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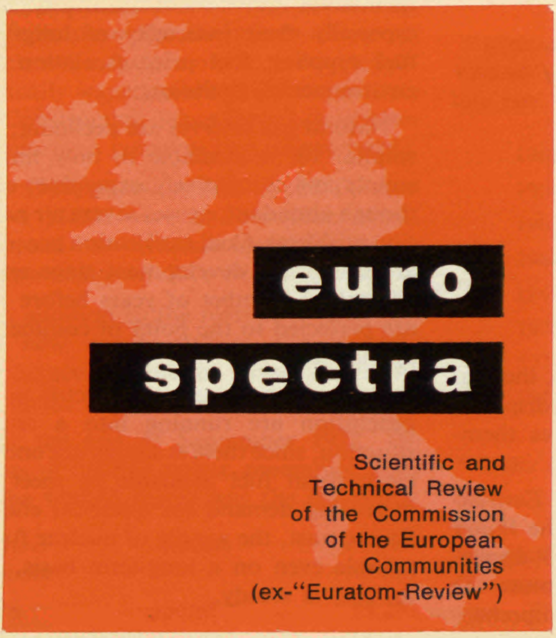

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The slight delay in the publication of this issue, which was beyond our control, gives us the opportunity of emphasizing the topicality and importance of the Conference on Security and Cooperation in Europe which is to open in Helsinki on 2 July.

By the time the "euro-spectra" reaches its readers we shall already know whether the great hopes and optimisms which attended the organization of the Conference will prove justified.

In all events it is certain that, with security and cooperation in Europe at stake, the issue is far too important for the Conference to be permitted to founder, with greater or lesser dignity, in a sea of high-sounding but empty press releases. Let us hope that this kind of conventional, well-polished "obituary" will have no reason to appear in the final communiqués issued at Helsinki.

*Nuclear power in the United States: present status and outlook**

A combination of adverse circumstances has slowed down the development of nuclear power; however, this is only a temporary setback, the challenge is thus well met and the future appears promising

GIORGIO BOGGIO

DURING THE LAST FEW YEARS the nuclear industry in the United States has had to face a number of problems stemming from design difficulties and growing public opposition to nuclear plants. The design difficulties are typical of a rapidly expanding young industry.

The promise of cheap power prompted the utilities to "go nuclear", especially in 1966-67. Industrial capacity became strained at a time when nuclear technology was still rapidly evolving and plants were steadily increasing in size and complexity.

However, reality soon cooled this initial optimism, since skilled workers were scarce and equipment failures, faulty installations and late deliveries of plant components were frequent.

The public's new sensitivity to environmental protection complicated this situation. Nuclear power became a major target for public opposition. Emotions and fears were easily aroused. In the first place, the concept of nuclear power is difficult for the public to grasp. In addition, many people still remember its original destructive use for military purposes.

Environmentalist action in the form of public hearings in connection with licensing procedures increased in number and duration, often holding up the operation of power plants which had already been built. The public's main opposition related to the limitations on the radioactivity released in the effluents of nuclear facilities, reactor safety margins, thermal discharges and radioactive waste disposal, and reactor licensing procedures themselves were greatly affected.

As a result of the *National Environmental Policy Act* of 1969 and the *Water Quality Improvement Act* of 1970, applications for reactor licences must be accompanied by much more comprehensive reports, including a cost/benefit analysis, in order to consider and balance the possible environmental effects against the economic and technical benefits of power plants.

The greater scope of license applications has imposed a serious burden on the regulatory staff of the United States Atomic Energy Commission *(USAEC)*, with consequent power plant hold-ups, and the combination of these problems has inevitably led to long and extremely expensive delays in the construction and operation of nuclear power plants.

An illustration of the delays is given in Table I, which shows the slippage in construction schedules—up to an average of 19 months for plants ordered in 1966. For plants ordered more recently, the lead time has been significantly increased from 4-5 years in 1966 to 6-8 years in 1971.

Only a temporary setback in nuclear power growth

Nevertheless, in order to satisfy the ever-increasing need for electrical energy, the utilities are turning more and more to nuclear power, despite the long delays, construction cost escalation and technical and public acceptance problems. The basic explanation lies in the comparative advantages nuclear reactors offer over fossil fuel fired power plants, which themselves are not free from problems, especially their insecurity of long-term fuel supplies, fuel price escalation and environmental pollution.

Natural gas reserves are declining; low sulphur oil is available in only limited supply and is relatively expensive; coal, though abundant, causes severe air pollution problems. Coal gasification processes are still in the development stage and it will take a number of years before they are perfected to the point of commercial application.

Conventional sources of electric power generation are running into a critical situation, since there is simply not enough clean fossil fuel available to meet the increasing demand for electrical energy. By contrast, the supply of nuclear fuel is reliable even on a long-term basis, and its cost is steady.

1972: a record year for nuclear power growth

Orders for nuclear power plants by US utilities piled up so fast in 1972 that the total electric power of nuclear origin ordered in that one year will set an all-time record.

In the first nine months of 1972, orders for 24 units were awarded, with a total net capacity of 25 489 MWe.

The record is so far held by 1967, with a total capacity of 26 216 MWe for 31 units.

Table I: *The slippage in nuclear plant construction schedules reflects the unrealistic optimism of earlier estimates.*

Contracts placed in	No. of units	Typical Original Plan (years)	Average slip (months)
1966	20	4-5	19
1967	31	5-6	12
1968	15	5-6	13
1969	7	6	16
1970	14	6-7	6
1971	21	6-8	2

GIORGIO BOGGIO, *Delegation to the United States* of the Commission of the European Communities.

* Manuscript received december 1972

The announcements of new thermal power plants in the first three quarters of 1972 clearly indicates the shift to nuclear power. Table II presents the recent trends in nuclear vs fossil fired plant announcements. This shows that the enthusiasm for nuclear development which was a feature of the years 1966-67 gradually waned as the problems mounted. Construction delays forced the utilities to return to conventional power plants.

In 1969, as few as 14% of new thermal power plants were nuclear. Since then, the trend has reversed, increasing to the nuclear share of 55% in 1972.

In addition to the fossil fuel shortage, the new trend reflects the utilities' acceptance of nuclear power, with its economy, safety and cleanliness.

At the end of September 1972, the status of nuclear power generating units in the United States was the following:

Number of units	*Statuts*	*Power (MWe)*
28	operable	13 261
52	under construction	45 330
70	ordered	71 502
		130 093

Industry's acceptance of nuclear power is essentially the result of the successful development of the light water reactor *(LWR)*. Credit for this achievement is shared by four strongly competitive companies - Westinghouse, General Electric, Babcock and Wilcox, and Combustion Engineering, listed in the order of their turnover.

The light water reactor "club" was recently joined by a new contender, Gulf General Atomic, which in 1971 sold four commercial high temperature gas-cooled reactors *(HTGR)*. In 1972 it continued its successful penetration of the highly competitive nuclear market with the sale of two more units. The nuclear power plants ordered in 1972 included the offshore nuclear island ordered by the Public Service Electric and Gas Company. This is a twin plant of 2 300 MWe, the reactors being mounted on floating platforms sheltered by a man-made breakwater about three miles from shore (see Fig. 1). Power will be transmitted to the shore by means of underwater cables.

The manufacturing method is one of the interesting aspects of this reactor concept. The reactor will be assembled on the platform, tested at a coastal manufacturing facility and towed to the selected site. The shipyard-type manufacture facility (see Fig. 2) will be a joint undertaking by Westinghouse and Tenneco Inc., thus uniting nuclear capability with shipyard expertise.

Offshore reactor siting appears attractive for sites off densely populated coastal

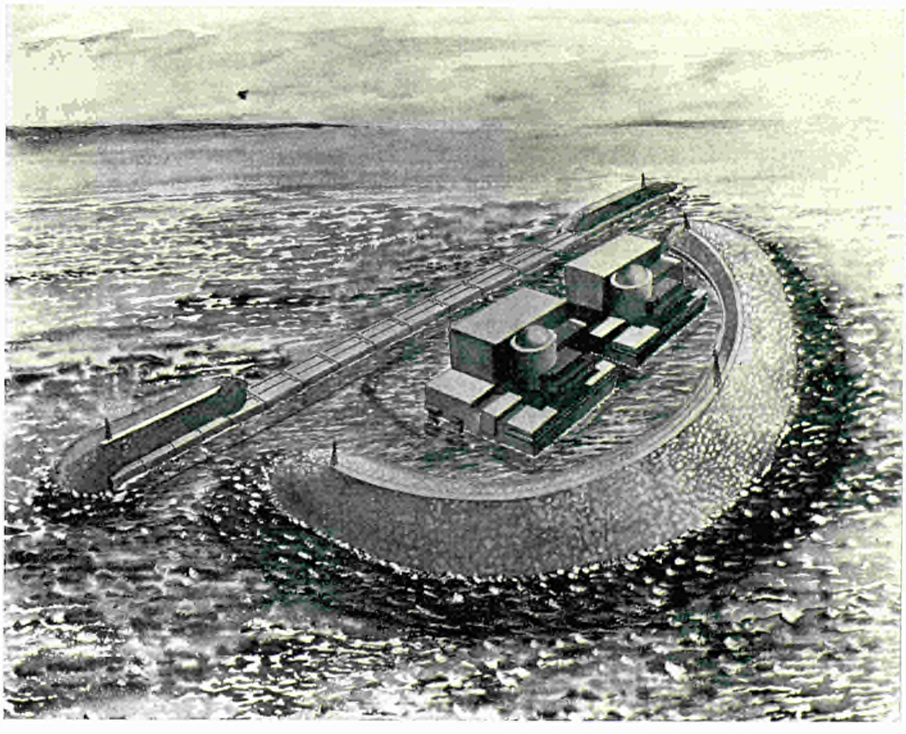
Table II: *By way of announcements of new power plant capacity, this table indicates the breakdown of power generation between conventional and nuclear plants. It clearly shows the shift to nuclear of the last few years.*

Summary of announcements of new steam-electric plant additions

Announcements in	Fossil		Nuclear		Total
	MWe	%	*MWe*	%	
1965	15 928	73	6 009	27	21 937
1966	20 096	47	22 477	53	42 573
1967	32 320	55	26 460	45	58 780
1968	24 600	62	14 803	38	39 403
1969	37 040	86	6 229	14	43 269
1970	29 910	69	13 491	31	43 401
1971	29 372	48	31 810	52	61 182
1972	28 772	45	35 173	55	63 895

* Units under 300 MWe and gas turbine installations are not included.

Fig. 1: *This artist's impression shows how the Public Service Electric and Gas Company of New Jersey will use the platform-mounted nuclear reactor concept. The two reactors are moored within a common breakwater. Power transmission to shore is by underwater cables. The site is almost three miles off-shore.*



