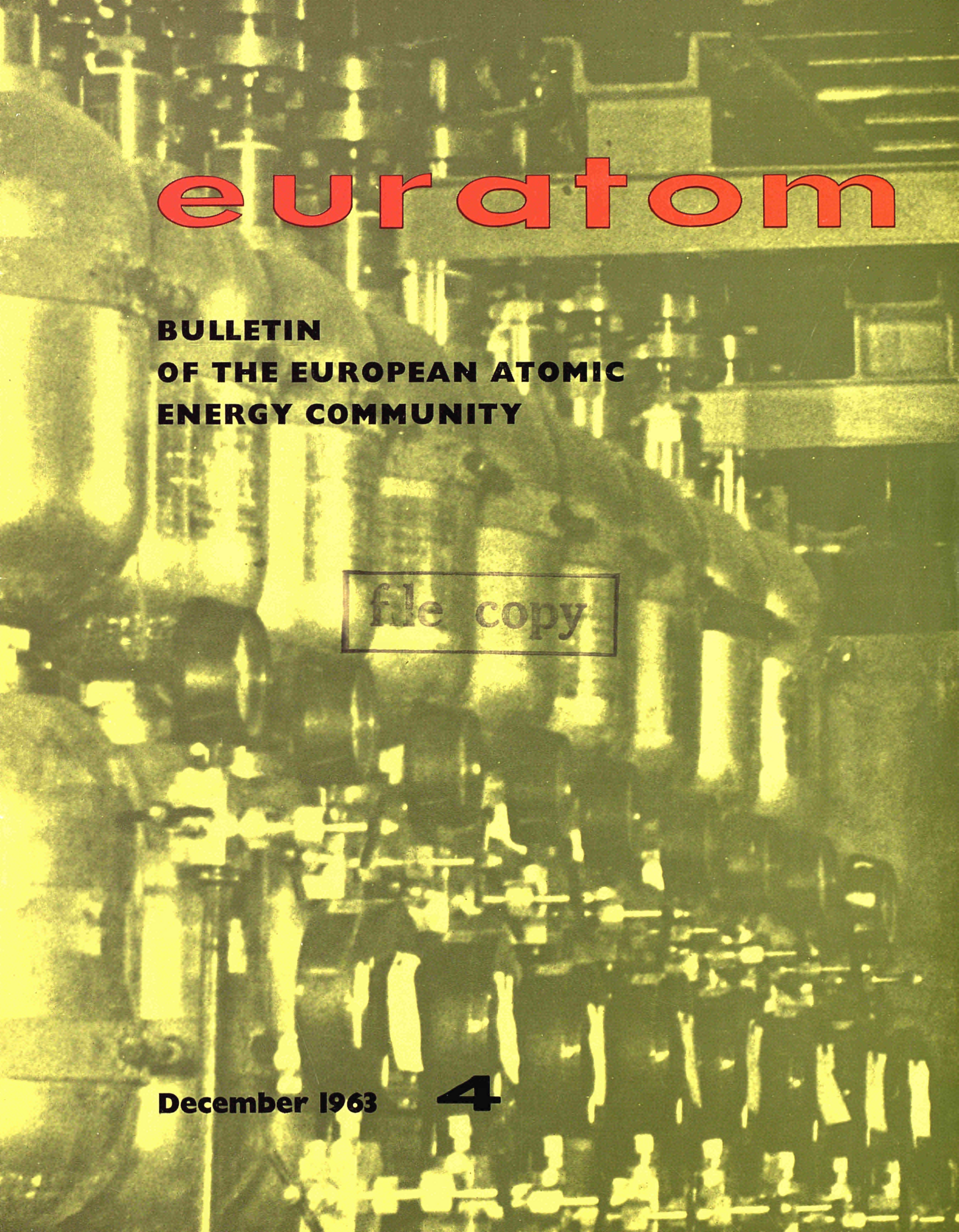

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BULLETIN OF THE EUROPEAN ATOMIC ENERGY COMMUNITY

December 1963 4

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1963 - 4

The Community's mission is to create the conditions necessary for the speedy establishment and growth of nuclear industries in the member States and thereby contribute to the raising of living standards and the development of exchanges with other countries (Article 1 of the Treaty instituting the European Atomic Energy Community).

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Nuclear energy was once the centre of interest of a mere handful of physicists whose activities were confined to their laboratories. Although it may be difficult for many of us to realise it fully, this situation has now changed radically: several nuclear stations with power ratings of up to several hundreds of megawatts are not only being offered on the market or being built but are actually producing electricity in various parts of the world.

We have thus reached the stage where attention is focused not only on the brilliant discoveries and inventions to which these plants ultimately owe their existence but also on the efforts in the field of technology which are indispensable to their practical success as electricity-producing units.

