densities, which are due to the circulating pumps and water separators being housed in the pressure vessel. The curves in Figs. 2 and 3 compare the chief dimensions of boiling-water and pressurised-water reactors. The same curves present the increase in weight and inside diameter of pressure vessels as a function of reactor ratings.

3 — *Containment:* the relative compactness of boiling-water reactors has led their promoters to develop the "pressure suppression primary containment". They were initially made of steel, but concrete is now also being used in some cases. *PWR* containers are much bigger than those of boiling-water reactors, since they have to house comparatively bulky items of equipment, e.g. the steam generators, circulating pumps and pressuriser. Unlike the system used with boiling-water reactors, the containment for pressurised-water reactors is purely static and capable of withstanding the maximum pressure associated with an accident. It consists of inner and outer containment structures, the air gap between them being ventilated and maintained at a sub-ambient pressure. For the Fessenheim plant, however, a single-walled containment structure has been adopted. The pressure resulting from an accident can be substantially reduced, however, by the adoption of an ice-condenser system developed by *Westinghouse*.

Fig. 4 gives a diagrammatical comparison between the principal dimensions and internal arrangements of containments for *BWRs* and *PWRs*.

Fuel and the fuel cycle. Light-water reactors of both types now use fuel assemblies consisting of Zircaloy cans containing sintered uranium oxide pellets.



Doel nuclear power plant: progress of construction work in April 1971. The large sphere on the right is one of the reactor containments.

1 — *Cladding:* Zircaloy is the only clad material currently in use, owing to is attractive property of low neutron capture. First-generation plants used stainless steel for a time, but its behaviour in boiling-water reactors was not considered satisfactory. The adoption of Zircaloy brought with it an appreciable reduction in the initial fuel enrichment.

Experience has led to slightly lower can thicknesses and the use of rods of a single length. The rise in burn-ups to levels over 25 000 MWd/t, however, has made it necessary to increase the space provided for fission gases.

A technique that has come into use recently involves pressurising the fuel rods with helium before the end plug is welded on, in order to enhance their mechanical strength at the start of their life and to achieve higher burn-ups.

Zirconium-base ternary alloys are now on test. They have better high-temperature properties and may provide an alternative to Zircaloy as a canning material for the future generation of light-water reactors.

2 — *The fuel proper:* Sintered uranium oxide in pellet form is the only material which has a fully developed technology behind it and whose stability under irradiation is well understood. The density of the oxide used is optimised for each particular case; the upper limit is about 93% of the theoretical density, in order to avoid excessive swelling due to irradiation. Sintered uranium oxide has good stability under irradiation up to approximately 50 000 MWd/t, which is sufficiently high for the fuel cycle costs to be minimised.

The difference in uranium oxide pellet diameters (12.4 mm in *BWRs* and 9.30 mm in *PWRs*) is due, among other things, to the different power densities, which stem from the thermal properties of their one-phase *(PWR)* and two-phase *(BWR)* coolant. The fuel cycle costs of both types of reactor are similar, despite the fact that large pellets are cheaper to produce.

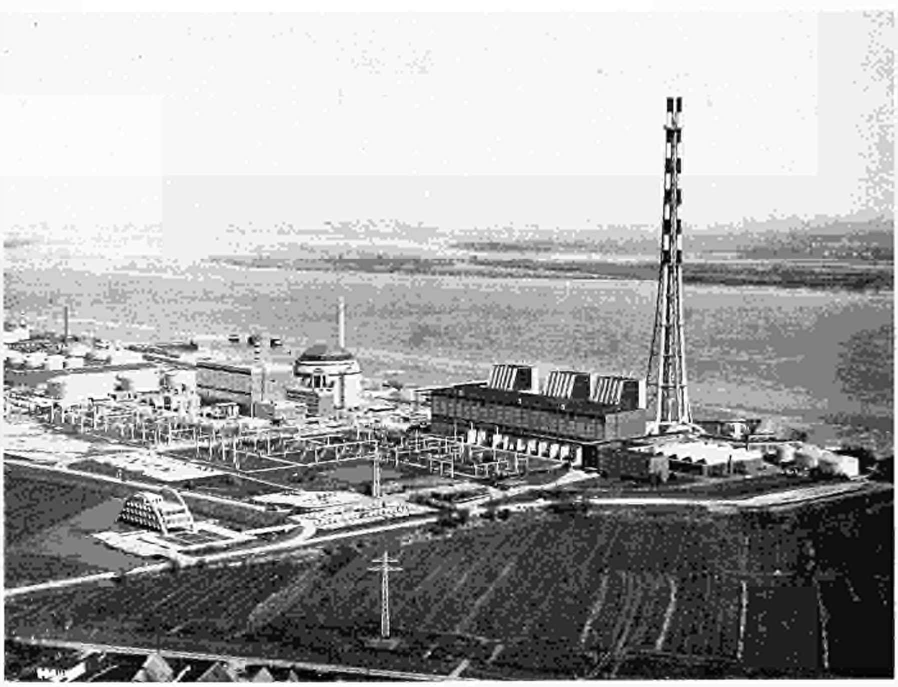
3 — *Fuel assemblies:* Fuel assemblies for pressurised-water reactors now have no external channel; the fuel rods are located by Inconel grid assemblies spaced at regular intervals and welded to the control rod guide tubes. In boiling-water reactors, the Zircaloy fuel channels cannot be dispensed with, given the existing design concept, because of the requirement for coolant distribution control in the presence of voids and guidance for the cruciform control rods.

4 — *The fuel cycle:* Both types of reactor have undergone a similar evolutionary process, culminating in the same loading procedure, a combination of fuel-element movements from the core periphery to the central region and checkerboard-pattern.

On start-up, boiling-water reactors are loaded with one type of fuel assembly, with the same average enrichment throughout. During the first refuelling the borated steel poison curtains located between fuel assemblies are removed from the core, together with 30% of the most depleted assemblies. The latter are stored and returned to the core as part of the second refuelling, when 50% of the core load is replaced. Subsequent loadings and unloadings are then effected by replacing a quarter of the fuel assemblies located in the central region. This pattern, as used up to the present, is likely to be extensively changed when fuel elements containing burnable poison come into use.

For their first core charge, pressurised water reactors generally have three approximately equal groups of fuel elements with different enrichments. The first two groups, having an enrichment below the core average, are placed, uniformly mixed, in the central region. During each annual refuelling one-third of the most highly depleted elements in the central region are removed and replaced by others from the core periphery.

Stade nuclear power plant, on the Elbe, near Hamburg, adjacent to conventional power station.



Experience obtained

1 — *Plant operating experience:* Availability and capacity factors [1] are indicators of nuclear power plant reliability. The capacity factor, however, differs appreciably from reliability in the case of a plant in load-following operation.

Fig. 5 plots the capacity and availability factors of plants in the Community and the United States against the number of years they have been in operation. The number of plants operating in each year is also shown, but it is still too low to establish a precise statistical evaluation of the mean availability and capacity factors. A trend towards improved plant reliability with increasing years in service is nevertheless apparent. It can be considered that reliability reaches a steady-state value after a relatively longer period (i.e. about five years) in nuclear plants compared with conventional ones.

2 — *The chief problems* (all subsequently solved) encountered during the commissioning and operation of the Community's five boiling-water and four pressurised-water plants were as follows (end 1971):

A. *Containments and associated equipment.* The construction of large containments has not generally entailed any major problems. In every case the requirements in respect of maximum permissible leak rate have been met with no difficulty. As regards leak tests, particularly periodic ones, an improvement in measuring procedures could save time, thereby helping to raise plant availability.

B. *Reactor vessel and internals.* The incidents particularly worth mentioning here are those which occurred in

[1] Availability factor $= \dfrac{\text{available generating capacity (MWh)}}{\text{hours in the period considered (h)} \times \text{maximum power (MW)}}$

Capacity factor $= \dfrac{\text{electricity generated (MWh)}}{\text{hours in the period considered (h)} \times \text{maximum power (MW)}}$

		First generation *Dresden 1*	Second generation *Gundremmingen*	Present generation *Philippsburg 1*	Future generation
Year of ordering		1955	1962	1970	1975
Net electrical output	MWe	180	237	864	1 600
Net efficiency of plant	%	28.7	29.6	33.6	33.8
Specific power	kW/kg^U	11.5	17.2	22.4	30
Average power density	kW/l	28.9	40.9	51.1	70
Average burn-up in steady-state conditions	MWd/t^U	11 000	16 500	27 500	27 500
Average steam fraction at core outlet	wt %	5.17	8.36	13.6	—
Specific coolant flow	t/h/MW	18.6	15.3	14.75	—

Table I. *Boiling-water reactors* (BWRs) *: change in the key parameters (design values), and estimated main characteristics of the future generation.*

Table II. *Pressurised-water reactors* (PWRs) *: change in key parameters to date (design values) and estimates for future generation.*

		First generation *Yankee*	Second generation *Obrigheim*	Present generation *Tihange/Biblis 1 **	Future generation
Year of ordering		1956	1965	1969/1970	1975
Net electrical output	MWe	110	283	870/1 146	1 600
Net efficiency	%	28.1	31.1	32.7/33.1	33.5**
Specific power	kW/kg^U	18.8	23.3	38.1/34.9	46
Average power density	kW/l	58.4	68	100/86.7	110
Average burn-up in steady-state conditions	MWd/t^U	8 200	24 000	33 000/31 500	35 000
Power per m^3 of coolant	MW/m^3	5.35	5.85	10.3/8.20	—
Secondary steam pressure	atm. abs	32	50	55/52	60
Temperature difference across reactor	C°	15	25.4	39/31.8	—
Specific coolant flow rate	t/h/MW	43.6	24.2	17.25/16.3	—

* Plant designed for load-following operation.