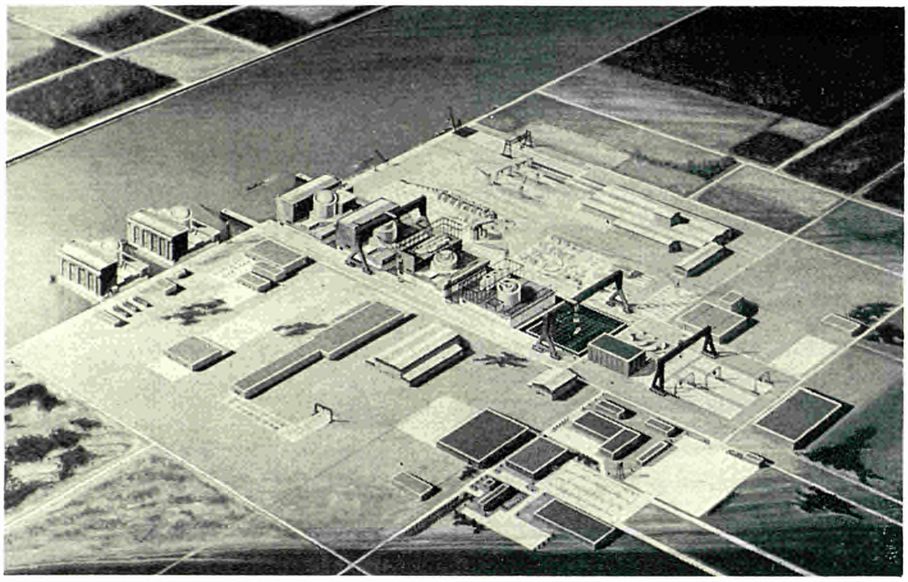
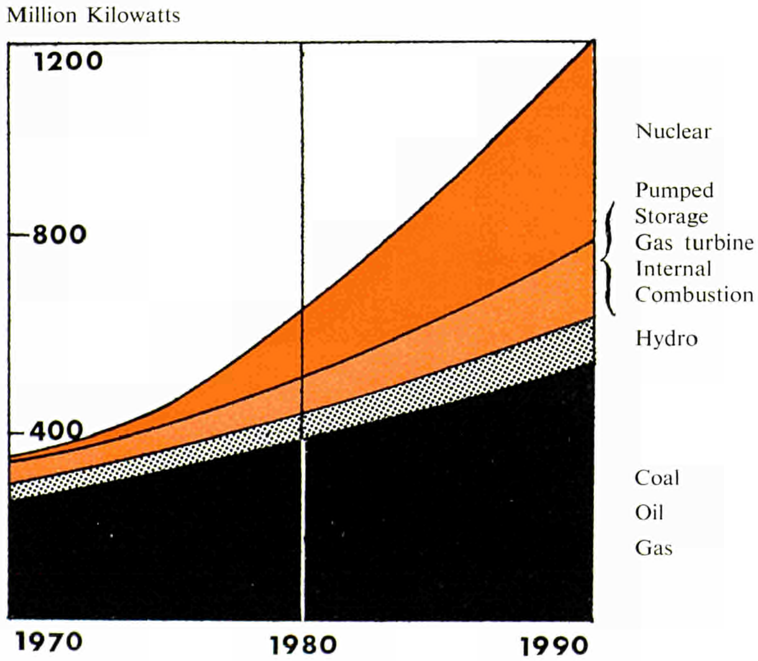


Fig. 2: *Floating nuclear plant facility. Using a new slip on Blount Island, the joint venture planned by Westinghouse and Tenneco will manufacture floating nuclear power plants on a production line basis. The honeycomb steel platforms will be fabricated at the end of the channel. At subsequent assembly stations, standardized components will be brought together in progressive stages until the complete plant is ready for functional testing—the final process before delivery to the utility's off-shore site.*

zones and offers a number of advantages, including an unlimited supply of cooling water without thermal pollution problems, a potential reduction of seismic problems and increased standardization through assembly-line fabrication at the manufacturer's facility. The environ-

Fig. 3: *Projections of US electric generating capacity up to 1990 (million Kilowatts). The contribution of nuclear power is predicted to raise rapidly from the present negligible fraction to about 40 % of total electricity generation by 1990.*



mental aspects of this concept are now being examined. Another interesting 1972 order, showing the competitive position nuclear power has achieved, was placed by the oil-rich state of Texas, its first ever.

Outlook: nuclear power's future role in electrical energy

Electricity generating capacity in the US will soar from the 340 000 MWe level of 1970 to about 670 000 MWe in 1980 and up to about 1 260 000 MWe in 1990, according to forecasts by the Federal Power Commission.

By 1990, nuclear power will provide 40% of US electrical energy needs, compared with today's almost negligible level.

Fig. 3 shows a graphic representation of these projections, while Fig. 4 gives the yearly forecast of nuclear electric generating capacity up to 1985.

Since most nuclear reactors in operation or on order are light water reactors, this type will most probably continue to form the basis of nuclear power progress up until 1985. Light water reactor development is still expected to bring about significant improvements in terms of operating experience, better performance of reactor components, progress in fuel technology, more sophisticated core design, plant standardization and increased unit power. Fig. 5 features an artist's impression of the latest design of General Electric boiling water reactor *(BWR)*. The concept known as *BWR-6* includes an improved core design and reactor components with higher reactor safety margins and a new concept of concrete reactor containment.

In the late 1980's and early 1990's the high temperature gas-cooled reactor *(HTGR)* should conquer a prominent position in the nuclear market, which it is predicted will henceforth be dominated by fast breeder reactors.

Translated into figures, the forecast by reactor type is as follows:

Installed capacity (thousands of MWe)

Year	1970	1980	1990	2000
LWR	7	145	371	348
HTGR	—	3	62	181
Breeders	—	—	14	374
Total	7	148	447	903

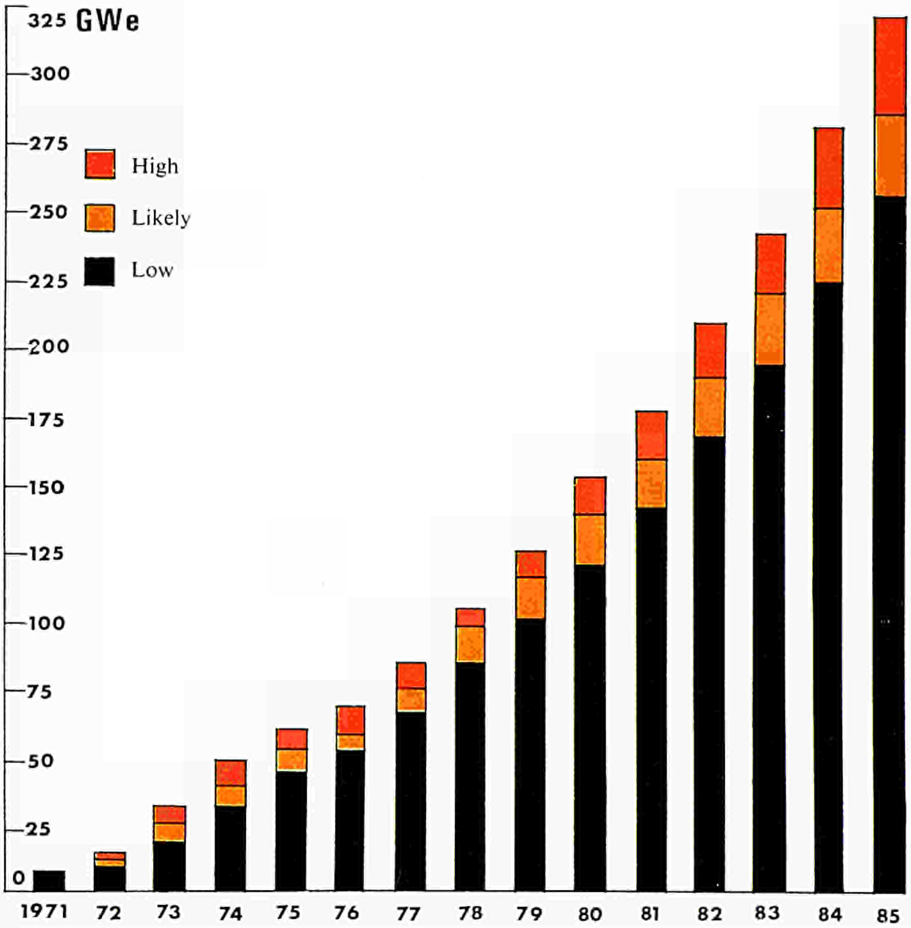


Fig. 4: *Forecast 1971-85 of installed nuclear electric generating capacity in the United States (GWe).*

If the projection is taken further into the future, the advent of fusion power is foreseen as a commercially viable means of electric power production by early in the next century.

High Temperature Gas-Cooled Reactors — High temperature gas-cooled reactors should be singled out for their development prospects, since they offer promise of substantially improved fuel utilization through the use of the uranium/thorium fuel cycle and better thermal efficiency.

The use of a prestressed concrete reactor vessel will also enhance reactor safety. This feature, together with a reduced discharge of thermal and radioactive waste, will help make *HTGR*'s environmentally acceptable.

Furthermore, the concept offers considerable potential for the direct coupling of the reactor to a gas turbine. Gulf General Atomic *(GGA)* is launching a gas turbine development programme aimed at the construction of a large *HTGR* gas turbine plant, to be operational in the mid-80's. Fig. 6 shows a drawing of the major features of such a plant. The gas turbines, installed in cavities in the prestressed concrete pressure vessel, would be connected to the electric generators outside via long shafts.

The reference output of the plant is 1 000 MWe, to be generated by four gas turbine-generator units.

As the heat discharged by the *HTGR* gas turbine system is hotter than is the case with steam cycle systems, dry cooling towers can be used economically, thus allowing greater choice in plant siting.

In the United States a *HTGR* prototype of 40 MWe, Peach Bottom Reactor, in operation since 1967, has provided evidence of the excellent performance of *GGA*, new fuel design and the smoothness of *HTGR* operation. Fort St. Vrain Reactor, a *HTGR* demonstration plant

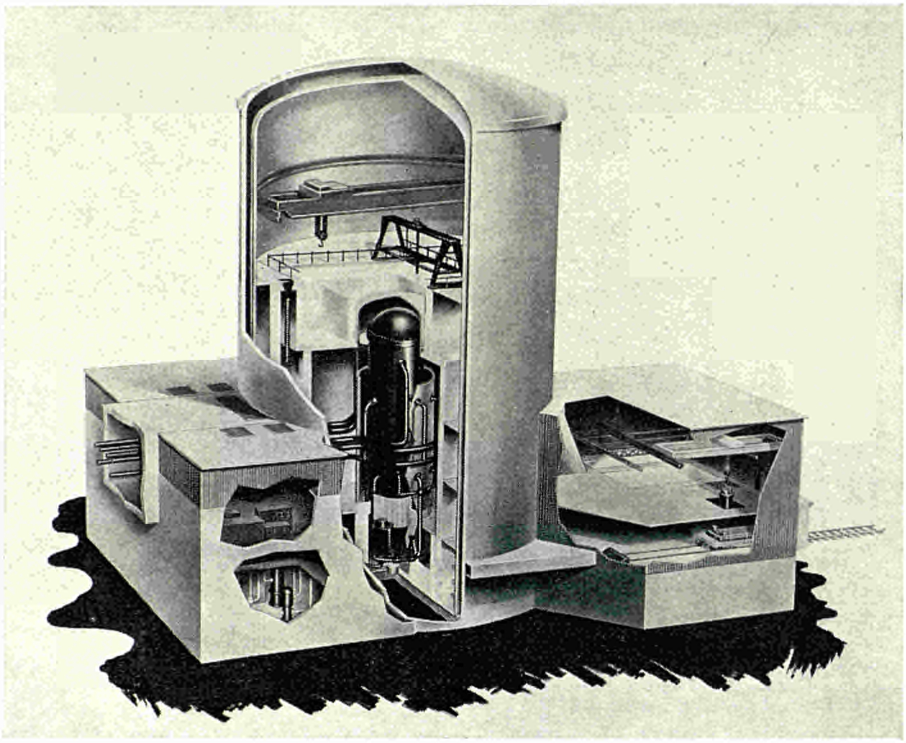


Fig. 5: *Artist's impression of latest General Electric boiling water reactor design:* BWR-6. BWR-6 *features improved core design and reactor components with greater safety margin, in addition to a new concept of concrete reactor containment* (Mark III) *and new turbine building layout to optimize total plant design.*

of 330 MWe, has been completed and will start operation in 1973 (see Fig. 7).

Fast Breeder Reactors — The development of commercially competitive fast breeder reactors has become a national objective since the President's Energy Message to Congress on 4 June 1971, in which he said "Because of its highly efficient use of nuclear fuel, the breeder reactor could extend the life of our natural uranium fuel supply from decades to centuries, with far less impact on the environment than the power plants which are operating today".

This statement summarizes the main incentives for developing the fast breeder, namely, their capability to conserve and extend nuclear fuel resources for several centuries by producing more fissile plutonium than they consume fissile uranium, together with their improved thermal efficiency over light water reactors. Among fast breeder reactor coolants, first priority is given to a liquid metal—sodium—on account of its excellent heat removal characteristics. In addition, the more advanced technology of the sodium-cooled fast breeder reactor offers better chances of early commercial development than do other types.

Unlike other countries (USSR, Great Britain, France), which are concentrating their *FBR* development efforts on demonstration plant operation, the United States' *LMFBR* programme has favoured a broad-base technology development. Through numerous experiments, the programme attempts to acquire wide knowledge of the main issues involved in reactor safety, fuel performance and component reliability.

In this context, some major programmes should be mentioned. Sound experience has been acquired through the design, construction and operation of the Experimental Breeder Reactor II *(EBR II)*. *EBR II* has now been working for about nine years, supplying very useful information on component performance, materials behaviour and operational stability. The Southwest Experimental Fast Oxide Reactor *(SEFOR)*, a 20 MWe sodium-cooled mixed plutonium/uranium oxide fast reactor, has successfully completed its experimental programme and is being decommissioned. The major purpose of the programme was to measure the Doppler coefficient accurately and to prove that *LMFBR* has a prompt negative Doppler coefficient sufficient to limit effectively the energy released in power excursions.