This practical attitude pervades this issue, which is devoted to the five nuclear power plants which figure in Euratom's Participation Programme. The authors have in most cases followed the project about which they are writing from its very beginning; thus, in the case of the SIMEA and SENN plants, they have seen the plant gradually rising from its foundations, lived moments where crucial decisions had to be taken on alterations to the design of the installation, followed the long series of tests before start-up and experienced the excitement of the reactor's first approach to criticality.

Their next responsibility will be to follow the behaviour of the plant when it is in full operation, helping to record the information which will be produced and to assess it for the benefit of the European Community's industry as a whole.

Euratom participation in power reactors

CLAUDE RAMADIER *Director of Industry, Euratom*

EDOUARD PARKER *Head of the "Power Reactors-Nuclear Plants" Division*

During the next few years the most important data to be obtained concerning power reactors will be those gained from the operation of the first reactors to be commissioned. Even now, the information obtained presents considerable interest, a fact which is clearly evidenced by the success of the IAEA Conference on Operating Experience with Power Reactors, held in Vienna from 4 to 8 June 1963.

The European Atomic Energy Community, one of whose tasks as laid down by the Treaty of Rome is to further the development of the Community's nuclear industry, has realised the need for gathering data on the operation of power reactors. On a wider basis, it is Euratom's view that the experience and results to be obtained from the design, construction and operation of power plants are extremely valuable for the development of the Community's nuclear technology. It is for this reason that the Community decided to launch a programme of participation in power reactors.

Five power reactors

This programme, initiated by the Euratom Commission, consisted in awarding contracts worth a total of 32 million dollars to five of the Community companies engaged on the construction of power plants.

These are as follows:

— the Società Elettronucleare Nazionale (SENN), which has built a 150 MWe net power plant in Italy, equipped with a dual cycle boiling-water reactor.

— The Società Italiana Meridionale Energia Atomica (SIMEA) which has built a 200 MWe net plant equipped with a natural uranium/graphite/carbon dioxide reactor.

— the Société d'Energie Nucléaire Franco-Belge des Ardennes (SENA), which is building on the Franco-Belgian frontier a power plant running on a pressurized-water reactor and developing 242 MWe net, which can later be stepped up to 266 MWe net.

— the G.m.b.H. Kernkraftwerk RWE—BAYERNWERK (KRB), which is building a 237 MWe net plant in Bavaria equipped with a dual-cycle boiling-water reactor.

— the Samenwerkende Electriciteits-Productiebedrijven (SEP), which has undertaken the construction of a 50 MWe net power plant operating on a boiling-water natural circulation reactor.

The first two of these contracts (SIMEA and SENN) were signed at the end of 1961, the third (SENA) in mid-1962, while the last two (KRB and SEP) were signed respectively in March and in June 1963.

Carrying out the programme

For their part, the contract holders communicate to the Commission all the data obtained throughout the period covered by the contract with regard to the design, construction and operation of the plant. These data are supplied either in the form of documents and reports, or are gathered on the spot by engineers seconded to contract holders.

The following *documents* must be submitted by the contract holders:

— design and construction drawings and specifications

— operation and equipment manuals

— operational data

The *reports* contain technical, economic and safety information relating to the plant. Certain reports appear regularly (annually or quarterly), others supply overall data (on completion of the work concerned or of the contract after four years' running). Finally, others contain information of a specialized nature relating, for example, to questions of health and safety, the transportation of fuel elements and accidents or incidents occurring during operation.

The information, reports and documents thus received can be used by the Commission and communicated to third parties in the Community by the Commission with the agreement of the contract-holders. Certain information can be published. It is in this way that the first annual reports of SIMEA, SENN and SENA were published.

In actual practice, contract-holders have regularly submitted the reports and documents required, copies of which can be distributed to Community industries and public bodies, and which can be examined at the Euratom head office. They at present make up a total of more than 10,000 pages of text and drawings.