** If cooling towers were used, efficiency would be 32.0 %.

two pressurised-water reactors of identical design. In both cases the thermal shield (a cylindrical structure, 80-90 mm thick) was caused to rock on its supports by the forces generated by the coolant flow. In one plant this motion caused failure of the self-aligning linkages joining the three sections of the heat shield, which thus separated. In the other, the linkages were welded in place, so that the heat shield remained intact. In both plants over half the bolts joining the two courses of the core barrel were found to have fractured, as had some of the tie-rods used to stiffen the core support casting.

Debris entrained through the primary circuit caused damage, notably to the heat exchangers.

The following modifications were made to rectify the causes of the incidents:

—removal of the thermal shield;

—replacement of the barrel joint bolts by others of higher strength and with mechanical locking systems;

—elimination of the tie rods.

An increasingly obtrusive problem is that of periodic vessel inspections and surveillance of the internals. Considerable effort is now being devoted to this field: the development of more effective inspection methods is to be pursued.

C. *Fuel elements and associated components.* So far there has been no unscheduled shut-down of a water reactor because of faulty fuel elements. This is not to say that defects have never arisen, however. They take the form of leaks and, in rare cases, burst cans. Most defects, it seems, are due to excess humidity in the uranium oxide pellets; other causes are the impingement of foreign bodies in the water (pieces of steel wire, etc.) and the penetration of water in the cans which causes secondary defects. It has also been found that frequent changes in the power level have a certain effect.

D. *Turbine generators.* The number of cases of damage to turbo-generators in nuclear power plants is strikingly high—19 since 1963 in eight plants in the Community. Practically all plants not affected by defects also needed modifications before operating satisfactorily. There were two underlying causes:

—the design of saturated steam turbines had to be revised and extrapolated to high volumetric rates;

—the development of units of ever-increasing size has proceeded faster in the nuclear than the conventional field.

The defects in nuclear power plants were chiefly due to fatigue failures of blades. These result from operation close to the resonant frequencies, which occurs when blade fixing conditions change during operation or there is inhomogeneous steam and moisture content distribution. Other interdepending problems have been:

—speed control following load rejection;

—stage draining, which has often been inadequate:

—steam drying.

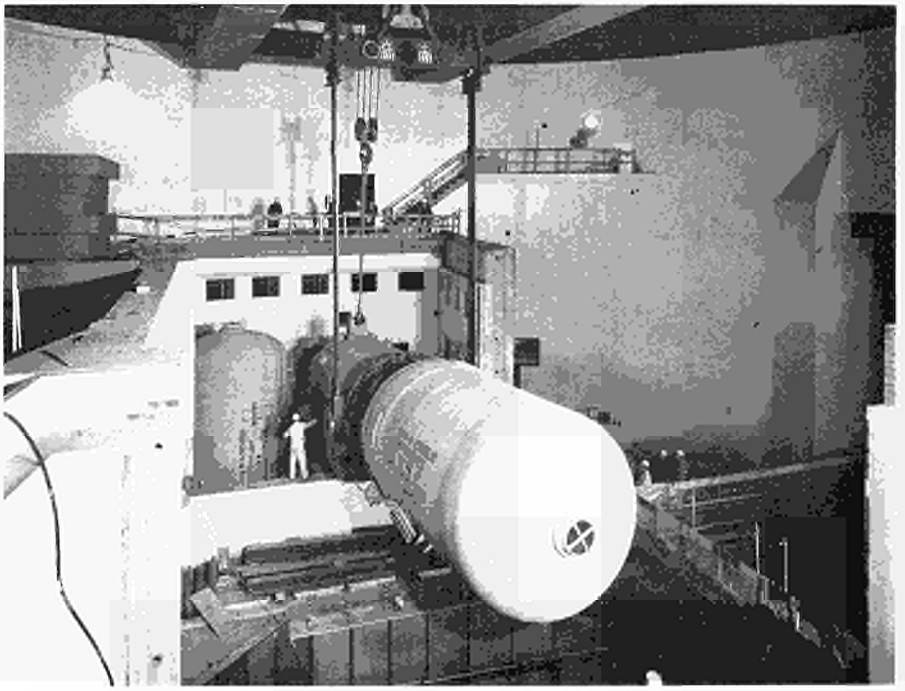
All these problems were ultimately surmounted by the manufacturers. Nevertheless, the operators would like to see the development of a monitoring system for the immediate detection of any departure from normal running conditions.

E. *Water, gas and waste treatment.* Apart from certain comparatively minor problems, e.g. with systems clean-up before start-up, decontamination of certain parts of plants and purification of refuelling pond water, the only problem experienced in this field by a Community plant has been the deposition of corrosive substances at certain preferential locations, such as the fuel element inlet nozzles. This problem has since been solved.

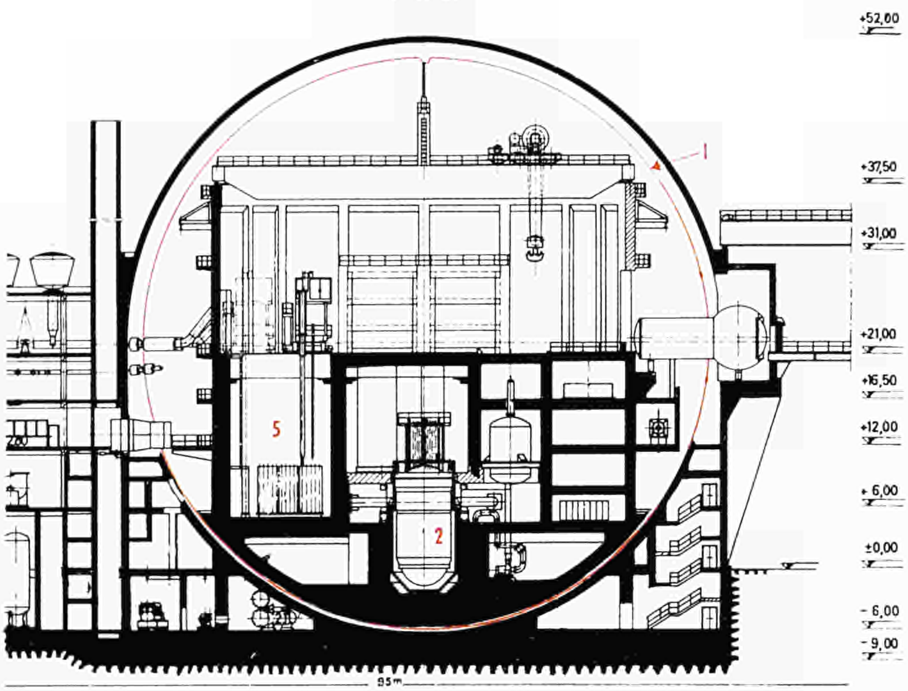
In conclusion: experience has shown that:

—most of the troublesome components are conventional or paranuclear;

Stade nuclear power plant, near Hamburg. The photo shows the installation of a steam generator in progress.



PWR



—hitherto, control systems, and reactivity control systems in particular, have caused no trouble;

—a nuclear power plant can be operated normally even with a large number of defective fuel elements.

The following are therefore essential:

—tighter quality control during manufacture;

—greater care in the design of para-nuclear and conventional components;

—a cautious approach to modifications, even apparently minor ones, to proven equipment when they are not tested in all the possible operating or fault conditions of the system in which the equipment is embodied; in this context, any substantial increase in size amounts to a modification;

—from the outset, the possible need to replace major items, e.g. the thermal shield or the heat exchanger tube bundles, during the lifetime of a plant should be borne in mind.

ECONOMIC ASPECTS [2] - SPECIFIC CAPITAL COST [3]

The present situation in the Community is far from uniform, owing to the varying degree of maturity attained by the industry, its different structure in the various countries and the lack of market interpretation. As a result, the capital cost of nuclear power plants ordered in 1969-70 falls

[2] All the economic data herein are given in 1970 values.

[3] The specific capital cost comprises all direct costs (site, civil engineering, the nuclear steam-raising system, turbine generator, electrical and auxiliary equipment, initial spares) and indirect costs (engineering, overheads during construction, contingencies, interest charges during construction and plant operating costs during tests).