The Enrico Fermi Reactor is also to be decommissioned. This sodium-cooled fast reactor of 200 MWth fuelled with a metal alloy or uranium and molybdenum, ran into trouble in 1966 when an incident involving fuel meltdown occurred. It was not until 1970 that repair work was completed and reactor operation resumed. Despite its unlucky history, the Fermi Reactor Programme provided experience in sodium technology, reactor components, fuel handling and personnel training.

The Fast Flux Test Facility *(FFTF)*, which will be completed in 1974, is a main step in the *LMFBR* Programme. It is a 400 MWth sodium-cooled fast reactor the major purpose of which is to provide a flexible test bed capable of testing fast reactor fuel assemblies and components under working conditions typical of those in the *LMFBR*. Through the *FFTF* project important experience will be gained in the design, construction, operation and maintenance of *LMFBR*'s.

Finally, the key pin of the *LMFBR* Programme is the 350-400 MWe demonstration plant, construction of which was recently decided.

The contract, estimated at $700 million, has been awarded to Westinghouse. However the other two bidders, General Electric and North American Rockwell, will be encouraged to participate in the project through appropriate arrangements.

Plant construction should start in 1974 on the Clinch River site in Oak Ridge, which is owned by the Tennessee Valley Authority *(TVA)*. *TVA* and the Commonwealth Edison Company, in cooperation with *USAEC*, will operate the plant, which should be completed by 1980.

The demonstration plant project will attempt to prove the *LMFBR*'s technical and economic feasibility as well as environmental acceptability.

President Nixon added impetus to the *LMFBR* Programme during a visit to the Hanford site in September 1971, when he announced his decision to request the authorization of a second demonstration plant.

The introduction of commercially competitive *LMFBR* plants is predicted for the mid-80's.

A promising back-up concept to the *LMFBR* is the gas-cooled fast breeder reactor *(GCFBR)*, which offers potential in terms of high breeding ratio, high thermal efficiency, low capital cost and freedom from the problems involved in handling liquid sodium. *GCFBR* development will derive great benefits from work on the *HTGR* in the field of reactor components from the *LMFBR* fuel testing programme.

The development of the *GCFBR* is expected to follow the *LMFBR* with a delay of about five years.

Nuclear fusion — From a longer term perspective mention should be made of nuclear fusion, the advantages of which for power production purposes are universally recognized. First of all, there is enough deuterium available in sea water to satisfy the world's energy needs for many thousands of years. Secondly, in these days of environmental concern, fusion is particularly attractive on account of its freedom from fission products and explosion hazards and its high efficiency in converting fusion energy into electricity. Not uncommonly environmental groups, when attacking fission power, claim that insufficient support has been given to the development of nuclear fusion.

However, the widespread belief of the scientific community is that the engineering problems which need to be overcome to bring fusion technology to maturity (e.g., the design of the vacuum wall, blanket, shielding, insulation and superconducting magnets) are such that it would be absurd to neglect the development of the *FBR* to concentrate on fusion. Furthermore, fusion power also

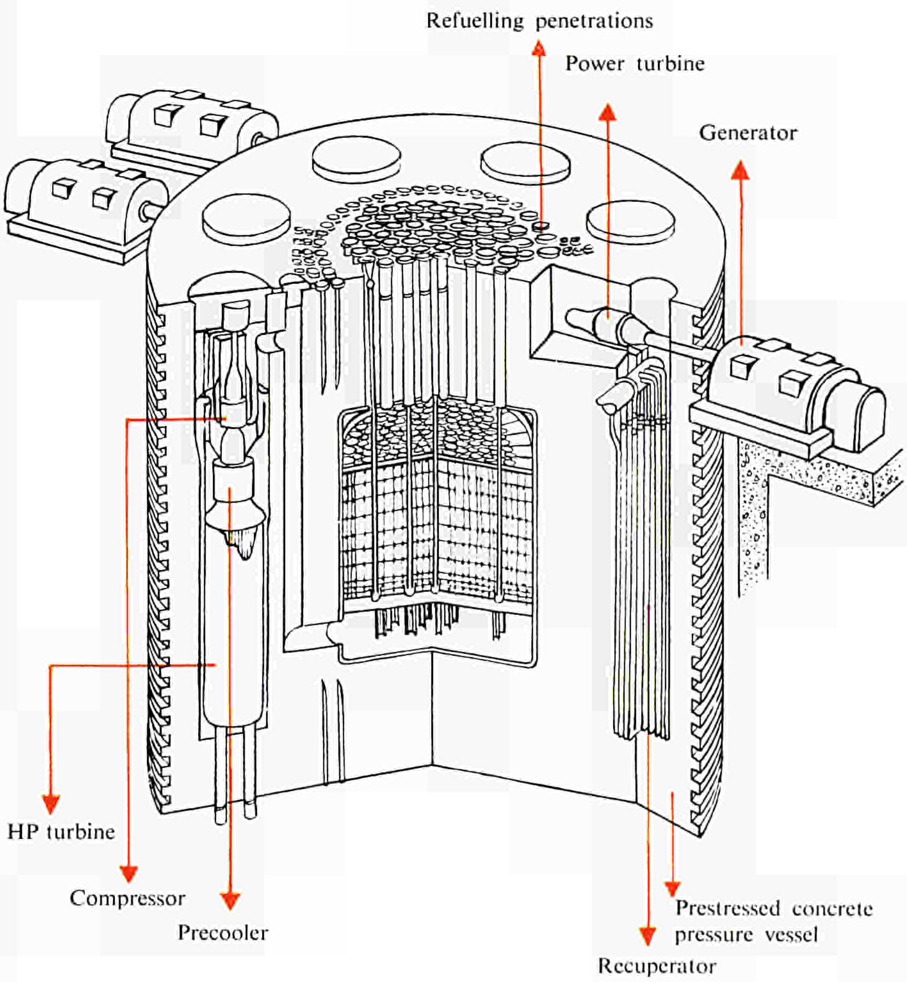


Fig. 6: *Direct coupling of a high temperature gas-cooled reactor to gas turbines. The sketch shows how the gas turbines are to be housed in pods in the prestressed concrete reactor vessel.*

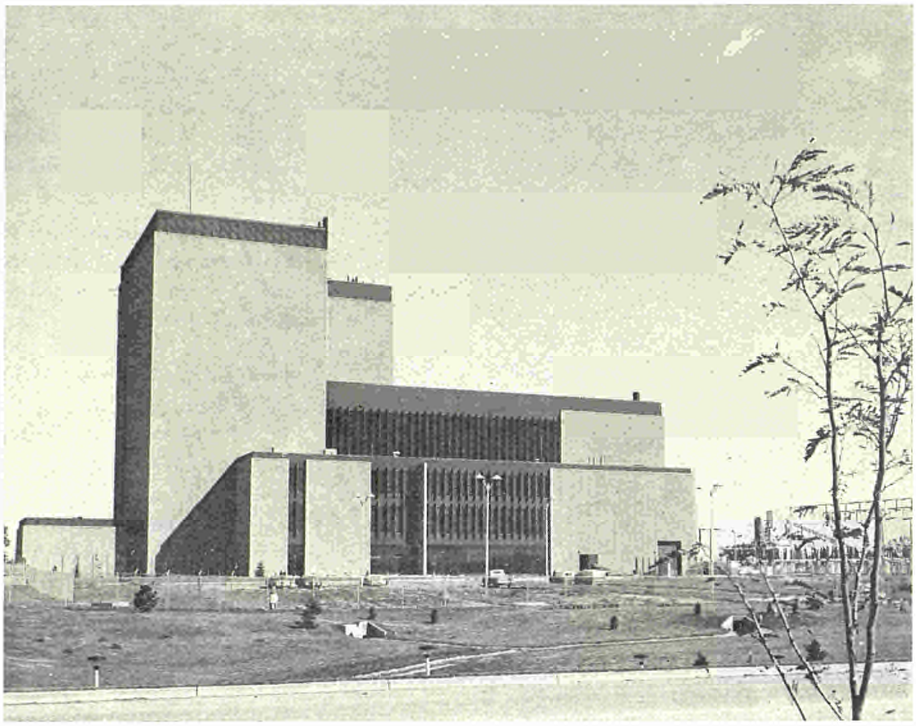


Fig. 7: *Fort St. Vrain, a* HTGR *demonstration plant of 330 MWe. The plant has been completed and will start operation in 1973.*

has some tricky environmental problems, such as tritium handling.

Demonstration of the scientific feasibility of fusion (interpreted as meaning breakeven between fusion energy output and energy invested to create the plasma) is the next goal in the fusion development programme. To attain this goal, several parallel paths are being explored which are characterized by different principles of plasma heating and confinement.

Recent success on both magnetic confinement and laser fusion has inspired confidence and optimism that the scientific feasibility of fusion can be demonstrated within the next decade. Thereafter, the development programme envisages the construction of plasma test reactors (10 MWth), experimental fusion power reactors (100 MWth), and prototype power reactors (250-500 MWth).

Finally, towards the turn of the century, demonstration fusion power plants (500-2 000 MWth) will be built for the continuous generation of economically and environmentally attractive fusion power.

Conclusions

The problems associated with nuclear power development in the United States must not be underestimated.

The over-optimism of the mid-60's resulted in a rush to nuclear power and found an industry unprepared to cope with the rapid increase in demand. As a result, delays in plant construction and cost escalations occurred. Increasing environmental concern on the part of the public and subsequent stricter requirements imposed an additional burden on reactor constructors and regulatory agencies. Now, however, the necessary adjustments are being made and nuclear power generation is considered an economic and clean means of meeting the nation's ever-increasing electricity needs.

The future of nuclear power looks bright. As a result of improved fabrication, performance and standardization, proven reactors will, it is estimated, provide about 30 % of all the electric power generating capacity by 1985. By that time such advanced converters as the *HTGR*'s will have established a base offering the utilities better fuel utilization and lower capital and operating costs. Meanwhile, the new contenders, the *FBR*'s, will have won their technical and economic spurs and will be able to offer a plentiful energy supply for centuries.

Finally, nuclear fusion development, although not free from high hurdles and uncertainties, promises to tap, on a longer range basis, a virtually infinite source of energy.

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On the subject of innovation...

An interesting solution to the economic use of research spin-off

ERNST GUILINO

> *Here is a second article—this time about a German institute—in the series on private or public bodies established for the purpose of helping to finance innovation.*
>
> *The first article in the series appeared in "euro-spectra", March 1972, Vol. XI, No. 1.*

RESEARCH and development are acknowledged as central factors affecting economic growth. Just as essential is the contribution they must make when the aim is for a constant or growing GNP to be accompanied by a rise in the quality of life for each individual. Applied research and development will provide the quickest path to directly useful results.

Basic research is important in that it triggers transformations which do not spring from an immediate need and are consequently to a large extent unplannable. These are just the very changes, however, that are of vital importance for the long-term development of the national economy.

It is common knowledge that over a period which, in the past, often equalled or even exceeded a human lifetime, nearly all scientific discoveries have found a technically and economically worthwhile application. Many of these have radically changed the lives of all the citizens of the industrial states. The period elapsing between the development of new ideas and their technical application has shortened in recent decades. Nevertheless, even today there is a widely held belief that no realizable short-term results are to be expected from basic research.

The style of scientific research has changed in recent decades. New and more complex problems are necessitating an ever-increasing amount of experimental equipment. Even small institutes now use electronic measurement and control techniques and modern data processing equipment to exploit their research results. Major research institutes, especially for nuclear physics, space research and plasma physics were born of the need for a widespread utilization of technology in the service of science. In methods of work and organization these major research institutes are closer to industry than to universities.

Every research scientist is nowadays forced to come to grips with technical problems. The new aspects of the questions under consideration—particularly in basic research—mean that the state of the art is often unequal to the experimental requirements. Technical and technological problems must first be solved if new scientific knowledge is to be won. Cases in point are the development of high-volume, superconducting magnets in fusion research, or the development of counters and energy analysers in nuclear physics.

ERNST GUILINO, Managing Director of the Technical and Scientific Department of Garching Instrumente GmbH.