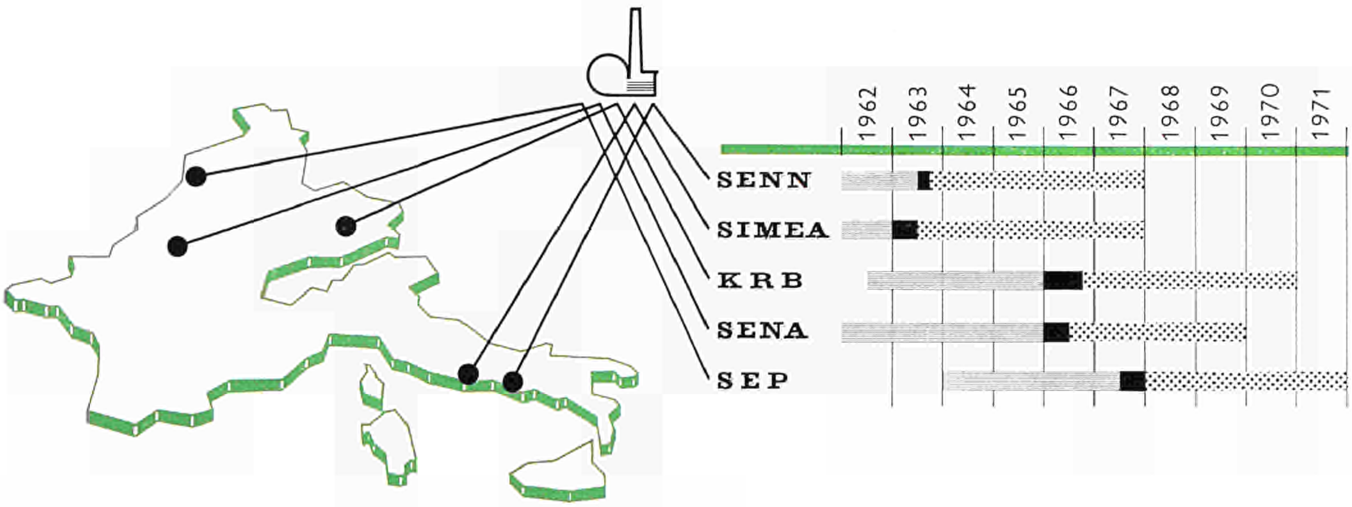


Figure 1
Euratom's programme for participation in power reactors built in the Six:

1 Start of construction work
2 Criticality
3 Full power
4 Expiry of participation contract

The most novel departure embodied in these contracts of participation, however, concerns the clause under which ten *engineers can be assigned* to each of the contract-holders at the same time. These engineers, who are Euratom officials and representatives of industries or public bodies within the Community, can observe the activities of the staff employed by the contract-holders, becoming integrated with these teams as far as is possible. Visiting scientists or students can also be attached to contract-holders for periods of study or training.
A total of 61 engineers from the six Community countries have been or are shortly about to be seconded to the SENN and SIMEA projects. These qualified engineers carry out on-the-spot studies of the problems which interest them particularly or participate in the work of the construction companies, especially commissioning trials. At the end of their assignment they must draw up a report. At the present moment Euratom has at its disposal about 34 such reports, constituting an invaluable source of information.
The information obtained depends on the progress achieved by the work being carried out under the five projects. The main items dealt with concern:
— Start-up of the SIMEA plant
— Pre-start-up tests on the SENN plant
— Finally, commencement of work on the SENA plant.
The information thus obtained is distributed by the Euratom Commission through the agency of the Member States. Besides, three meetings have been held so far for the benefit of industries and public bodies within the Community. The last meeting, which was particularly concerned with the results deriving from the commissioning of the SIMEA plant and the initial tests of the SENN plant, was attended by more than 200 people.

Promoting a fuel-element industry

The Commission has endeavoured to link up this programme of participation with the development of the Community's nuclear industry. For this reason the bulk of the contribution under this programme, about 17 million dollars, is payable only on condition that the fuel elements of the second reactor cores (the first in the case of the SEP plant) are manufactured in the Community. This is done in order to facilitate the creation and development of a fuel element production industry.
In two cases also, this participation covers the manufacture in Europe of certain reactor components, such as pressure vessels.
Finally, in the case of four projects, it is intended to cover some of the additional fixed overheads incurred during the first three years of operation, 5,400,000 dollars being earmarked under this head.

Research

In conclusion, mention should be made of the fact that part of Euratom's research programme, under the heading of its own activities as well as the US/Euratom agreement, is specifically devoted to the development of "proven"-type reactors. This programme is primarily concerned with the development of fuel elements and is centred on the reactors in which Euratom is participating. For instance it is planned to provide the instrumentation of the SENN core in order to be able to carry out a series of experiments, and negotiations are in progress with SENA on the same object. As for the SIMEA plant, experiments to be carried out have recently been decided upon with Euratom's agreement.
It should be stressed also that the Euratom programme of participation in five power reactors now in operation or under construction constitutes a novel form of collaboration between utilities, construction companies and an international organization.

As a result of this collaboration certain projects will be given a definite stimulus and a boost will be given to the development of the Community's nuclear industry, especially with regard to fuel element fabrication. Finally, in the years to come, it will enable extremely valuable and useful information on the construction and operation of five large nuclear plants to be amassed and distributed. This is only possible on a large scale such as that provided by a community of six countries.

The Garigliano nuclear power plant

This article is adapted from reports drawn up by U. Belelli, of SENN, and H. Nacfaire and M. Siebker, members of Euratom's Directorate General for Industry and Economy, seconded to SENN. (EUR Report No. 420).