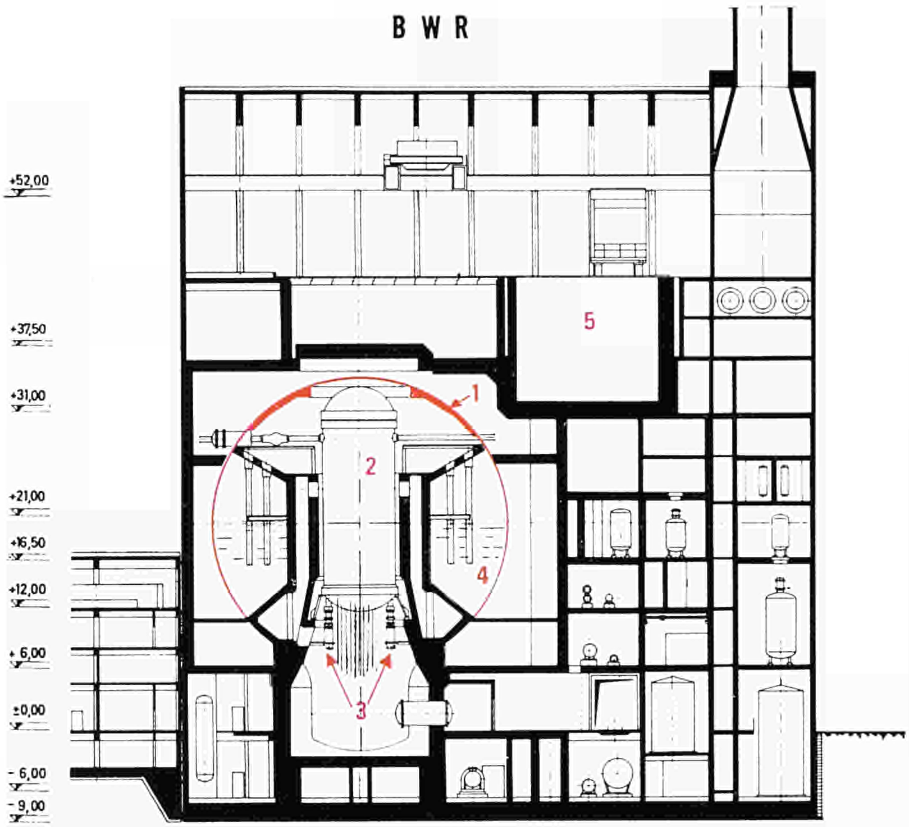


Fig. 4 : *Cross-sections of two 1 200 MWe nuclear steam-raising systems : at left, a* Siemens*-designed pressurised-water reactor, on the right an* AEG *boiling-water reactor.*

By the use of internally mounted recirculation pumps, the BWR*'s primary circuit can be housed entirely within the pressure vessel, resulting in a very compact containment.*

1. Containment.

2. Reactor vessel.

3. Recirculation pumps.

4. Pressure suppression system.

5. Irradiated fuel storage pond.

into two categories—140-160 and 220-260 u.a./kWe.

In the near future, it is reasonable to expect that this disparity in costs will gradually be whittled down, as the situation described above changes for the better, and the average cost, in 1970 values, for plants in the 800-1 000 MWe range ordered in the first half of the seventies will be in the region of 170-220 u.a./kWe.

In the longer term, improvements to the structure of industry, technical advances and the establishment of a genuine market for nuclear power plants in which competition will be a decisive factor should cut costs. To this combination of factors will be added the effects of increased standardisation and series production.

Furthermore, the tendency for electricity producers to instal a number of units of identical power on the same site also reduces the impact of certain items for reasons such as the following:

—the amounts of site clearance necessary is reduced;

—facilities can be used jointly (circulating water conduit, transmission lines, control room, fuel-handling machine, fuel cooling and storage facilities, decontamination equipment, etc.);

—the spares holding can be cut down;

—there is a substantial cut in the number of operating and maintenance personnel.

The building of two similar plants on the same site is estimated to save about 10%, compared with a single-plant installation.

Estimates made in 1970, both in the Community and the United States, put the specific capital cost (in 1970 values) for plants of around 1 000 MWe at: 155-190 u.a./kWe (ordered during 1975-80), and 145-175 u.a./kWe (ordered during 1980-85).

Fuel cycle cost: For plants now under construction in the Community fuel cycle costs are between 1.6 and 2.0 mills/kWh.

For plants commissioned in the periods 1980-85 and 1985-90, the estimated fuel cycle costs are of the order of 1.5-1.7 and 1.4-1.6 mills/kWh respectively.

The data on which these estimates are based are given in Table III.

The costs given in Table III relate to the steady-state fuel cycle for a 1 000 MWe plant, at a utilization of 6,500 h/year.

Operating, maintenance and insurance costs. The operating, maintenance and insurance costs used by the Community's utilities in estimating the cost of electricity generated by

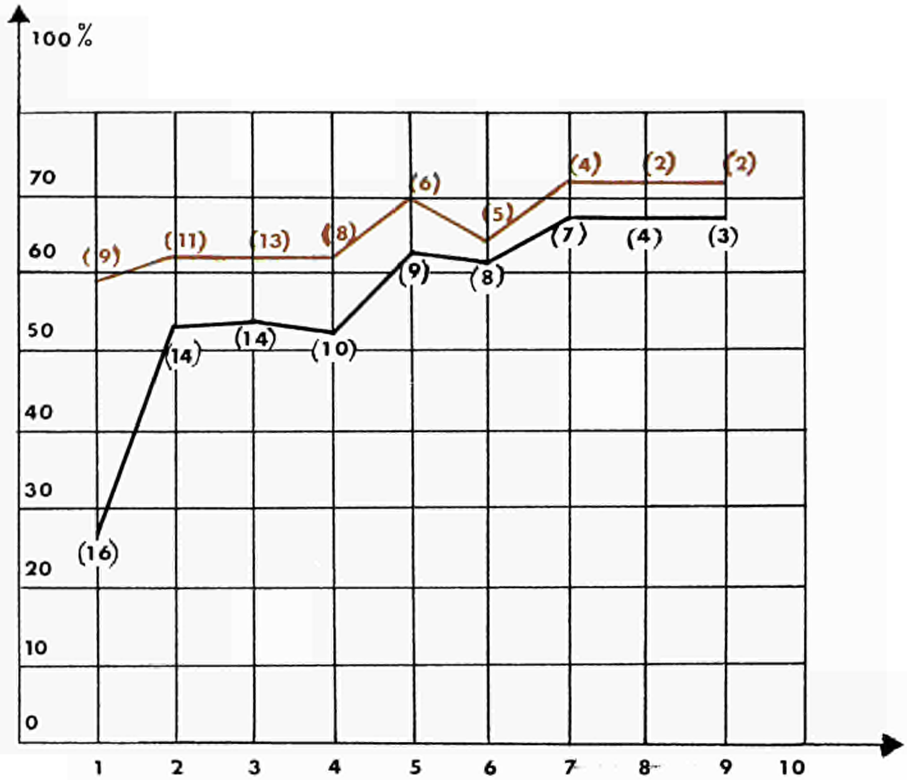


Fig. 5 : *Capacity (black) and availability factors (colour) of light-water reactor plants vs the number of years in operation, in the Community and the United States (the number of plants in operation is shown in brackets).*

Table III. *Data used as a basis for the estimated steady-state fuel cycle costs for a 1 000 MWe plant with an annual utilisation of 6 500 h/year.*

Year of commissioning		1975	1980	1985
Cost of natural uranium in U_3O_8 form	u.a./1b U_3O_8	6.0	6.0	6.0
Cost of conversion from U_3O_8 to UF_6	u.a./kg U	2.3	2.3	2.3
Fuel element fabrication costs	u.a./kg U	120	85	70
Enrichment costs	u.a./USW *	32	32	32
Irradiated fuel shipping costs	u.a./kg U	5	5	5
Cost of reprocessing irradiated fuel (including storage of radioactive waste)	u.a./kg U	35	35	30
Cost of reconversion to UF_6	u.a./kg U	4.5	3.0	2.8
Value of recovered fissile Pu	u.a./g Pu	7.0	7.0	7.0

* USW = unit of separation work.

plants now under construction are between 4 and 5 u.a./kWe a year.

They should trend downwards, to 3 and 2.5 u.a./kWe a year, respectively, for plants commissioned in 1980 and 1985, owing to the increasing automation of operating tasks and the setting-up of joint, specialist teams for maintenance work by groups of plant operators.

It is noteworthy that, for the United States, the *Edison Electric Institute* forecasts a constant value of 2.1 u.a./kWe a year for 1975 onwards.

Generating costs. On the basis of the economic data set forth above, the generating costs for the light-water nuclear power plants commissioned in the periods 1975-80, 1980-85 and 1985-90 vary between 4.9 and 7.1, 4.3 and 6.0 and 4.0 and 5.5 mills/kWh respectively, assuming utilisation of 6 500 h and with annual amortization at 10 and 13%.