Spin-off

Scientific advance therefore has a spin-off in the form of technical innovations and advanced developments, patentable inventions, and also know-how from major technologies. Whereas the primary results of basic research determine the technology of tomorrow, this spin-off has a direct influence on the technology of today, ensuring a quick return on the expenditure invested in research. This knowledge must be put at the service of science as quickly as possible so that the national economy, which provided the original financial backing, can reap the ensuing benefits.

The creativity of basic research should not be hampered, however, by simply considering the matter in terms of profit. Research institutes justifiably refuse to consider industrial exploitation as their task. Consequently, the knowledge which they have to offer to industry is almost always lacking in technical and economic terms. Research itself cannot help to provide the necessary information on capital input and marketing prospects which a firm needs in order to decide whether to make commercial use of new knowledge. In the past, this has often hampered the economically desirable flow of technically useful knowledge from research to industry.

Not only would intensive commercial activity go against the structure and aims of research institutes, but lack of time and staff would make it extremely difficult for them to take account of all market requirements when engaged in the—for them—uncongenial task of exploiting spin-off. This sensitivity to the needs of industry is, however, the first essential, if economically useful results are to be obtained.

A completely new solution

The *Max-Planck-Gesellschaft zur Förderung der Wissenschaften eV (MPG) (Association for the Promotion of the Sciences)*, an independent German organization for basic research, tried to overcome these problems by a new approach. In March 1970 it founded the *Garching Instrumente Gesellschaft zur industriellen*

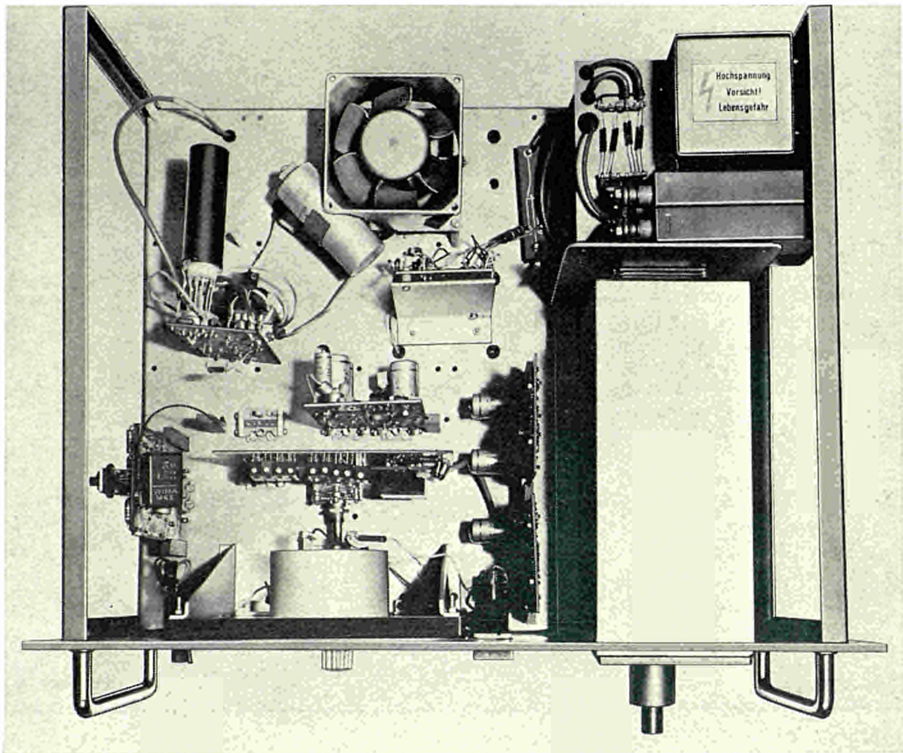


Fig. 1.

Nutzung von Forschungsergebnissen mbH (GI) (Association for the Industrial Utilization of Research Results). The Association was set up as a genuinely commercial undertaking with a capital of DM 500 000, organizationally separate from the *MPG* and with a staff ot its own.

The broadly defined company objective "Economic utilization of the experience and inventions of scientific institutes, with particular reference to the Max-Planck institutes" permits *GI* to choose the most appropriate method of exploiting each individual product, including development and production by *GI* itself as well as the marketing of these products on its own account.

MPG thus tries to avoid the disadvantages of existing forms of utilization company. Pure patent utilization centres, which are usually institutionally linked with research institutes financed out of public funds, are hampered by being confined to issuing patents and by the fact that they are unable to seek further means of exploitation or to raise funds on the capital market. Pure production companies ("spin-off companies") engaged in the direct exploitation of individual research results are not in a position to do justice to the wide range of developments stemming from the Max-Planck institutes.

The enjoyment of such a high degree of independence and freedom of action implies a higher economic risk for *MPG* in its capacity as chief partner; this risk is limited by making the company of the GmbH type; this also makes the scale of the economic success or failure controllable.

The position aimed at by the *GI*, i.e. intermediary between research and industry, finds repeated expression in its structure.

The management of the company is advised and supervised by an advisory council consisting of six experts from industry and science.

Granting of patents

An important part of the *GI*'s task is, of course, to file patents and registered designs of the Max-Planck institutes and to assess their economic potential, to set up industrial contacts and ultimately to conclude patent agreements. According to the formal statement of the company's objective, this service is at the disposal not only of the Max-Planck institutes, but also of all research institutes which wish to avail themselves of it. Most of the items which are at present exploited by means of patents (approx. 701) come from the Max-Planck institutes; contributions are also made, however, by the *DFVLR*[1], the *Hahn-Meitner Institute* in Berlin, the *Gesellschaft für Strahlenforschung und Umweltschutz* in Neuherberg near Munich and various institutes attached to institutes of technology. Two patent applications have been filed by independent inventors.

A total of 39 contracts have been concluded by the company in its active life of slightly more than two years. The subjects covered by these contracts range from high-grade physical measuring apparatus (e.g., ionic microprobes) to small items of laboratory equipment (shields, filters), from the manufacturing process for a substance for detecting drug abuse to biological sewage plants. Almost all of the *MPG*'s scientific fields are represented.

Main terms of contracts

Experience gained hitherto has led to the development of a preferred form of licencing agreement, which can be modified in each individual case according to circumstances. A number of important conditions are common to all agreements, however. The payments made by a licensee are divided into a fixed fee, payable on conclusion of a contract and not repayable under any circumstances, and a fee which is dependent on turnover. The fixed entrance fee helps to cover the institute's development costs and ensures that the licensee will have an interest in actual commercial exploitation. Furthermore, all contracts can be immediately terminated should a licensee be demonstrably guilty of insufficient activity. Liability is contractually limited to the veracity of the assurances given to the licensee during negotiations with regard to the scope and quality of the subject of the contract. Another condition guarantees that further research at the institute, freedom of publication and the possibility of scientific cooperation shall not be adversely affected by the granting of a licence. Since practically all licensing contracts are concluded long before a patent is granted, and sometimes even before laying open to public inspection, an agreement is necessary whereby, in the event of rejection or limitation of patent rights, the licensee shall be allowed to reduce his licence payments on each item produced. The actual impairment of economic success is taken as the yardstick of the amount of this reduction.

Exploitation usually begins immediately after the patent has been applied for. During the priority year experience is gained which enables the decision regarding the extent of protection in other countries to be taken on a factual basis. On conclusion of a licensing contract in other countries, the costs of applications are as a rule borne by the licensee.

Distribution of proceeds

As, in the conclusion of licensing contracts, *GI* acts as commission agent, all licence income initially accrues to it. *GI* receives 20-33% of this income. These funds must also cover the costs incurred in other cases where the attempt at exploitation proves abortive. Handling fees, irrespective of the success of the operation, or regular budgeted payments are not paid to *GI*.

After deduction of commission, the remainder is divided into payments to the institute where the invention originated and payments to the inventor who, as an employee, is entitled to a share of the proceeds in accordance with the law governing inventions made by employees.

Prerequisites for successful licensing transactions

Experience hitherto has shown that there are a number of prerequisites for effective licence exploitation. One of the most important is the possibility of granting exclusive licences. The majority of those who have been parties to contracts hitherto stated that they would have had no interest whatsoever in a simple licence. The cost of developing a product from the working laboratory prototype stage, as a basis for a patent application, to the mass-producible industrial model stage is higher than that of developing the prototype. Without the protection of an exclusive licence, only the large industrial companies can afford to assume this innovation risk, which is further increased by marketing costs. Understandably, even these large firms are usually unwilling to accept such a risk. For small and medium-size companies, the innovation risk may well be unacceptable.

The experience gained hitherto with licensing negotiations indicates that the policy followed by national and supranational authorities, i.e., in general to grant only simple licences, constitutes a structurally undesirable form of preferential treatment for companies and hampers the exploitation of know-how acquired by means of public funds.

The success rate in licensing negotiations could be raised by offering extra services. No entrepreneur is interested in technical progress for its own sake. He seeks a better economic result in the form of increased and cheaper production, etc. The offer of a licence should therefore contain not only a technical description, but also an initial market assessment, and should also refer specifically to the technical and economic advantages estimated to be obtainable in the addressee's business. *GI* does not, therefore, offer inventions in the form of printed information sheets or prospectuses, although it would be cheaper to do so, but rather by means of personal letters. *GI* benefits from its own experience of the innovation process when preparing licence offers to the addressee. In fact, this is one of the reasons why *GI* should not just confine its activities to negotiating licences.

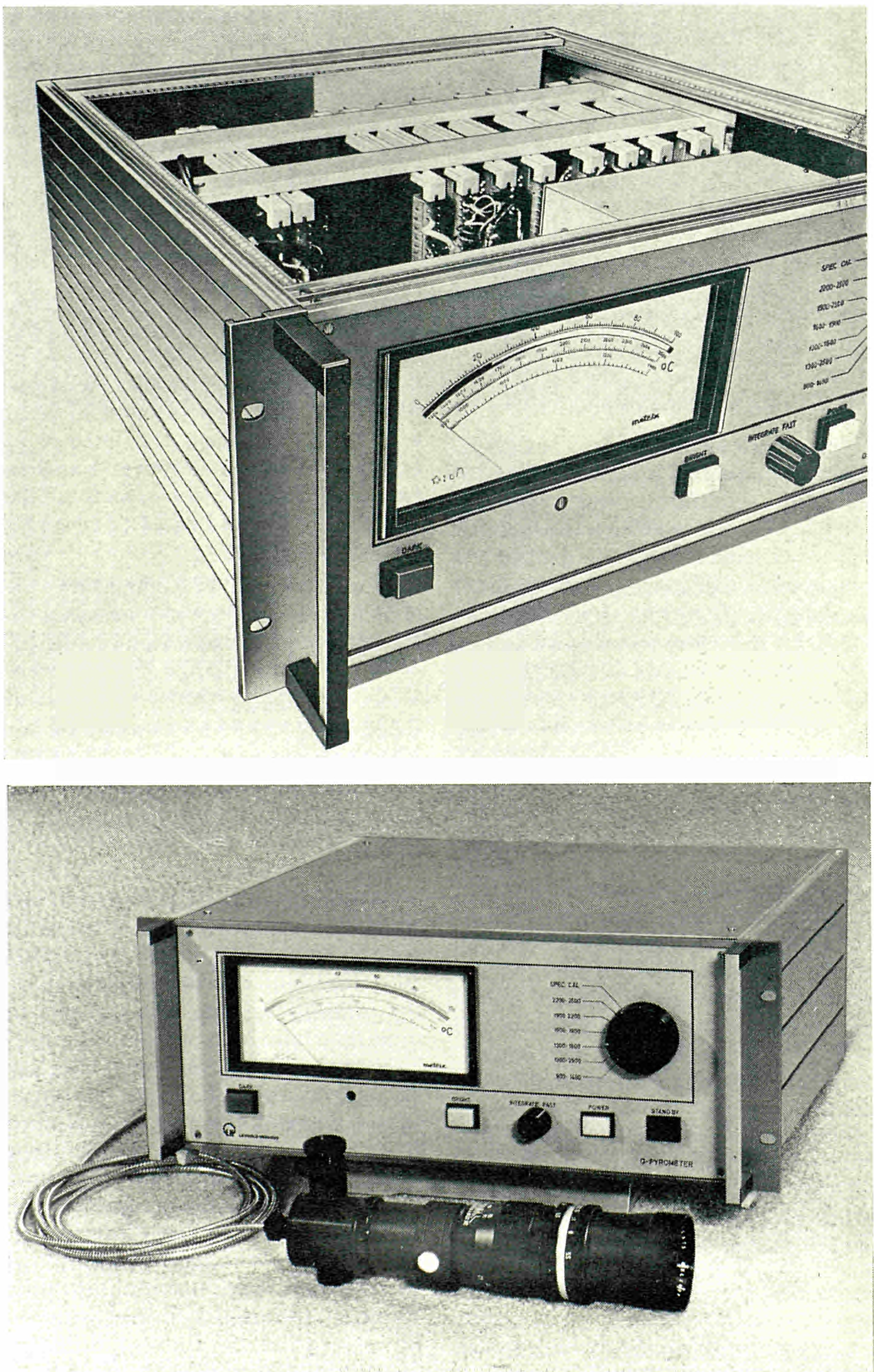
Another reason is that, in the initial years at least, the revenue from the licensing transactions by no means suffices to cover the fixed overheads. Remunerative trading is necessary in order to offset this shortage of capital.