By the time this article is published, the first full size boiling water reactor power plant in the Community will be approaching commercial operation at the mouth of the Garigliano river, north of Naples. This project, which represents for the Community an essential corner-stone of nuclear power production at low cost, went through the various stages peculiar to the history of nuclear energy. At the beginning of 1957, when the need for a new source of energy was being felt all over the world, the Italian power industry recognised that, as a result of the limited availability of primary sources of energy in the face of growing demand, Italy might relatively soon reach the point where nuclear energy could be competitive with conventional sources; consequently, in order to acquire the indispensable first-hand experience, it was advisable to build and operate commercial nuclear power plants.

These were the grounds for the initiative which was to lead to the realisation of the Garigliano plant, for the Società Elettronucleare Nazionale (SENN), with the approval and support of the Italian Government and the World Bank.

In October of the same year, invitations to tender were issued to the most qualified manufacturers in the field, and six months later the examination of the submitted bids started. At the conclusion of the examination, backed by the opinion of an international panel of well-known experts, the choice fell on the plant proposed by International General Electric Company, based on the "dual-cycle" boiling water reactor concept.

It should be borne in mind that this stage was completed as scheduled, notwithstanding the spell of depression which followed the initial euphoria which attended the first International Geneva Conference on the peaceful applications of nuclear energy.

The choice of that type of reactor was based not only on economic considerations, but also on the fact that it would be possible to derive benefits from the experience acquired by the manufacturer with a similar plant then being built at Dresden, USA. Actually, the Dresden plant was scheduled to enter commercial operation before the construction of the Garigliano plant started, and there was thus a chance for a full-scale demonstration of the excellence and safety of the boiling water reactor concept.

A contract was signed on September 9, 1959 with International General Electric Operations S.A. acting as a Prime Contractor for the whole project, except the civil works, the turbogenerator-condenser system and minor auxiliaries. Construction started early in 1960.

Among the first problems to be coped with, great importance was attached to the organisation of the work, observance of the construction schedules, and the detailed design of components. With reference to the components, advantage was taken of the experience being acquired in similar plants, and the necessary changes were made in order to render the Garigliano plant as up-to-date as possible. It is legitimate to state that these improvements made it possible to reach the desired goal.

With regard to the other problems, experience proved the necessity of setting up a sufficiently centralised organisation in order to enable decisions on any unforeseen difficulties to be taken promptly. Thus it was found essential to organise the design work in such a way as to avoid undue losses of time among the consulting engineers, the prime contractor and the customer. This aim is best achieved by means of an appropriate contract arrangement, whereby the cus-

tomer is accorded the direct benefit of the consulting services. Moreover, the observance of the schedules revealed the possibility of reducing construction times further without losing flexibility in the programmes. In particular, it was demonstrated that, for this type of reactor, contrary to the initial assumptions, it was possible to perform almost all the civil works before the arrival of the machinery. Significantly, the SENN sited the plant in the South of Italy. It has thus become at the same time a symbol of the aspirations of this developing area and a means of supplying the energy necessary to their realisation. A transmission line has actually been erected between the Garigliano plant and Naples, which is a trunk of the high-voltage line scheduled to link Rome and Naples through the Latina and Garigliano nuclear power plants.

In addition, the Garigliano Plant was the first project to be accepted in the Euratom/USA Joint Programme for Power Reactors and the only one involved in the implementation of the initial stage of the Programme. The related contract, signed in July 1961, called for USAEC guarantees on fuel supply and reprocessing in exchange for information on plant construction and operation. The Garigliano Plant was also included in the Euratom Participation Programme for the development of power reactors in the Community countries. This contract, signed in December 1961, provides for financial coverage by Euratom (up to $ 3,000,000) of the risk of losses being incurred during the initial plant operation period and an additional contribution of $ 4,000,000 in case of fabrication of fuel reloads in Europe. In exchange, the Community industries are entitled, through Euratom, to receive first-hand information on the design, construction, testing, start-up and operation of the plant. This information includes progress reports, special reports on specific subjects and, above all, presence at the site of a Technical Group composed of Euratom officials and engineers from the various Community organisations interested in the project.
Finally, we should not forget the particular experience acquired by the European manufacturers in the Community with which about 70% of the total commitment value was placed (see table on page 7).