CONCLUSION

In the Community, too, light-water reactors have now reached the stage of commercial service, particularly through the use of American licences and techniques. The Community's industry must therefore, bearing in mind its differing structure in the various countries, make a sustained effort in the coming years either to free themselves from dependence on those licences or to continue to develop the same techniques unaided, thus securing major outlets in the world market.

Although they are already regarded as proven and competitive, light-water nuclear power plants will be further refined and, doubtless, their design and construction will be modified to improve their economies.

From the technical angle, the required effort must aim at:

a) Higher power ratings, possibly culminating around 1980 in the commissioning of 2 000 MWe units. The size of certain plant items, particularly reactor vessels and turbosets, will pose severe manufacturing and transport problems, however, and will certainly require the development of new techniques for larger unit sizes.

b) The consolidation of existing technology and the achievement of better fuel element performance, together with the improvement of fabrication processes and quality control procedures.

c) The development of internationally applicable standards covering the design and acceptance of equipment, and plant safety criteria.

From the economic angle, the manufacturers' experience, the effects of series production and size and the standardisation of production should all be reflected in a substantial drop in specific capital costs in terms of constant prices.

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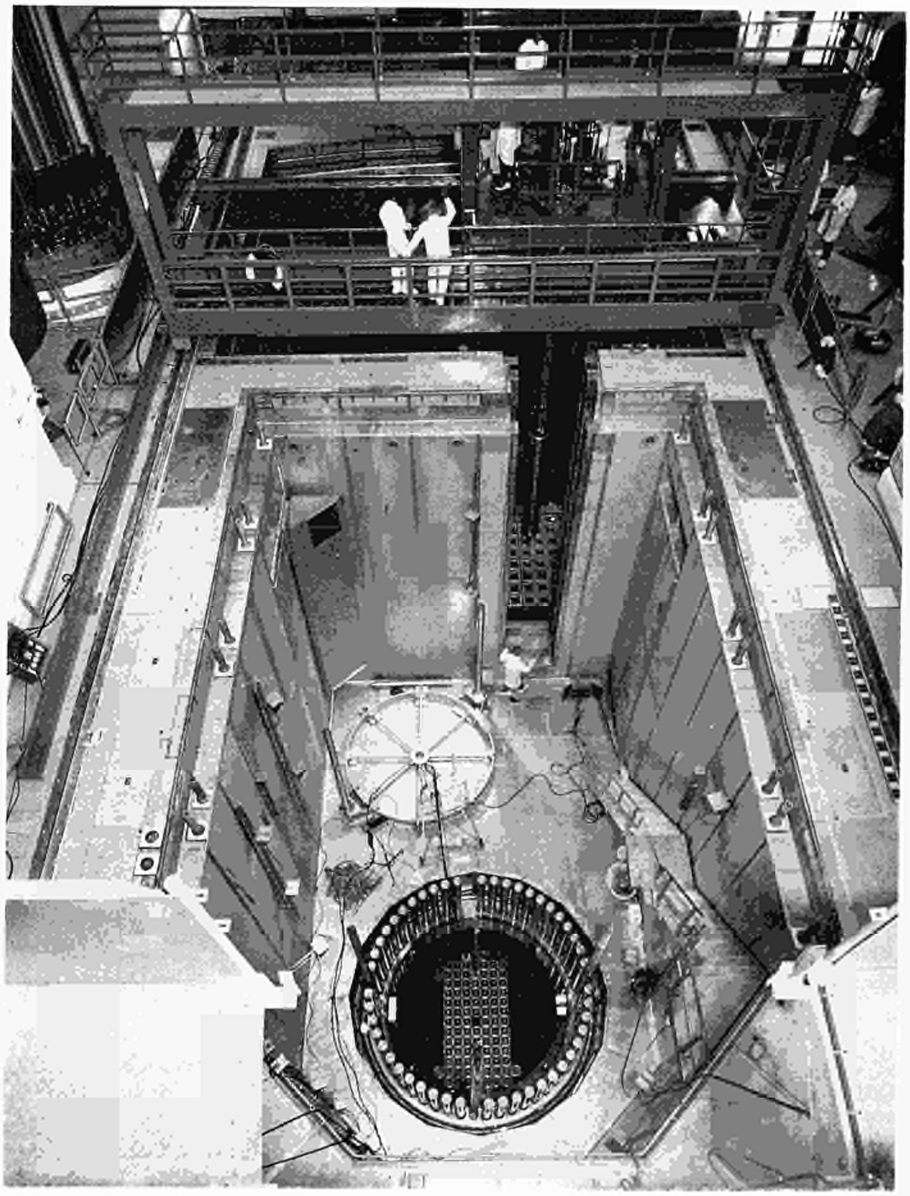
Stade nuclear power plant, Germany: reactor well.



Documentation machines?

"Documents remain silent for those who cannot give them life". (E. Renan).

LAURA CAVARA and ANDRE F. PARFAIT

Some history and background

Documents, documentation, information, data processing, electronics, computers—these words reappear daily in the contemporary language of documentation.

We have come a long way since the time when no more than a few words such as library, index, classification and catalogue were linked with the idea of documentation. These words contained no implication of mechanisation, automation or electronics. The human brain and hands sufficed, together with a minimum of static, inert equipment.

What existed before the advent of libraries as we know them? At the beginning of our era, legal texts of a secular or religious nature were recorded on papyrus or stone tablets. They were not intended to be circulated, bur rather to be consulted for strictly limited and specific reference purposes.

When Nefertiti married Amenophis IV, her beauty spoke for her, but her language prevented her from conversing with her husband. Since there were no general information media nor specialised language schools, it was by walking alongside the temple walls of Amazna, which were covered in hieroglyphics, that Nefertiti learned the language and history of the Egyptian people.

The beginning of the third century saw a massive collection of all kinds of written documents in Greece, which were placed at the disposal of the nation. As a result, information (or, more precisely, documentation) began to become "disseminated", firstly from town to town, then from one country to another. There were many different forms of classification, each author classifying his written knowledge in his own personal way.

It was not until the Middle Ages that monks in Europe began to analyse reports of events, the knowledge acquired in various fields and rules of conduct to be applied in both secular and religious matters. In 1448, Johann Gutenberg, the inventor of letterpress printing, working in association with Johann Fust, took on the task of printing and distributing works of general or particular interest, notably the Bible. No systematic means of circulating information or documents was developed. Documents existed, but were only accessible to the initiated, in the absence of any centralised means for collecting them and circulating them to the general public or on request.

Emergence of the dissemination of information

Let us turn to more recent times, when a new method of spreading information and knowledge emerged—the journal, or newspaper (from the Latin "diurnus", meaning daily). At first restricted—as is shown by the etymology of the word—to the day-by-day reporting of events, the newspaper soon began to appear in different forms, such as periodical publications dealing with political, literary and scientific news, etc. This led to an abundance of written material which, in the form of archives, constituted a fund of documentation which in turn could be used, among other things, to provide bibliographies on a given subject. Printing methods subsequently improved rapidly, thus facilitating the large-scale dissemination of all kinds of information.

Nevertheless, there was still no way of storing, classifying and circulating on request the existing information on any particular topic.

Because of the vast and rapid strides made by the most diverse scientific disciplines the man whose task it was to inform was compelled to seek new means of coping with the flood of documents and information. The demands of research workers in all fields of activity were such that once these means were found, they were quickly found to be inadequate for the task.

This is the reason why the modern documentalist has quite naturally turned to the technique which is most able to assist him in his work. This, as one can imagine, is the technique of calculating machines, which, depending on the work in hand and the period in history, have been known as accounting machines, statistical machines, computers, electronic brains, etc.

The computer is over a hundred years old

It very soon became evident that these machines which, to simplify matters, we call "computers" were the only ones with which documentation could be mechanised. There has never been, nor is there now, such a thing as a "documentation machine". Mechanised or automated documentation is done by means of computers, calculating machines and the like, adapted to specific needs accordingly.

LAURA CAVARA is editor of "euro-spectra". ANDRE F. PARFAIT is a member of the Directorate-General for the Dissemination of Information of the Commission of the European Communities.

It is quite surprising how far back in time one must go to discover the first ideas and devices which were originally intended for calculation purposes, but were already being used in neighbouring fields.

It is thus generally agreed that it was the Englishman Charles Babbage (1792-1871), a professor of mathematics at the University of Cambridge, who between 1834 and 1845 drew up the plans for an "analytical machine", that is, a computer. For want of technical facilities and sufficient capital, he never succeeded in perfecting this huge "analytical engine" which was to translate his ideas and theories into practice. Charles Babbage's designs have nevertheless always been regarded as the first step in the development of modern computers.

The real pioneer in this field was an American, Dr Herman Hollerith, (1860-1929), who built a calculating machine capable of more than simple calculation. He had been employed by the US Census Bureau and had the idea of submitting the results of the census to a mechanised form of analysis.