Preproduction series

Moreover, such trading can effectively support the granting of licences. Spare development and production capacity is a rarity in German industry today. It might therefore be profitable for the licensee to engage *GI* to design and build a limited number of appliances up to the stage of series manufacture, especially since *GI*, as a relatively small undertaking, has so far been able to keep its overheads below those necessary for large companies. This enables the licensee to put his new product on the market before building up his own capacity. The experience gained in selling the pre-

[1] Deutsche Forschungs- und Versuchsanstalt für Luft- und Raumfahrt.

Fig. 2.


SPEC. CAL
°C
DARK
BRIGHT
INTEGRATE FAST
POWER
STAND BY
G-PYROMETER

production series permits a far more accurate assessment of the final demand.

Figs. 1 and 2 show an example of these activities. The prototype of a quotient pyrometer from one of the Max-Planck institutes is compared with the more advanced instrument developed by *GI*. Up to now *GI* has received orders for and delivered 30 instruments. A similar number will probably be constructed before the licensee starts production. A further development contract is at present operative; in some other cases specimen apparatuses are being built.

Own products

The main drawback of the manufacture of preproduction series for licensees is that these contracts are issued irregularly and come to an end after a relatively short time. In order to reduce the difficulties inherent in this discontinuity, *GI* confines its activities to the development, final testing and in some cases final assembly on the premises of the specimen apparatus.

The manufacture of components is subcontracted to suppliers, who in the south of Germany are available in sufficient numbers and are of adequate quality. The fact that some of these are located in the underdeveloped areas of Bavaria which are handicapped by their close proximity to the frontier is a lucky secondary circumstance.

GI is building up a more regular and plannable branch of business through its practice of manufacturing and marketing equipment developed by itself.

For the preproduction series of the quotient pyrometer mentioned above, it proved necessary to develop a loadable reference voltage source, the possible applications of which were not limited to the pyrometer. These devices were therefore built and offered for sale separately; thanks to the relatively simple design they were the first product with which *GI* appeared on the market. Several hundred of them have since been sold, in particular to large German companies.

GI is building up a technically more sophisticated production line in the form of non-linear optics. Last year a variable-frequency giant-pulse laser was developed, based on a thesis written at Munich Institute of Technology. The frequency-doubled light of a ruby laser of holographic quality pumps an optical parametric oscillator, the output wavelength of which can be varied continuously between 400 nm (blue) through red into infrared (2500 nm) by simply rotating an $LiIO_3$ single crystal. Further development work is being carried out in order to close the small gaps which still occur in this tuning range. It is clear that a tunable laser light source of high spectral purity and intenstiy will be of great value in absorption spectroscopy, photochemistry, and, because of the short emission time, for examining the lifetime of excited atoms or molecules. The first of these instruments were delivered to clients at the end of 1972. This branch of business can be extended to cover fields associated with non-linear optics such as frequency doubling and multiplication. The interest expressed by clients up to now gives reason to hope that this field of activity can become self-supporting.

In accordance with the members' intentions when setting up *GI*, it is not proposed that this "home-grown" production should compete with industry on any appreciable scale. Where it does not benefit industry directly, as it does when building up a preproduction series for licensees, it involves equipment which, because of its very special nature and the limited numbers manufactured, is of no interest to large companies. The variable-frequency giant-pulse laser is the first instrument of its kind in Europe; a further variable-reactance oscillator is available only in the United States, but, in view of its properties, is a complement rather than a competitor. In principle, *GI* is prepared to hand over its own production operations to industry under a system of licences where this is commercially warranted.

Marketing

It is, of course, not sufficient just to build high-grade equipment: rather, it is the efficiency of sales operations which is decisive for commercial success. The decision to carry out its own production was easier for *GI* in that sales activities had already been included when *GI* was being set up: *GI*'s third commercial field of activity is the sale of standard equipment to institutes.

In large institutes with a relatively one-sided bias (e.g., MPI für Plasmaphysik, Garching) standard equipment is developed for the institutes' own purposes. Such equipment is used for frequently occurring tasks within the field of action of the institutes for which no commercial equipment is available. Since every important field of research is being investigated by various teams both at home and abroad, this standard equipment fills existing, albeit relatively small, gaps on the market.

An example of this kind of equipment is the supericonoscope camera shown in Fig. 3, of which *GI* have hitherto made more than 40. More than half of these are installed in the institute itself. The construction of larger series, however, led to a reduction in costs and the associated development costs. Through the intermediary of *GI*, the remainder of these cameras are now available on the free market; apart from being used in other research institutes, they are also employed in the laboratories of large domestic and foreign companies.

The only other competitive instrument in this field is a very expensive camera of US make. Since it has emerged that steady sales can be expected for this camera, *GI* is now taking over its subsequent manufacture.

Apart from the supericonoscope camera, noteworthy sales have also been achieved for pulse generators, surge capacitors, switching spark gaps and magnetic field coils.

In some cases, especially abroad, the marketing of the equipment produced by *GI* and the institutes was put in the hands of other companies; *GI* normally announce details of the equipment by means of advertisements or direct mail. *GI* reaches a wide circle of clients by having its own stands at three or four industrial exhibitions a year, providing the public at the same time with a survey of technical developments at *MPG*.

Turnover and revenue

GI has been able to keep operating costs at a relatively low level with its current staff of six. As has already been stated, the income from licensing negotiations was by no means sufficient to cover these operating costs.

Together with other branches of industry (development, production and sales), *GI* achieved a turnover of 0.5 million in its first year, which increased to 1.2 million in 1972. The rapid growth illustrated by these figures gives reason to hope for profits in the near future.

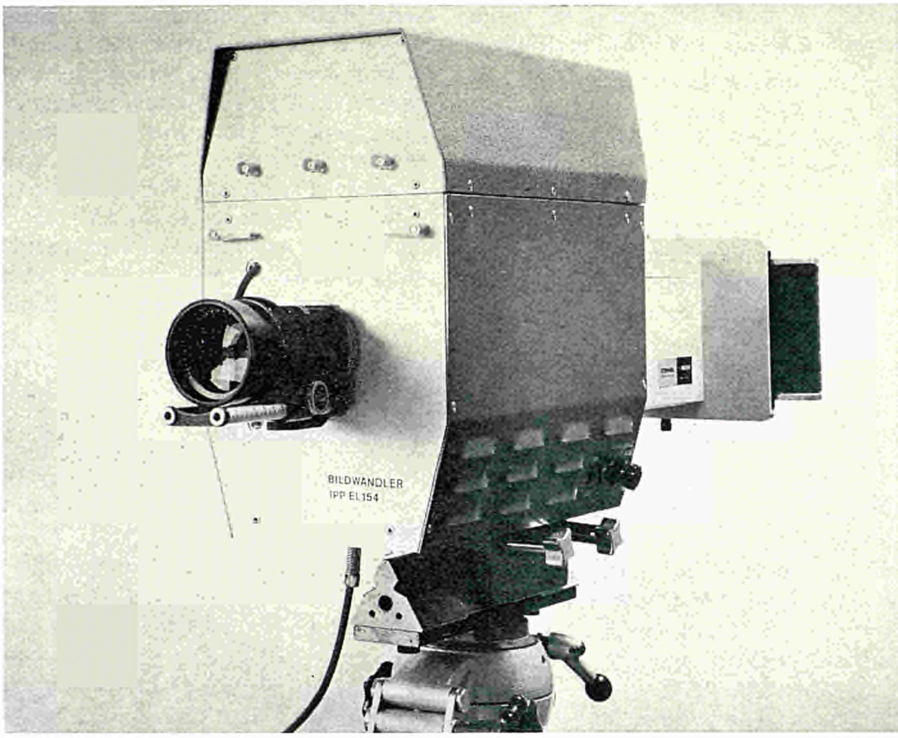


Fig. 3.

The distribution of profits on company shares is precluded by the Articles; they accrue instead directly to *MPG*, where they help to finance new research and development projects, though their contribution in the foreseeable future will be modest.

Benefit to MPG

MPG and its institutes benefit more from direct financial feedback and from services than from the estimated business profits, 67-80% of the income from licensing contracts being forwarded directly to the institutes; the institutes as well as the inventors, who are guaranteed a share under the law governing inventions made by employees, received several DM 100 000 in the first two years of operation. *MPG* attained savings on patent costs of a comparable amount. Employees' inventions which seemed to hold little promise of economic viability were made over to the inventors after examination. The high costs of further declarations in foreign countries are in most cases borne by licensees.

Even in cases where a licensing contract could not be concluded in the first year, the experience gained up to that time concerning the commercial viability of the product or process provides criteria on which to base a decision as to whether or not revenue from further declarations can be expected.

It is precisely the value of these services which does not emerge from the *GI* balance sheet, which therefore gives an incomplete picture of the benefits accruing to *MPG*.

Experience

The creation of *GI* was viewed with scepticism by certain institutes and by a number of industrial firms. In the meantime, scientists and industrialists have admitted that the services offered by *GI* benefit both parties while at the same time promoting such contacts between them as are necessary for the benefit of the national economy. Two years after the setting up of *GI*, the conclusion can be drawn that the novel step taken by *GI* of merging its licensing agency with its own commercial development and production activities served the purpose and helped to ensure that valuable technical and scientific know-how acquired with the aid of substantial public funds can be transferred to the user without further subsidies from tax revenue.

EUSPA 12-6

The Future of Automatic Information Systems

GEORGES ANDERLA

PICTURE TO YOURSELF, by a stretch of imagination, that a responsible research organization endowed with sufficient means has consulted a few thousand hand-picked European scientists and experts as to the main innovations which they think likely to occur and come into widespread use in the next 25-30 years. Assume further that this survey has produced several hundred of the most significant technological events, and that the same group of interviewees would then be asked to indicate what chance there is that these expectations will be realized, the year this is likely to happen and finally the scientific, economic and social implications of these future breakthroughs. Finally, suppose that some statistics were prepared on the basis of the replies received and then given to each of these scientists to induce him either to modify or to justify the forecasts he made in the first place.

The picture we have just outlined is far from being purely speculative; the story did actually occur, except that it did not take place in Europe. A Delphi survey of this magnitude, covering 4 000 scientists and experts and listing their considered opinions on more than 600 technological events, was undertaken and successfully completed in Japan in 1970-1971, with the support of the Minister for Foreign Trade and Industry, Mr Tanaka, who has since become Prime Minister.

We do not intend to describe at length all the advantages which industry and the Japanese government can derive from these forecasts, which are, incidentally, based on a broad consensus of opinion. The main interest of the Japanese survey —which was in fact preceded by a number of American surveys of more modest scope—is to be found elsewhere. What is really at issue here is the very nature of the social order which has the best chance of establishing itself in the world in the long run.

GEORGES ANDERLA, Institut d'Etudes Politiques and Université Paris-Panthéon-Sorbonne.

Science and information, the dual linchpins of post-industrial society

The experts are practically unanimous in their opinion that the end of the decade 1970-1980 will also mark the end of the industrial society and the advent of the information-oriented society. "Information" here is not to be understood in the narrow sense of information processing, but in its broadest sense, namely, the concept of information as a resource. For there is every reason to believe that this particular, yet intangible resource will by then supersede in importance many material and energy resources.

It is an open question when this central prediction, to which all the other forecasts are directly or indirectly linked, is most likely to be realized, and indeed whether or not it is well-founded.

Consequently, it is more necessary than ever to make an accurate estimate of the future expansion in the first instance of scientific and technical information, and then, in a wider sense, of the transfer of information in general and in all its forms.