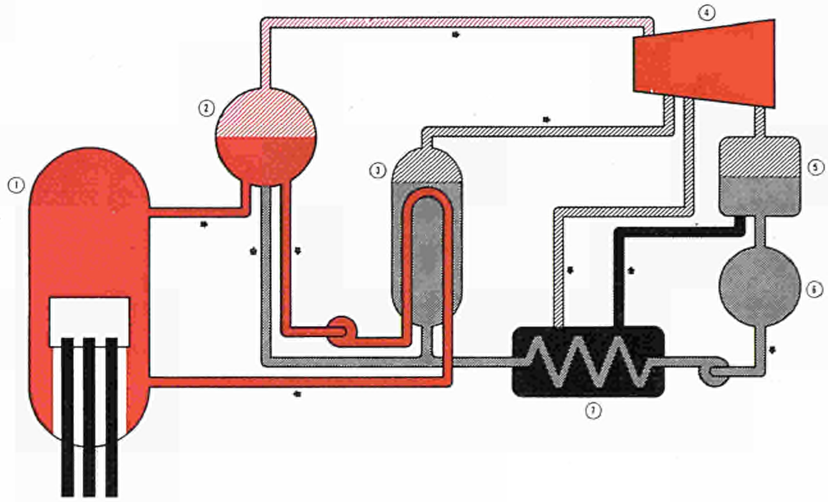
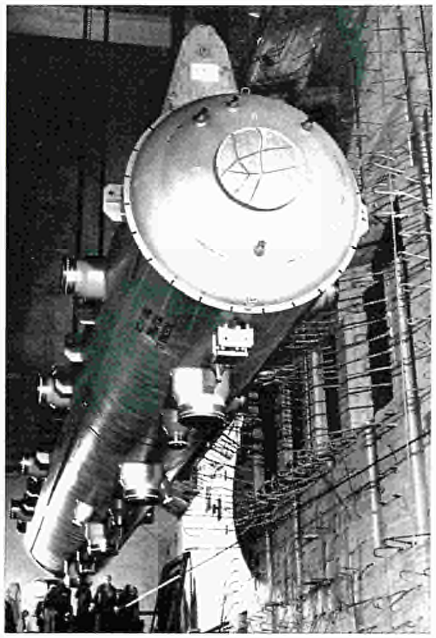


Figure 1—Schematic flow diagram (forced circulation dual cycle boiling water reactor)
1 Reactor vessel
2 Steam drum
3 Secondary steam-generator
4 Turbo-generator
5 Condenser
6 Demineraliser
7 Feed-water heaters

General features

What is perhaps most striking about a boiling water reactor plant is its general similarity with a conventional steam boiler plant. A "thermal", as opposed to a "fast" reactor needs a moderator system, which slows down the neutrons emitted by fission to the required "thermal" velocities. As ordinary water is a reasonably good moderator, the idea behind the boiling water reactor concept is to let the water fulfill this function—at the same time as it carries away the heat generated in the reactor core in the form of steam directly usable in a turbine. The complication of a separate moderator system is therefore absent as well as separate steam generators, at least for the main portion of the power plant output.
Figure 1 gives a schematic impression of

Hoisting of the steam drum



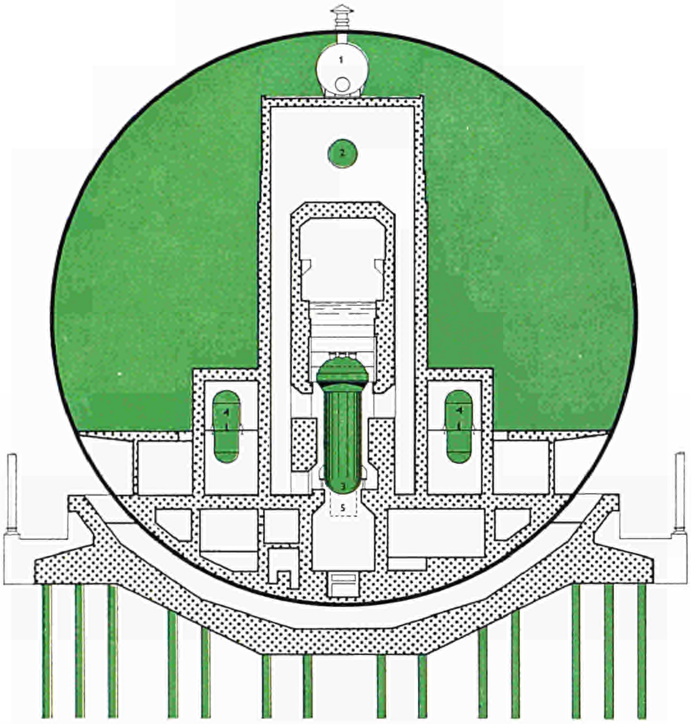


Figure 2 Vertical section through containment sphere
1. Emergency Condenser
2. Steam Drum
3. Reactor
4. Secondary Steam Generator
5. Control-Rod Mechanisms

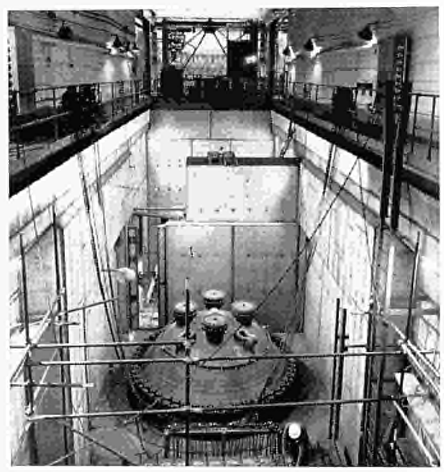
the arrangement of the main components and of the operating principle of the Garigliano plant. The water is driven upwards through the reactor core, becomes heated and passes in the form of a steam/water mixture into a steam drum. Separation takes place in the steam drum, the steam being admitted *directly* to the turbine; as for the water, it is sent by recirculation pumps through the tube-coils which are housed in the secondary steam generators and from there back to the reactor, after giving up some of its heat to produce low-pressure secondary steam. This secondary steam is admitted to the same turbine but, of course, at a lower pressure stage than the primary steam.
The exhaust steam is condensed and the condensate is sent by extraction pumps to a demineraliser system, where any impurities which it may have picked up are removed. Finally, the feed-pumps return the water to the steam drum and to the secondary steam generators.