In 1890, he had all the data regularly drawn from a census put onto punched cards. Hollerith's machine already consisted of a card punch, a card reader unit, a sorter and a series of counters, which together made up the basic components of a tabulator. With the help of this mechanical equipment, the results of the eleventh American census of 1890 were processed and analysed twice as quickly as in 1880. In the wake of these successes, Hollerith founded the "Tabulating Machine Corporation", later to become IBM.

Hollerith's machines have been continually modified and, during the first 25-30 years of this century, they constituted the basis of modern methods of data processing.

In 1937, faced with the increased demands of users and the growing complexity of the problems to be solved, the American physicist Howard H. Aiken, of the University of Harvard, designed the computer know as *"Mark I"*. This machine was completed in 1944. It was a colossal piece of equipment: it weighed five tons, its various parts were connected by 800 kilometres of wiring and it contained more than 3 000 electromechanical relays. It was highly successful and in particular could add and subtract 23-figure numbers in three-tenths of a second.

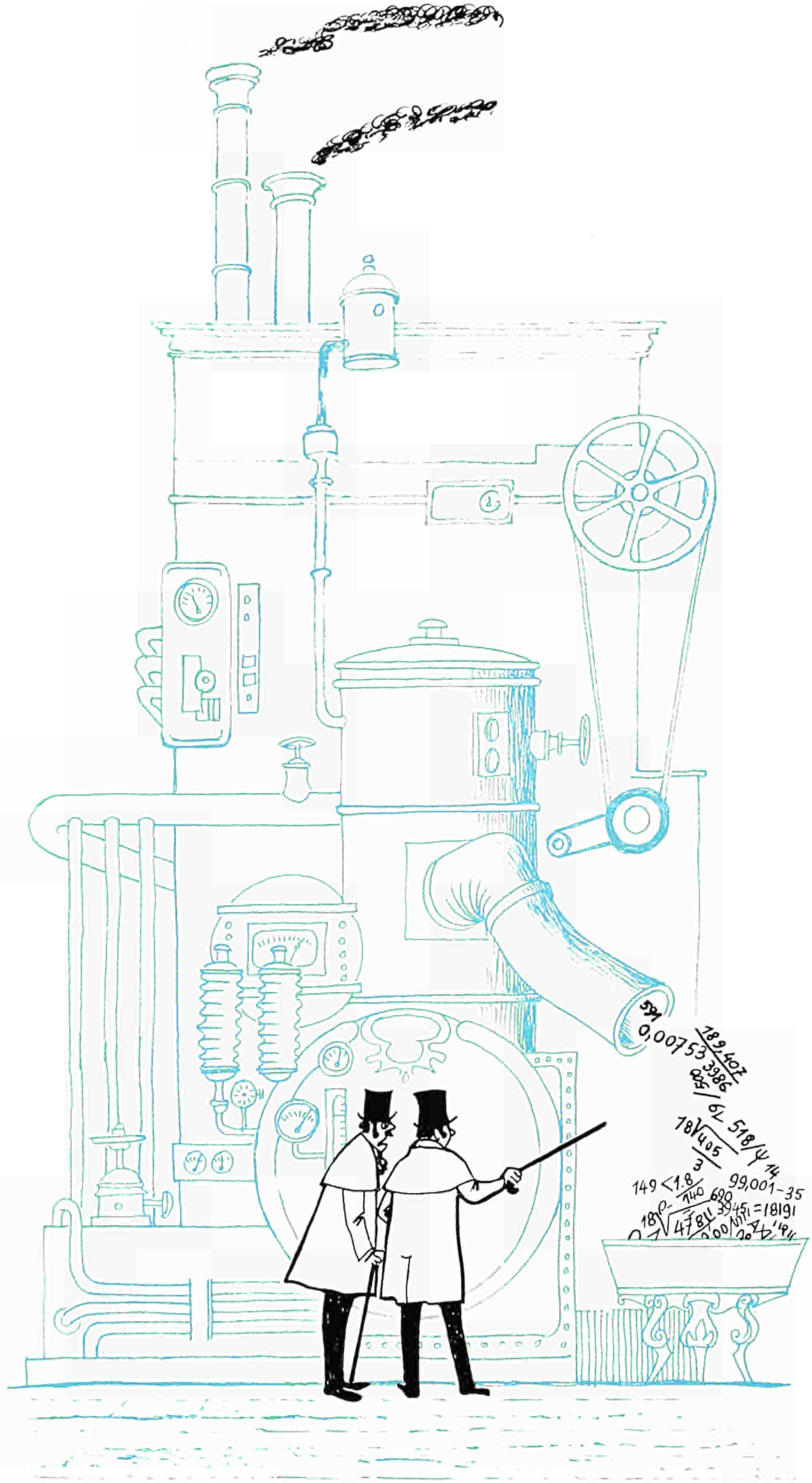
Synergism documentation/machines

However, it was essential to improve on these results, and this was done by two American scientists, S.W. Mauchly and J.P. Eckert. By replacing the mechanical components by electronic tubes, they produced a computer of great potential, intended for the US Army and called *ENIAC (Electronic Numerical Integrator and Calculator)*.

The computers which most closely resemble those we know today were the brainchild of J. von Neuman, who, in 1945, proposed storing the program and data to be processed in the computer's memory.

His ideas were not put into practice until 1950, when there was a boom in the production of one-off computers, especially in Britain and the United States. The University of Cambridge constructed *EDSAC*, an Aberdeen research laboratory built *EDVAC*, and the US Census Bureau brought out *UNIVAC*.

From 1950 onwards, those engaged in the construction of electronic computers began to speak of "generations". Two members of the first generation especially worthy of mention are the *IBM 650* and the *Bull Gamma drum* computer. The second generation began around 1958 when electronic tubes were abandoned in favour of transistors. This was the case with the *IBM 1401* and *7000*, the *Burroughs B 500*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and *B 5 500* and the *Bull Gamma 30*. The use of these machines was based on the two concepts of "software" and "hardware", the first referring to the intellectual and the second to the material aspect of the computer. It was therefore necessary to "speak" to the computer and in 1954 J. Backers of IBM led a research team which developed a symbolic language called *FORTRAN*. This was followed by *COBOL* in 1960, then *PL/1*, *ALGOL*, etc.

This brings us to the third generation, which is characterised by the use of miniaturisation. This generation includes the *IBM 360*, the *Siemens 4004*, the *Univac 1108*, and the *Burroughs 2 500* and *3 500*.

Let us now take a look at the developments taking place at that time in the field of automated documentation systems, that is, the efforts made to use existing computers for documentation purposes. These were accompanied by numerous but usually unsuccessful attempts to construct automatic documentation machines (which did not involve the use of any known computers).

The *Science Information Service—National Science Foundation* was set up in the United States by means of an Act passed by Congress in 1950. This body was especially concerned with finding keywords and developing codes for a "machine language" of documentation. At that time, there were grave doubts about the economic viability of the conventional data processing equipment on the market. Furthermore, no general documentation system had yet been mechanised, any studies and concrete results produced being confined to certain very restricted fields of activity. The Dutch Patent Office, for instance, had set up an automated (or mechanised) documentation system on the subject of automobile carburetors covering about 15 000 patents, and *ICI (Imperial Chemical Industries)* had produced a mechanised documentation system on the polymerisation of polyamide compounds.

During the same period, the Compagnie des Machines Bull had been using a computer named *"Gamma 60"*, whose memory bank could answer 120 000 questions at a rate of 1 000 a day. The cost per answer was in the region of just over one dollar.

Transistorisation and the use of magnetic tapes contributed greatly to progress in this field.

At the *US Patent Office*, the American D.D. Andrews had created a mechanised documentation system for priority research on patents. It was, however, restricted to one specific area of chemistry, that of synthetic polymers. For his work, he used a slightly modified version of the *IBM 305 RAMAC*. It will be noted that machines were still being used which were not originally intended for documentation purposes. Since the *IBM 305 RAMAC* had quite a limited capacity and a very complex electronic structure, it was not proved to be viable for documentation work other than simple analysis.

The Dutch *Bataafsche Internationale Petroleum Maatschappij* in The Hague had also begun research into mechanising the documentation of patents, using standard computers.