Such is the prospective evaluation which we are going to attempt, using, amongst other things, some figures contained in two recent studies which we had the opportunity to carry out for the *OECD* [1], and developing at the same time a number of new lines of approach.

[1] Future needs for information specialists – A forward study. Part I. A survey of surveys. Part II. Future supply of and demand for scientific and technical information. *OECD* Study, Paris, 5.4.1972.

To begin with, here are some significant figures. The total stock of our scientific information in 1970 can be estimated, after excluding duplications, at about 25-30 million documents and records of all types. The annual output of new scientific information is at the present time in excess of two million articles, technical reports, proceedings of meetings and other primary source items. Finally, the number of authors of scientific writings and recordings is certainly higher than 10 million.

Since the turn of the century, scientific activity and the volume of literature produced by research workers have increased in geometrical progression, doubling every 10-15 years. An indefinite exponential growth at such a high rate is unthinkable, and it was therefore expected that the rate of increase would slow down, especially after the early fifties. Our research shows that, far from showing any letup, the quantitative increase in scientific information is on the contrary tending to accelerate.

The main forces and factors of growth

This accumulative process, which is bound to produce some formidable material problems—problems of data acquisition, storage and redistribution—can be explained by the combination of several growth factors acting moreover in conjunction with a powerful, built-in accelerating mechanism.

In correlation with the increase of expenditure on research and development, the number of scientist authors is continuing to rise, in the world as a whole if not in each country. Their inventive and literary "productivity" is growing at the annual rate of 2.5-4% per capita. The human sciences are already at a par with the exact sciences as regards the volume of texts produced. Whereas the volume of scientific information is growing fast, the growth of technological information and data is even faster.

This upward trend is fostered by the general introduction of new measuring, recording and reprographic techniques, and by the widespread use of simulation as a scientific investigation method. The high rate of expansion which has been maintained in the generation of new information is also due to the emergence of new scientific disciplines and to the breaking-up of older disciplines into

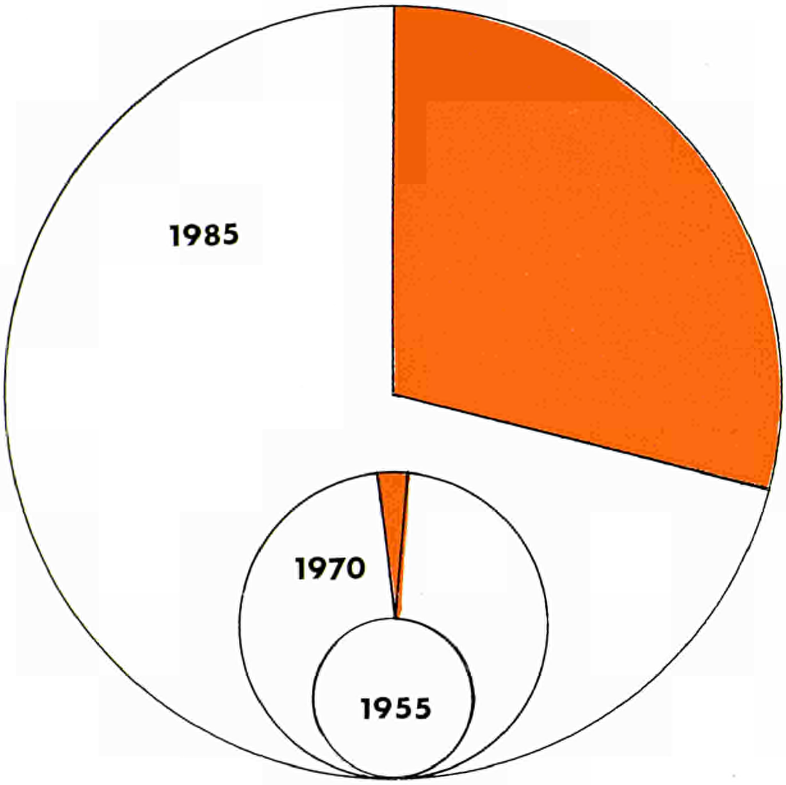


Fig. 1: *Quantitative growth of information in relation to accelerated automation: in retrospect for the period 1955-1970 and as forecast for 1970-1985.*

The volume of scientific and technical information (from primary sources) has quadrupled over the last 15 years. From now until 1985 it can be expected to increase sixfold over the 1970 level, showing a growth rate, assumed to be constant, of 12.5% a year.

Whereas automatic systems (shown in colour in the diagram) only carry out the transfer at the present time of about 1-2% of all information, around 1985 automatic systems and networks will process 50 times that amount and will therefore deal with between a quarter and a third of all data communication.

several new specialized fields such as biochemistry and laser/maser technology which are expanding at a double-exponential rate. The fragmentation of science, far from ruling out pluridisciplinary research, in fact calls for it, and hence for pluridisciplinary information. While information as a resource (or input) contributes to these various types of growth, information as knowledge (or output) is sustained by them.

The impetus of the growth of information transfer seems to be ensured by some independent intrinsic force, which acts synergetically with all other growth factors. Assuming that the number of scientists suddenly ceased to rise and all the other growth factors were similarly cancelled out, the supply of and the demand for information would nevertheless continue to increase.

Any change which modifies, however slightly, the existing order of things, for example, the definition of a new economic or scientific policy, or the fixing of new social objectives (environment, quality of life, etc.), creates new information needs requiring at the very least the selection or synthesis of old information (repackaging) and calls, in fact, for additional information.

Quantitative estimates covering the next 15 years

Consequently it is likely that by about 1985 the production of new information will reach 12-14 million items annually, i.e., six to seven times the present rate. The total stock of documents will then be something like 120-150 million. An extremely vigorous and prolonged expansion—somewhere in the region of 12-13% per annum—may therefore be expected.

It can reasonably be assumed from the estimates that 15 years from now the supply of and demand for information, particularly scientific and technical information, will be 20-25 times that of scarcely 15 years ago.

Conventional manual methods will clearly be unable to cope with these vast quantities of data. In 15 years' time the choice will inevitably be one between asphyxiation in a deluge of unorganized information, and automation on a huge scale, which will be bound to bring with it an organized system of information processing and transfer, beginning with certain priority sectors.

The experts agree that in the fields of research and technology, medicine and health, education, culture and the mass communication media, there will be in about 1985 more than 40 different applications of data processing, even though some of them will be complementary. Altogether, the number and capacity of automatic systems fulfilling the needs of this socio-cultural sector will in 1985 be almost 100 times that of the electronic data processing facilities existing at present.

In addition to these specific needs there will be the demand for information—sometimes comprehensive and sometimes individualized—originating in the apparatus of production and distribution, political authority and public administration, and innumerable decision-centres, not forgetting the wide range of different institutions and individuals in their capacity as citizens, consumers, producers, tax-payers, litigants, social security beneficiaries, etc.

In general it may be estimated that by about 1985 automatic systems will be able to deal with the transfer of 25-30% of all information. This proportion may at first sight seem modest, but it should not be forgotten that in the meantime the mass of information to be collected, stored and redistributed will have multiplied six or seven times. This means that one quarter of the total volume in 1985 will already be half as much again as the total amount of information produced and put into circulation today.

The days of present automatic information systems are numbered

Nevertheless, since man's brainpower cannot be extended indefinitely, it will be necessary to design future information systems in such a way as to supply complete, relevant and noise-free information to every individual or collective user.

It will soon prove impossible to achieve this level of efficiency and personalization, at tolerable cost, simply by improving and enlarging existing systems, as people are too inclined to believe. It is likewise quite erroneous to suppose that phenomena of these dimensions can be brought under control by setting up networks (wrongly called integrated) through the interconnection of independent specialized systems.

Actually, the systems which at present carry out—after a fashion—the function of information transfer appear to be totally inadequate for the needs and the degree of complexity which will have been attained by the middle of the next decade.

It is a fact that all our present systems operate on the principle of linear data processing, which consists in repeating the same operations in their entirety as many times as there are demands to be fulfilled—that is, very few at the moment. But since the quantities to be processed will increase exponentially and needs will become diversified, the solution will have to be sought on the lines of a, say, three-tier system, i.e. a) standardized, yet systematic processing of all input data, followed by b) their processing using a sophisticated segmentation of interest-profiles, to be followed up when required by c) "tailor-made" processing in the final stage.

In order to achieve some significant economies of scale, several conditions will have to be fulfilled. Not only should the total volume of demands increase to the point where exploitation on an

Fig. 2: *Successive stages in the development of scientific information culminating in the concept of total information.*

The future of automated information is the product of an evolution beginning three centuries ago and characterized by the exponential growth of each of the different types of information, each of which was added to the others rather like the successive layers of an onion.

Some significant dates stand out in this process, roughly as follows:

1665 – emergence of the first scientific articles (primary information);

1830 – publication of the first digests and abstracts (second-level information);

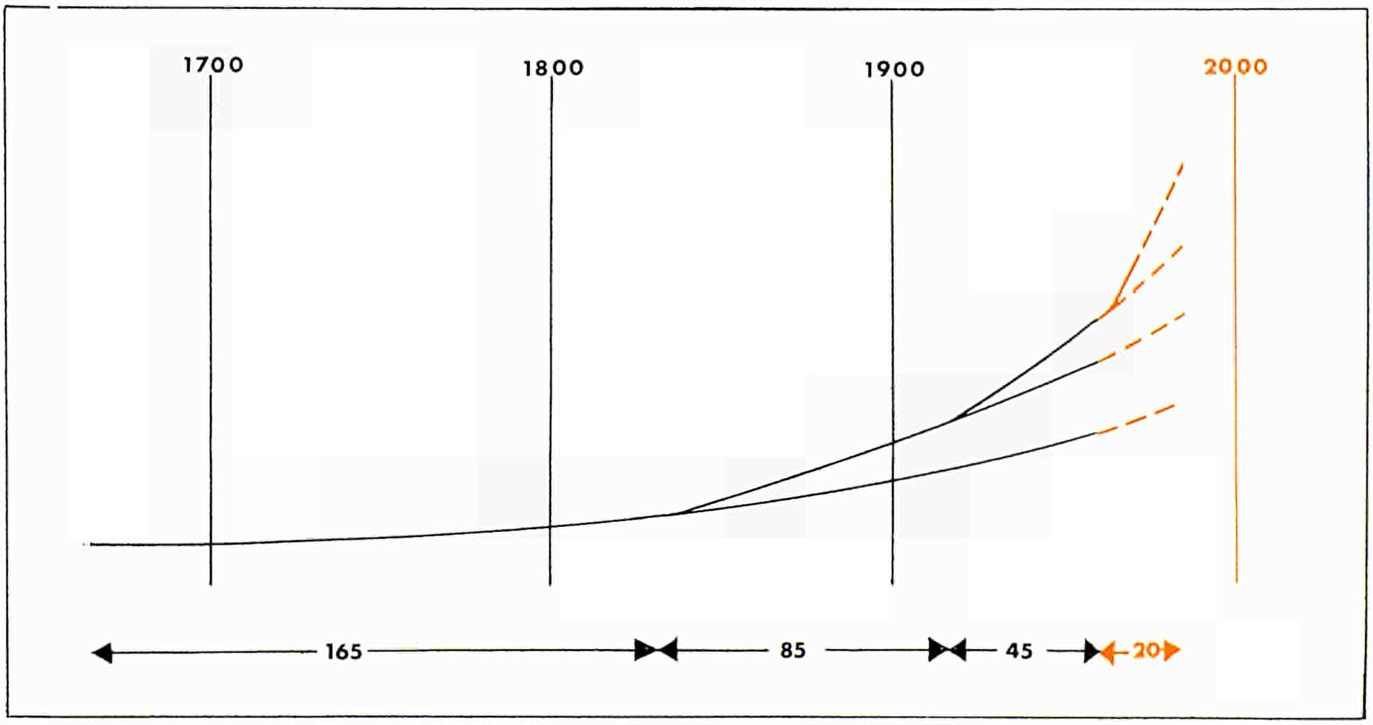
1915 – distribution of selected up-to-date information (third level);

1960 – beginning of the automation of specialized information (fourth level: analysis and synthesis of information);

1980 – automation and permanent recycling of all information (superior level of information, or integrated and/or individualized information).