It could be said that, if it were not for the presence of a reactor vessel instead of a combustion chamber and the complication of secondary steam generators, the general resemblance at which we have already hinted would be almost complete.
It is because of the introduction of these secondary steam generators into its design that the Garigliano reactor is termed a "dual-cycle" boiling water reactor. They are there mainly in order to enable the power of the reactor to be asjusted within a certain range without having to resort to the control rods. Should the load on the turbo-alternator rise, the resulting speed decrease triggers off the following series of events: more secondary steam is admitted to the turbine; hence the water passing through the secondary steam generators on its way from the steam-drum to the inlet of the reactor vessel has to give up more of its heat than before; the temperature of the water entering the reactor is therefore reduced, with the result that the formation of steam bubbles in the core is delayed. Consequently the fuel is surrounded by a mass of water of greater density than before and the neutrons emitted by fission are more effectively moderated; this has the effect of improving the probability of fission reactions taking place or, in other words, of increasing the reactivity of the core. The reactor power consequently rises to meet the demands until the pressure at the normal turbo-alternator speed is restored. In the event of a load-drop, the reverse procedure occurs. During the described transients primary steam pressure is maintained constant by means of a pressure controller acting on the primary steam admission valves.
The system which has just been outlined makes it possible to obtain smooth responses to varying load demands in the range 70% to 100% of full power. Below the 70% level, the control rods, which introduce "poison" i.e. a neutron absorbing material into the core have to be repositioned.

The reactor pressure vessel

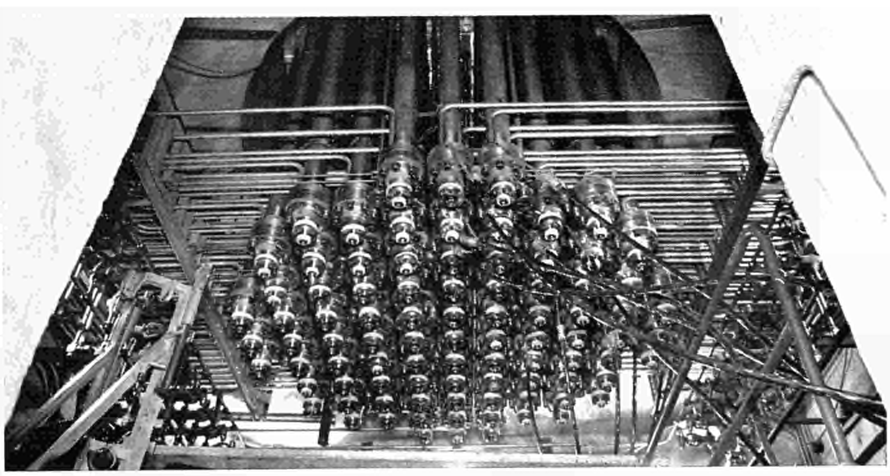
The reactor pressure vessel (see Fig. 3) consists of a vertical cylinder with a hemispherical base and a flange at the top which receives a bolted-on head. The vessel is provided with various nozzles of which the principal ones are those

Reactor cover



The main items fabricated in Europe were:

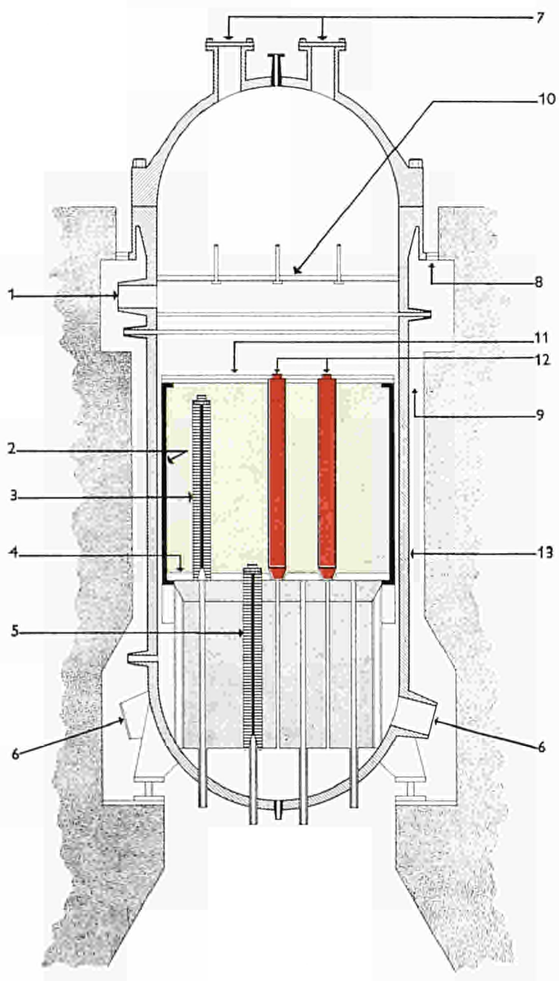
BELGIUM	Hanrez:	Butterfly valves for the condenser system
FRANCE	Ateliers J. Battignolles:	Emergency feed pump
	Le Creusot:	Stainless steel plates for the steam drum shell
GERMANY	Mannesmann:	Stainless steel piping
	K.S.B.:	Pumps for special loops
ITALY	Ansaldo:	Turbine (160 MW) and condenser system
	Terni:	180-ton reactor pressure vessel, shaping of containment sphere plates, emergency condenser
	Franco Tosi ATB:	Steam drum
	Termomeccanica:	Demineralisers
	Bonaldi, Tosi FMB:	Heat exchangers and feedwater heaters (with Monel tubes)
	Dalmine:	Carbon and alloy steel piping
	Gavazzi:	Control rod drive hydraulic system, instrumentation and control panels
	Ansaldo S. Giorgio:	Generator, electric motors, main transformers and exciters
	C.G.E.:	Auxiliary transformers
	Worthington:	Pumps
	S.I.A.C.:	Containment vessel plates
	SENN (in conjunction with Prof. Morandi and Ebasco Services Inc.):	Civil works detail design
	Italstrade:	Civil works
NETHERLANDS	Stork:	Secondary steam generators
	Dikkers:	Primary system main valves
	Rotterdam Drydock:	Reactor internals



Control rod drives

SENN—Figure 3:
The reactor vessel

1 *steam/water outlet*
2 *thermal shield*
3 *control rod in inserted position*
4 *lower support grid*
5 *control rod in withdrawn position*
6 *feed water inlet*
7 *loading ports*
8 *water seal*
9 *ventilation air space*
10 *deflector*
11 *upper guide grid*
12 *fuel elements*
13 *vessel wall*



which serve for the inlet and the outlet of the coolant.

Although the vessel and structural elements within it are basically made of ordinary steel, they are lined with stainless steel. The purpose of the lining is to eliminate corrosion as far as possible. Admittedly such drastic action against corrosion is not taken in the case of conventional steam generators, but this is mainly because they do not have to reckon with the free oxygen resulting from radiolytic decomposition of the water. In a reactor, corrosion would entail the formation of radioactive compounds, mainly metal oxides, which would not only tend to foul up the whole primary circuit and cause heat transfer difficulties but would lead to radioactive contamination.

Primary water circuit

As most parts of the primary circuit are in contact with the primary cooling water, they are either entirely made of stainless steel or equally resistant alloys or at least clad with such a material.

The steam-drum receives a steam/water mixture containing approximately 8% by weight of steam and has to supply steam with a quality of at least 99.9%; in other words, not more than 0.1% of water may be carried over. The main purpose of this stringent requirement is to reduce to a minimum the carry-over of solids present in the water because of the fact that the solids are inevitably radioactive.

The reactor core

One essential feature of a boiling water reactor is, as already mentioned, that it uses water not only as coolant but also as moderator. It so happens, however, that ordinary water's tendency to absorb neutrons is substantially higher than that of heavy water or graphite. It is conceivable for a reactor moderated by heavy water or graphite to be fuelled with natural uranium, i.e. uranium containing only 0.7% of the fissile isotope U^{235}, because the neutron "economy" is good. On the other hand, in the case of a reactor moderated by ordinary water, the inferior neutron economy has to be compensated by slightly enriching the fuel in uranium-235. Thus in the Garigliano reactor, the average enrichment of the fuel rods is 2%.

The core of the reactor consists of 208 fuel assemblies arranged in a square lattice. Each fuel assembly, which itself consists of a cluster of 81 fuel-rods, fits into a channel. Spaces are left between the channels, which act as guides for the control rods (so-called, although their section has the shape of a cross).