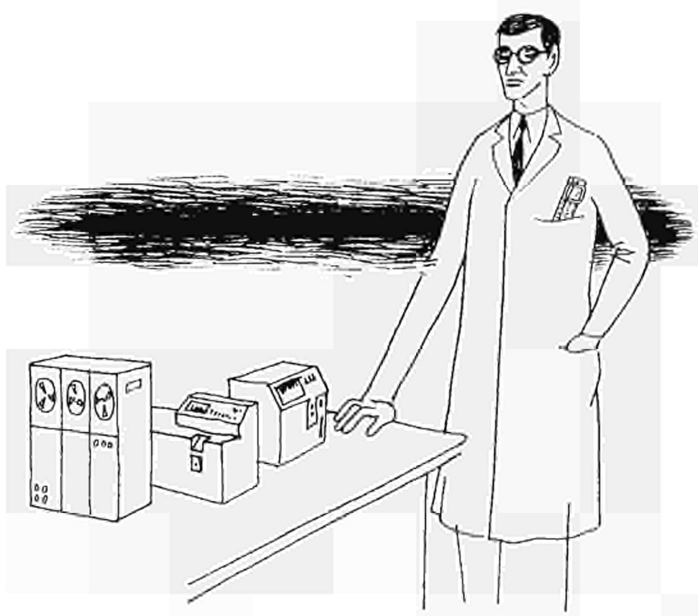
The Hollerith section of the *Max-Plant-Gesellschaft* in Germany used the *IBM 077*, *082* and *421* to feed bibliographical data into a computer. This department limited its activities to the field of aerodynamics. Also in Germany, the *Gmelin-Institut* had built a mechanised documentation system on alloys. They utilised *Univac* and *Remington Rand* equipment, working in conjunction with the Computer Centre of the *Battelle Institut* in Frankfurt. This documentation covered a very restricted area of nuclear energy.

Between 1950 and 1960, other documentation systems were developed which, although mechanical, did not involve the use of computers.

Then a Frenchman, Dr Samain, invented a device based on optical principles known as *FILMOREX*, which was adopted by the smaller documentation centres.

At the same time, the *Bell Telephone* company was striving to discover a way of reducing the human element and speeding up data transmission and distribution.

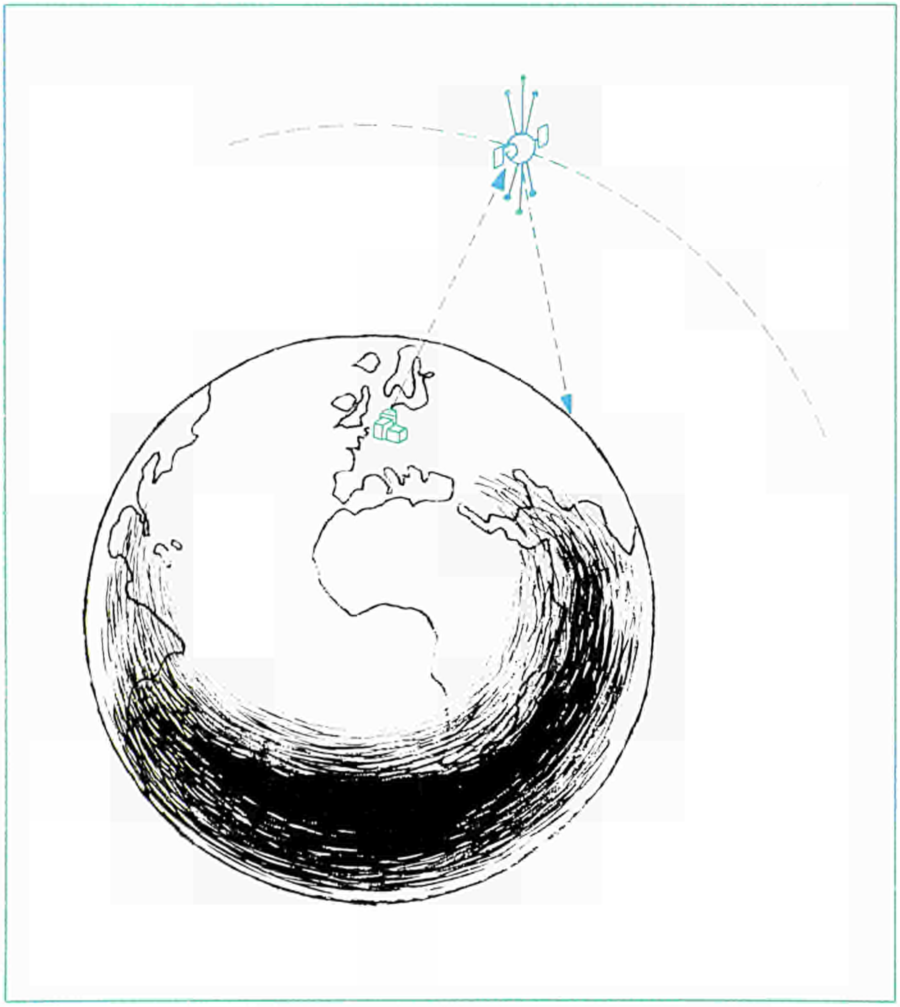
In the USSR, virtually the same research work was being carried out as that under way in Europe and the United States, although detailed information was hard to obtain. Statistics revealed that 1 200 people (two-thirds



of them university graduates) were engaged in work on mechanised documentation systems, and that 10 000 others had been consulted.

Present and future prospects

During the years of fruitless effort before about 1960, there were no significant practical achievements. Just over ten years ago, research operations began with the aid of some new computers, which in 1965 led to the emergence of the first systems of mechanised documentation, largely intended for international use. The Euratom Commission is one example of the many bodies which acknowledged the pressing need for automatic documentation systems. It encouraged the research necessary for the development of the *ENDS* system (European Nuclear Documentation System), designed by its own Centre for Information and Documentation. This system was set up in 1966 and is at present installed at Luxembourg under the Directorate-General for the Dissemination of Information of the EEC [1].



The design of this system is such that its use can be extended to cover other fields, those being studied at present including metallurgy and agriculture.

At the time of writing, users can ask a computer a question directly; this is a great step forward in the sphere of mechanised documentation, but better things are planned for the future, such as the use of artificial satellites to transmit information from one continent to another.

Before the end of this century, there will certainly have been other important achievements. One particular field of research is concerned with improving the programming of texts to be fed into the computer. A significant parallel problem now under study may soon be solved, namely, that of machine translation. Much important work is being done on this subject and partial conclusive results have been obtained.

At present, it is impossible to predict the final stage in the development of automatic documentation techniques—there are limitless and unforeseeable possibilities. The present stage of development is hardly equal to the growing demands, and so the process of perfecting and creating must go on.

At all events, the increasingly efficient mechanisation of documentation systems constitutes yet another means by which the peoples of the world may be brought closer together in a spirit of mutual understanding.

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[1] More detailed information regarding the type of work done, the potential of this system and its specifications may be obtained by writing to the above Directorate-General.

Technical Notes

The Commission's *technical notes* give descriptions of original results obtained under the Euratom research programmes. Their purpose is to enable firms to decide whether they should consider industrialising these results.

On the basis of article 12 of the Euratom Treaty, a non-exclusive licence may be granted on the results covered by patents, in so far as the licensee is in a position to make effective use of these results. The conditions of the licence, as well as the royalties for technical assistance, will, for each individual case, be fixed after joint consultation.

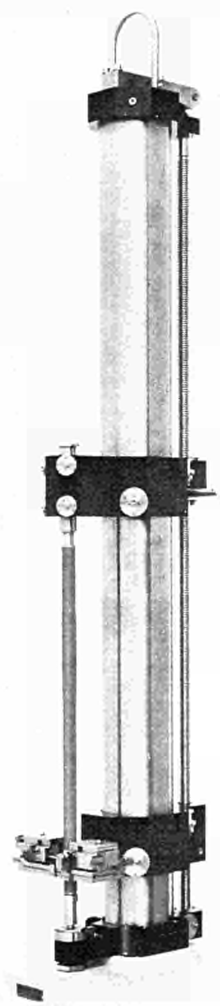
Requests for additional information should be sent to: Commission of the European Communities, D.G. XIII-A, 29, rue Aldringen, Luxembourg.

— 49/C: Metrology rig

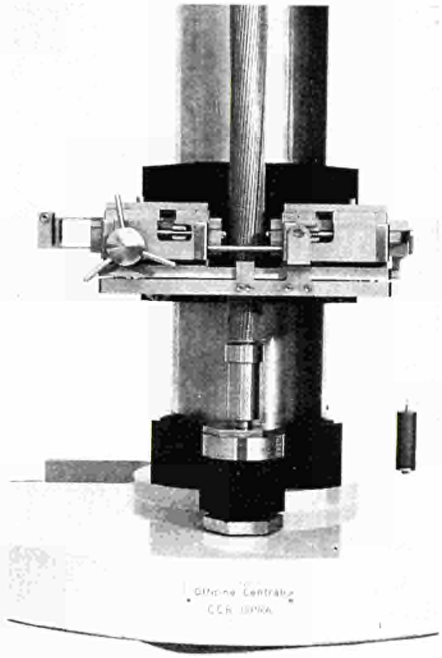
This rig was produced at the *Joint Research Centre's* Ispra establishment for the simultaneous measurement of the misalignment and the variations in diameter of cylindrical rods, whether smooth or finned, in nuclear fuel elements.

The measurements are carried out by means of inductive pick-offs with signal transmission via a measuring bridge and amplifier to a recording unit. The rod to be measured is placed parallel to and against a vertical column forming the body of the rig, between a fixed point located at the base of the column and a point on a counterbalanced slide which can move up and down the column.