Each successive stage has seen the creation of a new type of facility, e.g., (a) *scientific journals;* (b) *bibliographic description services;* (c) *specialized libraries and analysis centres;* (d) *data banks and automatic systems;* (e) *teleprocessing networks on a vast scale.*

The successive stages lasted 165, 85, 45 and 20 years respectively. This approximately geometric progression simultaneously underlines the acceleration of the general increase of information, gives an indication of the growing complexity of this phenomenon and, finally, confirms indirectly the forecasts regarding the emergence around 1978-1980 of large integrated information networks.



industry-like scale will be possible, but above all the initial standardized processing method will have to be carried out in depth and the profile-segmentation processing will similarly have to be taken as far as possible in order to minimize the non-divisible expenditure on the final individualized processing stage.

Future remote processing systems will have to be capable of providing indifferently a very wide range of services: answers to specific questions, comprehensive or selective reviews and reference lists, retrieval of texts in abstract form or in their entirety, "browsing" facilities, initiation of the inquirer into a field new to him, and complex synthesis to aid in the formulation of new hypotheses of research or application. There will have to be other services in addition to these conventional ones: information for engineers and technicians, automatic error detection, programmed instruction and management information prepared to fit the requirements of different management levels.

These future systems will also have to be able to operate on-line and off-line and to be subject to much stricter constraints as regards reliability, access conditions, response time, instantaneous translation, feedback, etc.

In the present stage of their development, automatic information systems (which in actual fact represent the supply side) only provide two or three different types of service each, and this either free of charge when they are subsidized, or at relatively high rates, which in the private sector necessarily has to apply. The consequences of this setup are well known: a very limited circle of users, chronic under-utilization of the installations and the connected telecommunications facilities, frequent and often contradictory criticism from different categories of users but levelled almost exclusively at the inadequacy of the services.

In the future, therefore, it will be necessary to bring about a fundamental change in this relationship between supply and demand, by matching supply to rapidly-growing and highly-diversified demand. Yet, this "match" can only come about by giving up the repetitive processing and retrieval of each specific piece of information, in favour of the concept of the multidimensional processing of information in its entirety.

Multiple networks to ensure the recycling of total information

This change of approach of course will have some major repercussions.

It will sound the knell of that parochial spirit which still seems to typify the majority of existing automatic information systems and which is not altogether concealed by the declarations of intent of their managers who declare themselves prepared to support inter-system exchanges but have nothing more in mind than a modest dose of hardware compatibility.

Standardized in-depth processing (stage 1) and again segmentation-oriented processing (stage 2) will require an entirely new set of both EDP and bibliographic techniques, from the initial analysis and classification, which in future will have to to be multi-facetted, to retrospective research methods, which in the last resort will have to be based on the use of grids and successive switching, via a corresponding organization of data bases, access to which will have to be on a hierarchical system.

As regards design and organization, the network formula will doubtless be the one to assert itself. However, the type of network which is most likely to prevail in the future will almost certainly have only a very remote relationship with the currently accepted idea of network. For it will not be sufficient to interconnect individual specialized and decentralized systems and subnetworks and make the corresponding hardware and software compatible.

The different parts and pieces, or nodes, of the vast, net-like organization for automated information will have to be continuously groupable and regroupable in a thousand different ways: initially this will certainly be in accordance with users' needs determined *a posteriori*, and later it will follow estimated needs, i.e., in accordance with their frequency distributions which will be possible to determine in advance by means of sophisticated simulation.

Only then will it be justified to speak of the recycling of information, which in fact means nothing else but the rational and systematic re-use, at any time, of the totality of information immediately or potentially available.

EUSPA 12-7

The reshaping of transport networks as a result of regional planning

JACQUES FEDERWISCH

Regional planning

REGIONAL PLANNING causes land to be assigned uses in accordance with specific criteria resulting from the political will of the governments or administrative authorities of a region. Such an assignation of use prescribes areas for the development of homes, industry, business centres and other services, included among which are the transport infrastructures necessary to provide human and commodity mobility in the most harmonious manner. Natural trends in the standard of living also give rise to an increased need for goods and services, coupled with a sometimes explosive growth of mobility.

The development of transport infrastructures takes place against such a background. Through a feedback effect, however, the provision of new infrastructures affects the regional pattern by attracting new settlement and traffic activities (Fig. 1).

Economic science enables these various effects to be plotted on a theoretical basis, but their mathematical quantification usually comes up against the precise definition of units of measurement and the acquisition of scientifically valid data, a fact which explains certain apparent discrepancies among the various regional studies. Because no one has yet been able to devise a general formula of practical value, we still have to refer to specific instances.

The problem is increasingly tricky where the regions in question are more densely populated, more highly industrialized and/or enjoy a higher standard of living.

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Mobility of labour and goods and the removal of customs barriers

Until recently the various Member Countries of the European Community were enclosed within political frontiers side by side with customs barriers that restricted—or hampered—inter-state trade.

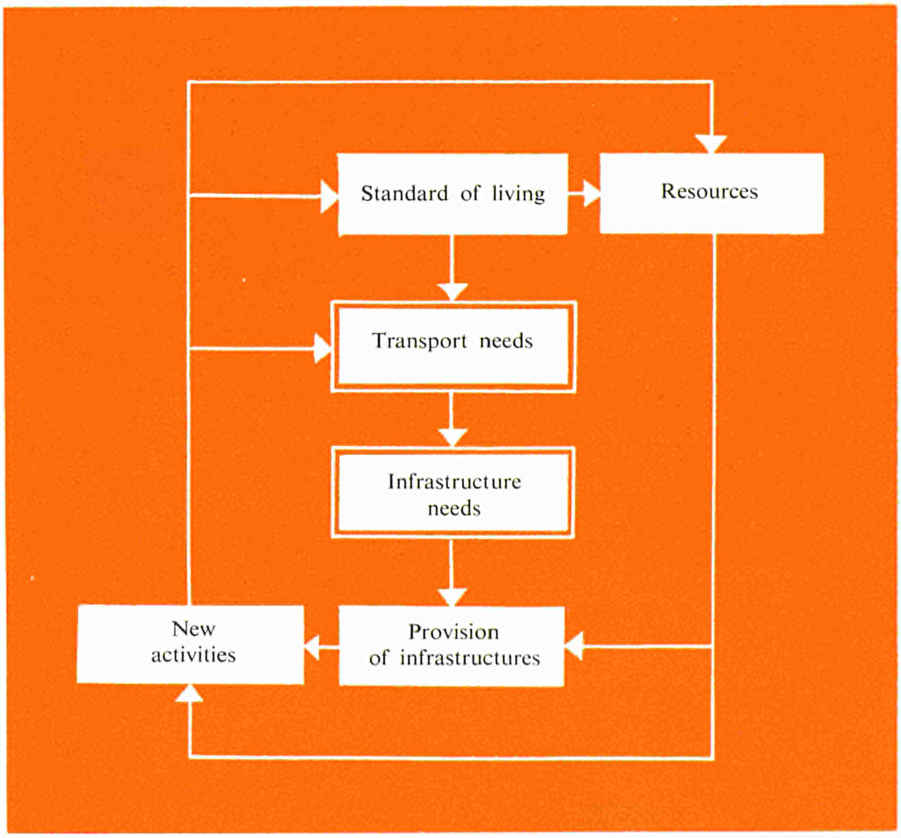
If, for example, we look at the map of road and railway networks in Western Europe before 1960 we see that almost all of the roads and railways came to a virtual halt at the frontiers.

Air transport and inland navigation remained unfettered purely as a result of a structure which is peculiar to these forms of transport and to the specific nature of these lines of communication.

The removal of certain customs barriers within Europe naturally stimulated links between the infrastructures of the States concerned.

The development of the highway network is the prime, or indeed the sole, motive force behind the regional development that leads to the formation of a vast megalopolis. Nevertheless, according to studies carried out in the United States, three essential prerequisites must apply simultaneously [1]:

Fig. 1: *Transport and infrastructure cycle: natural development in the standard of living give rise to an increased demand for goods and services and mobility. The development of transport infrastructures takes place against this background. However, as a result of the feedback effect, the setting up of a new infrastructure affects the regional pattern through induced attraction of new settlement spreads and new traffic flows.*



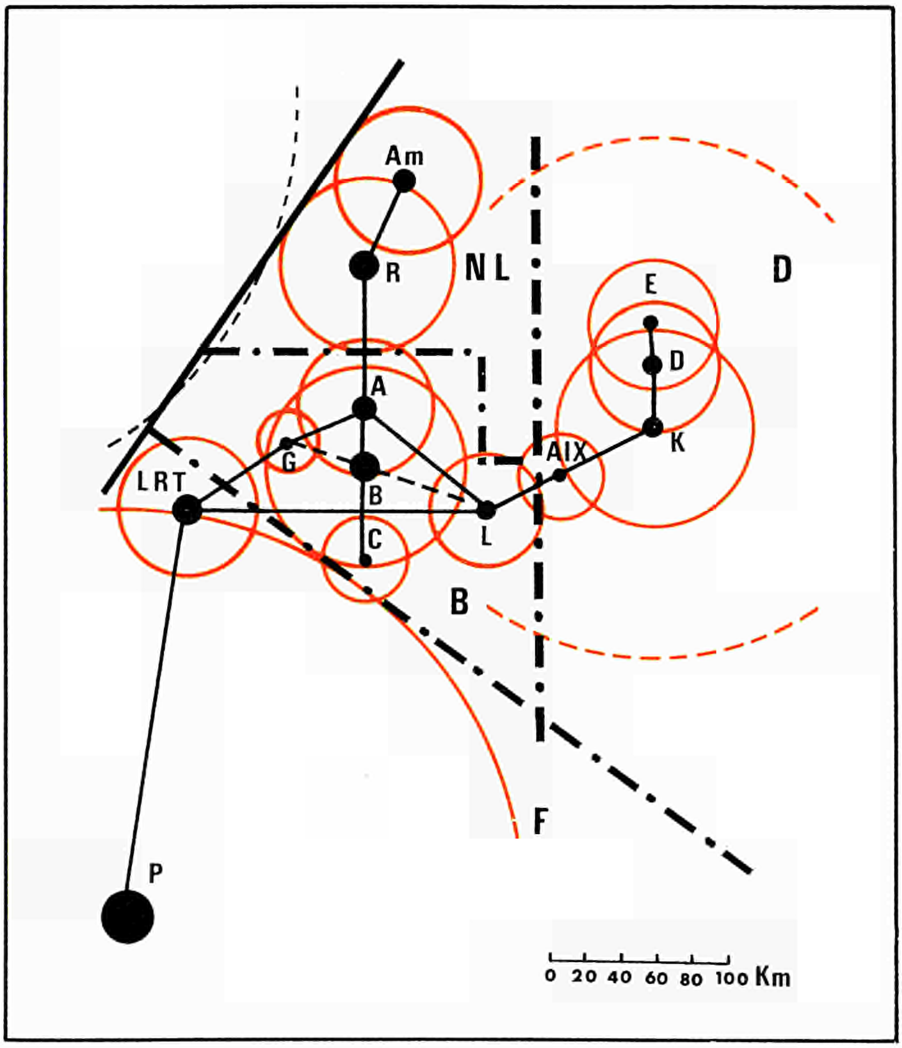


Fig. 2: *Megalopolitan development of North-West Europe.*

L	:	Liège
G	:	Ghent
C	:	Charleroi
Am	:	Amsterdam
R	:	Rotterdam
K	:	Cologne
E	:	Essen
D	:	Düsseldorf
Aix	:	Aachen
A	:	Antwerpen
B	:	Brussels
LRT	:	Lille
P	:	Paris

The circles indicate the catchment areas for the conurbations. The large broken circle on the right denotes the cumulative attraction of the German conurbations.

- a broad expanse of water: the Atlantic coast beside the Boston-Washington axis, the Pacific coast beside the San Francisco-San Diego axis;
- large industrial metropolises: New York, Los Angeles;
- a suitable highway network providing a permanent link between organized developed urban centres: Boston, New York, Philadelphia, Baltimore, Washington.

In Europe, the public authorities are aiming at faster point-to-point travel, conurbations, increased trade and tourist traffic, a solution to the problems of the mobility of labour, and a greater catchment area for the ports. Such is the tacitly approved basis for the efforts to formulate a common transport policy within the European Community.

Specific influences on transport infrastructures

Let us examine the specific instance of Belgium which, as a result of its geographical location, is the meeting-point of numerous trade routes [1].

The central location and the international role of the country warrant a study of the way the highway network in which it is integrated influences the economic development of north-west Europe in a zone involving five of the Member States of the European Communities (West Germany, Belgium, France, Luxembourg, The Netherlands) and possessing a population of about 50 million.