A second slide, moved along the column by means of a worm, supports in turn a small carriage which travels in a horizontal plane and is equipped with two touch-probes located in the plane passing through the two points.



These two touch-probes, one of which is integral with the horizontal carriage whereas the other is movable along the latter, are brought against the rod by means of a weight. The distance between the probes can be set. Calibration is effected on a reference diameter brought against the rigs' lower point, which can likewise be rotated through six positions, thus allowing measurements to be taken in three different planes at intervals of 60°.



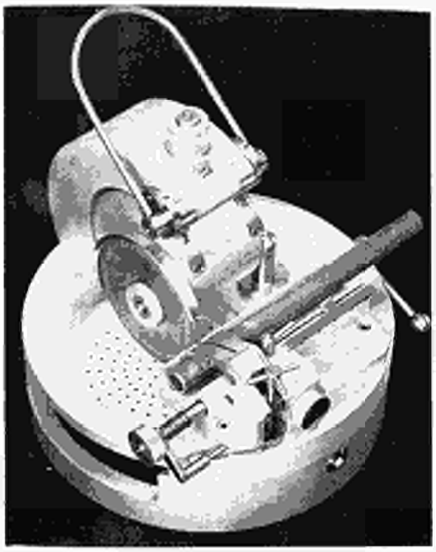
Technical data:

—Minimum rod diameter: 10 mm
—Maximum rod diameter: 40 mm
—Rod length: 1 200 mm
—Accuracy of measurement:
  —on diameter: ± 0.005 mm
  —on misalignment: ± 0.01 mm
—Recording speed: 5 mm/sec
—Location of sliding carriages: by ball bearings
—Correction of linearity defects in the worm drive to the probe slide: via a system of universal joints.

— 61/C: Remote-controlled sectioning machine

This low-speed, diamond-wheel sectioning machine for making transverse cuts through ceramic rods with or without cladding, was designed for operation entirely by remote control.

The machine was produced at the *Joint Research Centre's* Ispra establishment with a view to the hot-cell sectioning of ceramic fuel materials for the purpose of taking samples for examination in special cells: sections for



metallographic tests, specimens for density measurements, samples for chemical analysis, etc.

The machine's small size and low weight render it suitable for use inside a cell; it is easy to manipulate, so that all operations can be carried out with the aid of master-slave controls.

The only connection required external to the cell is for the current supply to the motor.

The simple design facilitates construction at a low cost.

Technical data

—Cutting diameter: from 2 to 40 mm
—Cutting time: approx. 5 minutes for a 10 mm diameter cut through uranium oxide clad with stainless steel
—DC motor: 24 V nominal
—Wheel speed: variable between 0 and 330 rpm
—Cutting fluid supply: splash feed in the trough.
Rods of any length can be cut.

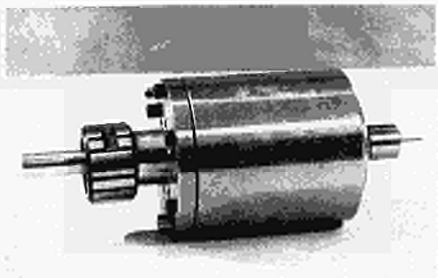
The length of the sections is set by means of an adjustable stop to an accuracy of within ± 0.1 mm.

— 64/C: High-speed motor

High-speed electric motors are generally of the synchronous type. Their armatures rotate on ball bearings lubricated by a separate system and the speed is regulated by varying the frequency of the motors' power supply.

The compact motor developed at the *Joint Research Centre's* Ispra establishment uses a turbine fed with gas under pressure as the drive unit, the turbine speed being a function of the gas pressure.

The turbine is supported on pressurised gas bearings, which take up the axial and radial loads from the motor.



The motor consists of:

—A cylindrical casing incorporating turbine and bearing supply ducts;
—Two symmetrical air-cushion bearings;
—A turbine fitted with blades or vanes;
—One or two thrust bearings depending upon the intended application of the motor.

The prototype can rotate at speeds which can be varied between 0 and 100 000 rpm under continuous operating conditions.

By using the turbine shaft as a tool fixture (drill, grinding wheel, etc.) it has been possible to employ the motor for reaming and drilling small holes in various materials, and especially for drilling printed circuits.

Technical data:

Turbine

—type: radial-blade
—gas: via holes arranged tangentially around the cylindrical casing
—No. of blades: 8
—number of gas-supply holes: 9
—diameter of holes: 0.5 mm
—moment of inertia: 2.6×10^{-5} kgm^2
—weight: 0.250 kg
— materials:
—turbine: steel
—shaft journals: stellite

Radial bearings

—type: peripheral chamber
—gas supply: via radial holes
—minimum pressure: 0.3 kg/cm^2
—maximum pressure : 3 kg/cm^2
—radial load: 3.5 kg
—consumption: 0.2 l/sec air at 1 kg/cm^2
—material: Deva antifriction alloy

Thrust bearing

—type: peripheral chamber
—gas supply: common to radial bearings
—axial load: 1.5 kg
—consumption: 0.04 l/sec air at 1 kg/cm^2
—material: Deva antifriction alloy.

The continuous variation of the speed between 0 and 100 000 rpm has been obtained at turbine supply pressures ranging from 0 to 8.5 kg/cm^2, the pressure at the bearings varying between 0.4 and 3 kg/cm^2.

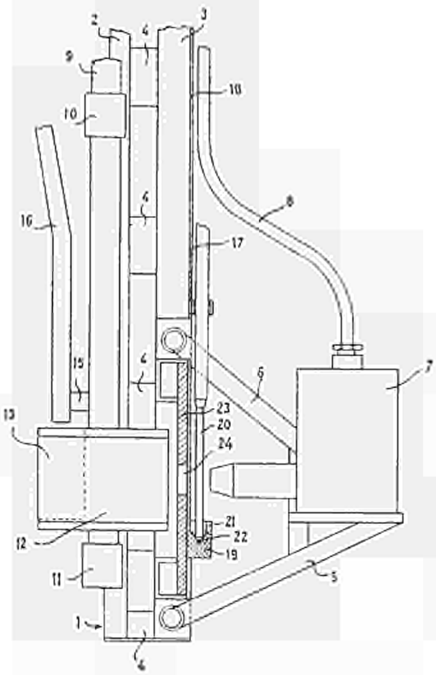
— 551: Underwater X-ray apparatus

This apparatus was developed for the radiographic inspection of objects under water. It is eminently suitable for use in the pool of a nuclear installation, in which it can serve for the examination of radioactive objects such as capsules, loops and fuel elements.

The apparatus consists essentially of a support structure (1) to which are attached an X-ray generator (7) and a film mount (12). The latter can be rotated by means of a shaft (9) for the purpose of changing the film and regulating the exposure time.

Manipulation of the object to be examined (20) is effected at a distance, as is also the changing of the film.

The film is contained in a protective capsule, which can be raised and lowered via a guiding device (16).

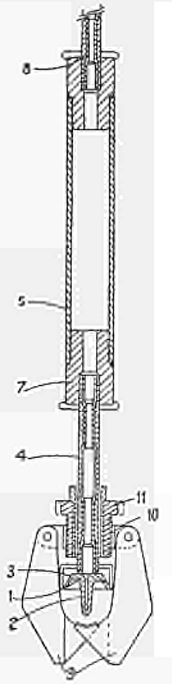


(French patent specification No. 1 515 861 or British patent specification No. 1 138 483.)

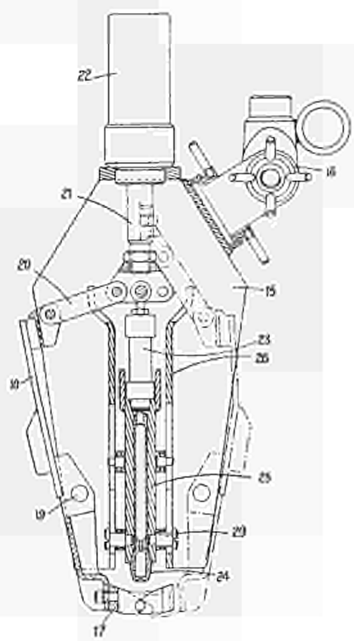
— 639: Device for bleeding gas from a sealed enclosure or for introducing it into such an enclosure

The device can be operated at a distance. This, in conjunction with the fact that the gas cannot come into contact with the ambient air, means that the device is eminently suitable for handling dangerous gases such as the fission gases from a fuel element.

When gas is being evacuated the enclosure is clamped in a gripping device, after which it is punctured by a perforator in the form of a pneumatically operated hollow needle, the area around the puncture being hermetically sealed against the ambient air.



After the evacuation of the gas into a capsule, which is maintained at an underpressure, the capsule is crimped tight and cut off.



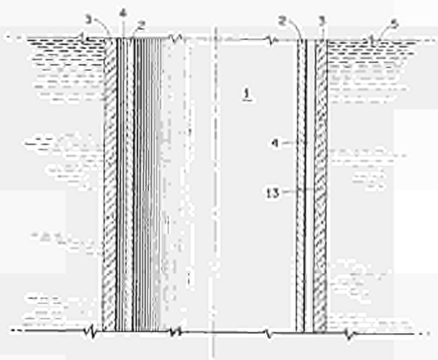
The device can also be used in a liquid medium.