According to the principle stated above the growth of megalopolitan zones can occur through the coalescence of lesser zones which have generated a highly developed economy, in regions where the population density per unit area stimulates a maximum growth of trade, requiring fully-integrated transport networks.

The study of the spheres of influence of the major, radially overlapping conurbations in the countries concerned is based on the existence of a genuine relationship between the population volume, the area covered by and the number of districts in each conurbation (Fig. 2).

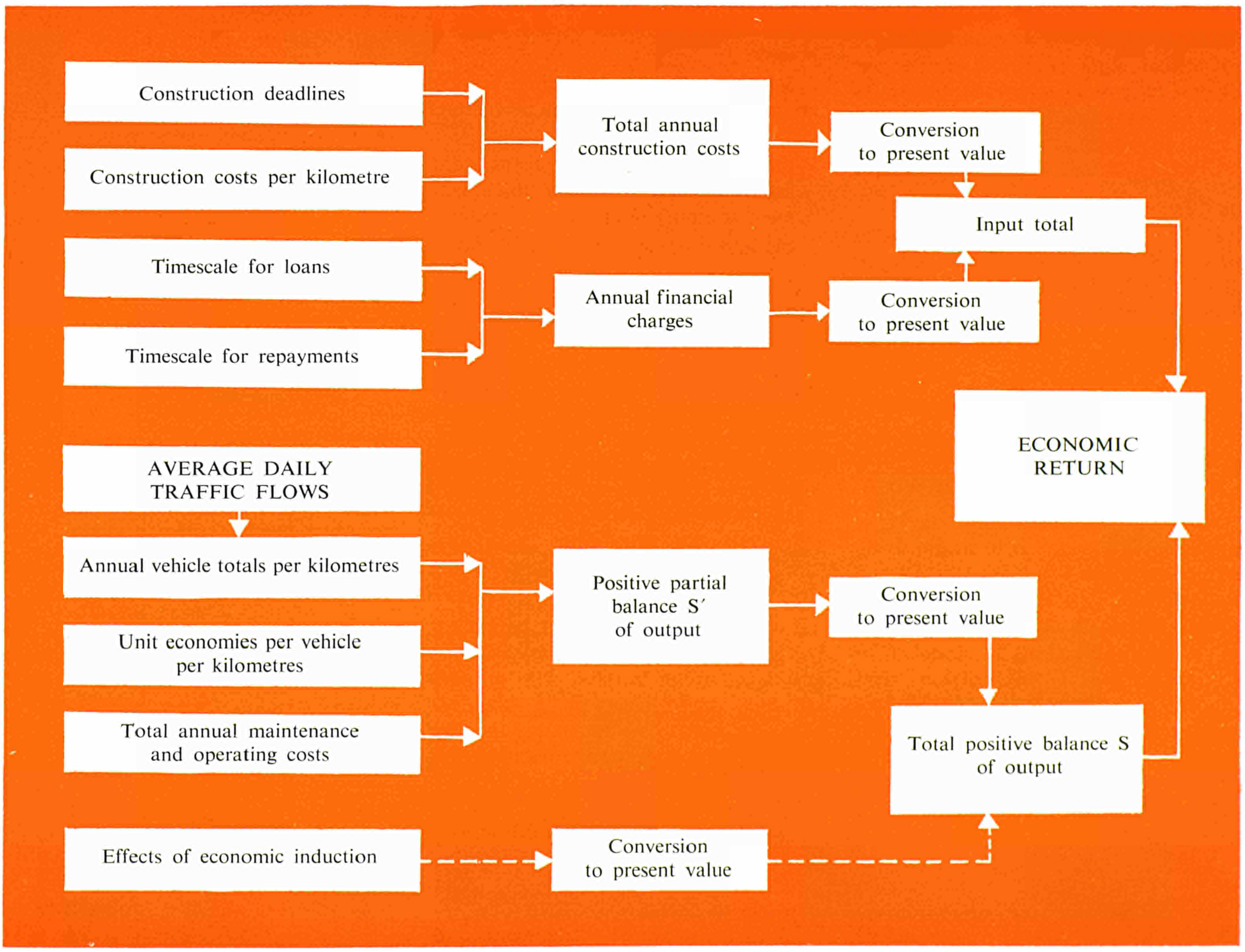
Through the effects of induction the construction of major lines of communication (such as motorways) between the various conurbations promotes urban concentration and consequently the formation of a megalopolis.

Hence, high capacity transport infrastructures promote megalopolis growth.

Beyond doubt, the entry of the United Kingdom into the European Community and the opening of the Channel Tunnel will be influences capable of creating a London megalopolis which would complement and sometimes compete against the Paris megalopolis and would extend across Belgium as far as the Ruhr. It is easy to deduce the essential characteristics of its transport networks—i.e. its infra-

[1] According to the paper submitted by Belgium at the 13th International Congress on Load Transport held in Tokyo in 1967. Question VII: Economic Questions — Rapporteur Mr G. Marinx.

Fig. 3: *Calculation of the technical/economic return on transport infrastructures.*



structures—which will have to be particularly diversified and essentially flexible.

Lastly, we should emphasize the sociological function of transport infrastructures integrated into a complex of this type:

- they promote cohesion between groups and a certain "universality" in their specific reactions;
- they influence the organization of these groups, depending on whether regional or national policy decisions dictate the prohibition, slowing down or stepping up of intercommunications by maintaining the *status quo* or developing suitable networks at a faster or slower rate.

Economic studies

Although the siting or improving of infrastructures is governed—often tacitly—by reference to the socio-political criteria summarized above, the decisions relating to investment are essentially dependent upon the foreseeable return on investment offered by the work in project.

Schematically, the economic yield of an investment in transport infrastructures is the ratio between:

- the total future marginal profits accruing from the utilization of this investment (output), and
- the total investments required (input).

The output consists essentially of savings and profits, both direct and indirect, whereas the input comprises the total outlay in investments and financial charges.

The process of successive calculations enabling these assessments to be made is relatively simple (Fig. 3).

It is, however, undeniable that there are particularly important economic induction effects that stem from the industrial and other activities attracted by the new or improved infrastructure.

The authors are unanimous in stating that the assessment of economic induction is a particularly thankless task; there are no exhaustive and consistent methods for this.

A bibliographic study has revealed two types of induction:

- induction due to the actual carrying out of the works, which is thus of short duration;
- an economic boost due to the attraction of new activities.

A gap in the evidence still needs to be filled, namely the enhancement of the value of the natural heritage; the land adjacent to the infrastructure increases in value, all other things being equal.

Table I : *Results of a study carried out in France on the effects of the highway investment programmes on economic development and more specifically on the gross domestic product (GDP). These programmes, which are restricted to the national greenfield network, are estimated over the period 1960-90.*

Investments throughout the period	zero	limited	normal
Rate of immediate return on investment	—	12 %	7 %
Structure of the primary network in 1990	250 km	11 700 km	15 670 km
Total investment (in thousands of francs)	—	37 097	67 658
Load factor in 1960	1.00	1.00	1.00
Load factor in 1990	3.50	4.40	5.40
GDP percentage generated by cumulative investments since 1960			
up to 1970	—	9.5 %	6.5 %
up to 1990	—	13.8 %	18.5 %

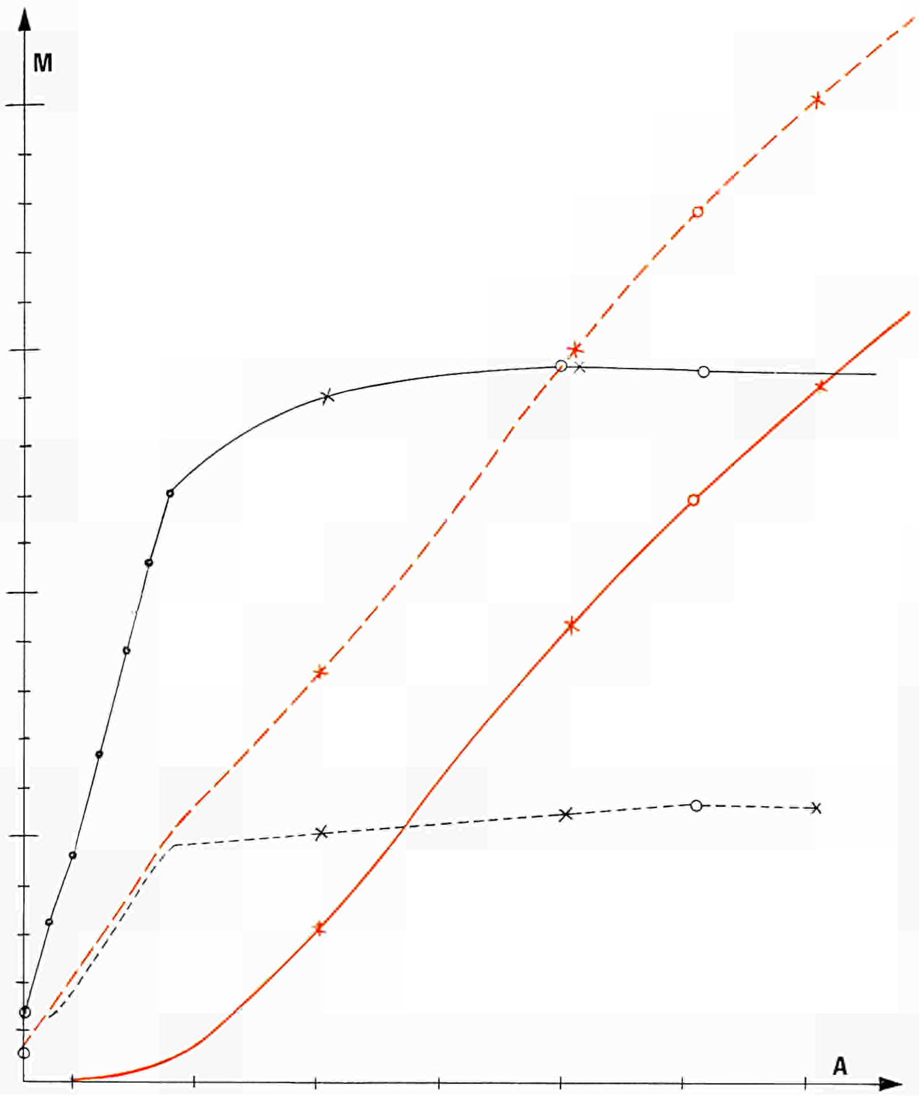


Fig. 4: *Example of an assessment of the return on transport infrastructures where the definite output is compared with the probable input.*

A = years M = amounts involved

black – continuous curve = input
– broken curve = economic induction

coloured – continuous curve = normal output
– broken curve = output including induction

In each individual instance it is necessary to draw graphs comparing the assured output with the probable input (Fig. 4).

By way of an illustration we refer to the attempt made in France to assess the effect of the highway investment programme on economic development and more specifically on the gross domestic product [2].

These programmes were evaluated for the period 1960-90 and restricted to the national greenfield network. Several theories of a political nature regarding the level of financial outlay and the operating status of motorways led to the options and results shown in Table I.

[2] According to the paper submitted by France at the 13th International Highway Congress held in Tokyo in 1967. Question VII: Economic Questions — Coordinating Rapporteur Mr J. Thedie.

Conclusions

An economic study of infrastructure investments makes it possible to calculate coherent programmes in line with the objectives set by the national and regional political bodies, and to appraise the effects of these programmes on economic development. It does not yet provide a means of assessing the contribution to regional planning in its broadest terms.

However, the measures towards harmonization adopted by the *EEC* and implemented by the Member States are bringing about a reshaping of the regions, based essentially on the development of urban or megalopolitan structures.

A case-by-case analysis of this development is feasible and would enable the gaps in economic science to be plugged by socio-political reasoning.

Within the *EEC* the harmonious development of transport infrastructures is taking shape. The accession of the new Member States will certainly have repercussions on the respective spheres of influence of the existing centres but their development is such that the tendency will generally be to enhance the economic induction of existing infrastructures.

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See also *Revue Belge des Transports*, n. 1 (1973).

The studies mentioned in the article "Cavitation" by PIATTI, LUBEK and MATERA ("euro-spectra" Vol. XI (1972). n. 4, pp. 93-101) are financed by the European Coal and Steel Community (ECSC), *according to article 55 of the* ECSC *Treaty.*

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2nd International Conference
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