(French patent specification No. 1 508 103 or British patent specification No. 1 122 088.)

— 688: Thermal insulation

This form of thermal insulation, which was developed at the *Joint Research Centre*, Ispra, is particularly suitable for insulating hot tubes immersed in a cold liquid, though it can also be used for insulating other types of surfaces such as tanks.

The insulation consists essentially of a jacket of porous material arranged concentrically around the tube, or other object to be insulated, at a distance of a few millimetres.



The annular space between the jacket and the tube contains vapour of the surrounding cold liquid.

The jacket, which is self-centring around the tube, can be made from five layers of silica felt 0.3 mm thick.

(French patent specification No. 1 529 550, British patent specification No. 1 147 905 or United States patent specification No. 3 396 079.)

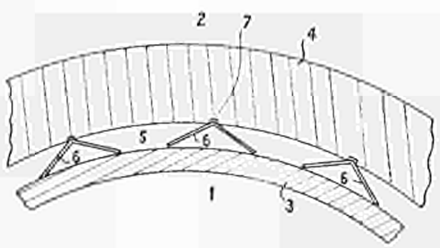
— 725: Heat exchanger

For reasons of safety it is sometimes necessary for heat exchangers to be double-walled.

In the interests of improved heat-transfer efficiency, the *Joint Research Centre* at Ispra has developed a double-walled exchanger in which the space between the walls contains flexible plates, made of the walls, to which, however, in order to avoid mechanical stresses, they are not rigidly attached.

The plates can be bimetallic, so that a rise in temperature will cause them to bear harder against the walls.

In addition, the space between the walls is filled with a slowly circulating gas.



(French patent specification No. 1 529 570, British patent specification No. 1 153 068 or United States patent specification No. 3 438 430.)

— 729: Welding of composite metal/metal oxide tubes

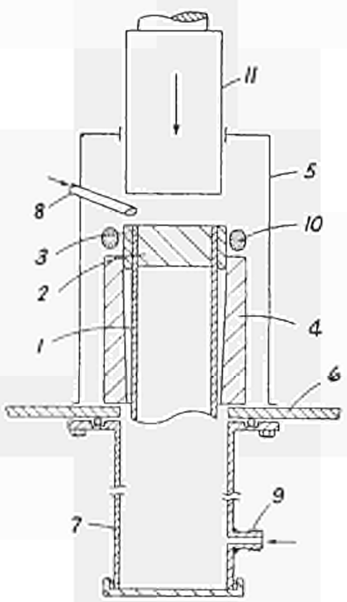
At the *Joint Research Centre*, Ispra, a process has been developed for the welding of composite metal/metal oxide tubes without impairing the favourable properties of the materials. The tubular elements to be welded can be of the same composition or different compositions.

The process consists essentially in introducing the extremity of one element into that of the other and fitting a retaining sleeve around the outer tube at the location of the desired junction.

After being subjected to induction heating, the whole assembly is forced through an extrusion die, whereupon the sleeve is removed.

The process is particularly suitable for tubular elements made of *SAP* (sintered aluminium powder), though one of the elements may be of metal, such as aluminium, magnesium or an alloy, while other cermets can be used instead of *SAP*.

(French patent specification No. 1 532 678 or British patent specification No. 1 158 458.)



— 836: A method for the production of an electrical and mechanical connection between a GeTe semiconductor and a metal electrode

This method was devised at Ispra *Joint Research Centre* in the course of the development of thermoelectric generators based on semiconductors. First, a thin film of pure iron is caused to diffuse into the semiconductor at about 550° C, then the iron residue is removed from the surface; finally, a sandwich is formed out of the semiconductor, a gold foil and the electrode, and heated at 550° C under compression for five hours. The layer of iron, which has diffused into the semiconductor to a defined depth, proves to be a stable diffusion barrier during extended operation at high temperature, preventing the poisoning of the semiconductor by atoms of gold or of the electrode material. In addition, a thick diffusion layer, known from experience to be brittle, can no longer form.

(German Patent Application No. 1 489 271, French Patent Specification No. 1 505 185 or British Patent Specification No. 1 162 106.)

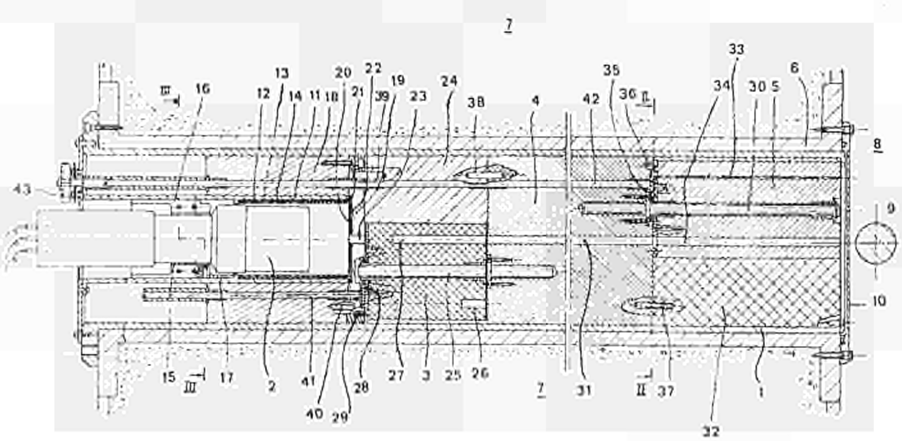
— 845: Investigation of gamma- or X-radiation

At the *Joint Research Centre*, Ispra, a device has been designed for the non-destructive testing of objects that emit gamma- or X-radiation, such as irradiated fuel elements.

The device consists of a single cylindrical unit containing, in addition to a detector, an adjustable drum with filters for regulating the intensity of the low-energy gamma- or X-radiation flux and an adjustable drum with diaphragms for regulating the intensity of the flux at the detector.

Owing to its compact design the entire device can be placed in one of the existing pods in the wall of a hot cell.

(French patent specification No. 1 537 438.)



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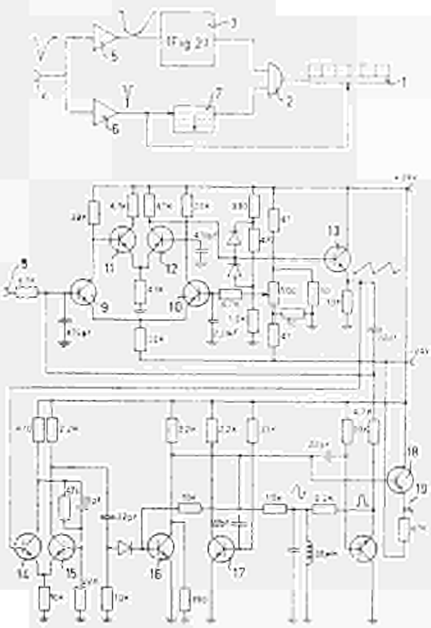
— 868: A circuit arrangement for digitalising an analog value of short duration

This transistorised circuit first converts the analog value (e.g. the amplitude of a current or voltage pulse) into a sine-squared pulse the area of which is proportional to the original analog value. The sine-squared pulse is then counted with respect to area (= integrated) by means of a voltage-to-frequency converter and a digital counter.

The counting period is automatically synchronised with the pulse carrying the analog value, and is preferably about twice as long as the duration of the sine-squared wave in order that statistical noise is largely cancelled out.

The circuit displays higher precision and a shorter duration of measurement compared with conventional arrangements of similar cost in which the amplitude for digitalisation is stored until the operation of the analog-to-digital converter has built up.

(German Patent Specification No. 1 178 599, French Patent Specification No. 1 542 138 or British Patent Specification No. 1 178 599.)



Information session "Technical Measures of Dust Prevention and Suppression in Mines"
Luxembourg, 11, 12 and 13 october 1972

The Commission of the European Communities will organize on October 11th, 12th and 13th 1972 an information session on technical measures of dust prevention and suppression in mines. The overall topic which will be discussed mainly concerns the results of research carried out with the financial help of the ESCS in this field. However other aspects of the anti-dust measures in mines can be brought up.

The reports will be focussed on the following chapters:

—Dust suppression measures during winning operations

—Measures against dust during operations other than winning

—Dust measurements

—Physics of dust

—Epidemiology of pneumoconioses (research on the origin and the development of pneumoconioses).

The working languages of the information session are French, German, Italian, Dutch and English. Simultaneous interpretation will be provided in these languages during the whole session.

Additional information concerning this session can be obtained from:

Commission of the European Communities
General Directorate Social Affairs
Secretariat of the Information Session
"Dust Prevention in Mines"
29, rue Aldringen
LUXEMBOURG (Granduchy of Luxembourg)
Tel.: 292-41.

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