Control

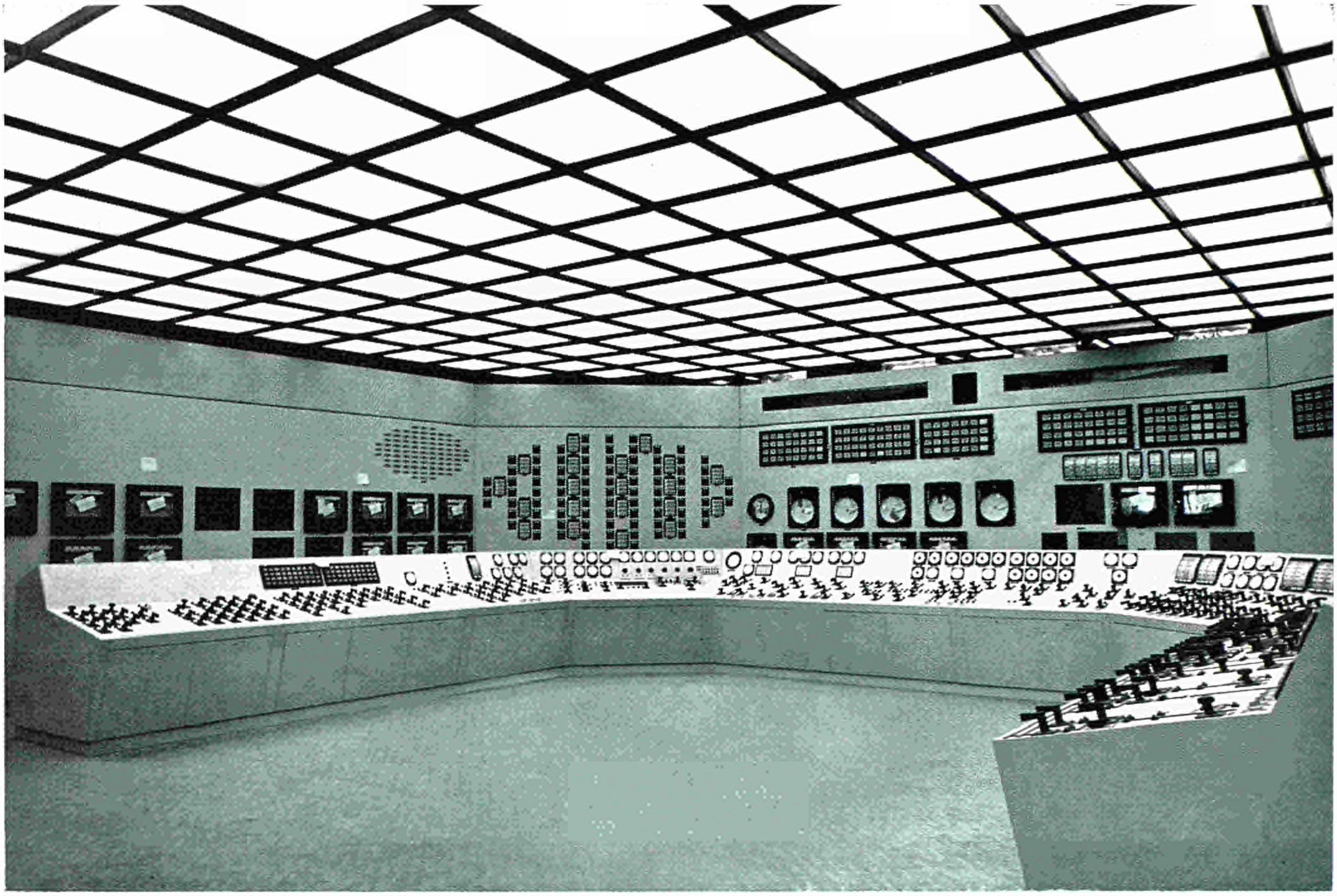
The reactivity of the core is controlled by 89 neutron-absorbing control rods which are uniformly distributed throughout it. Their insertion and withdrawal is effected from *below* the reactor vessel by means of a hydraulic mechanism.

The operator in the control room responsible for actuating the control rods has at any time a complete picture at his disposal of the neutron flux throughout the core. The information is given to him by a set of 12 independent neutron sensitive chambers arranged around the reactor vessel and, in addition, by 80 fission chambers installed at regular intervals in the core. The operator can thus position the control rods so as to prevent the occurrence of high flux peaks which would entail overheating and possible damage to the fuel-elements in their neighbourhood.

It is extremely unlikely that the control-rod system should fail completely. However in order to eliminate the risk which attends this remote possibility a system has been installed which allows a neutron-absorbing solution to be injected into the reactor water. It comprises a tank which stores the liquid at atmospheric pressure and two pumps either or both of which can be started by the operator in the control room.

Turbo-alternator and condenser

A special feature of boiling water reactor plants at the present stage of their development is that they use saturated (i.e. non superheated) steam. This means that the turbine has to handle larger quantities of steam and that special devices have to be used to reduce the humidity content which increases as the steam expands through the different stages.



Control room

The condenser and its auxiliaries are of conventional design, but it should be mentioned that the air ejector is of large capacity in order to allow for the extraction of the hydrogen and oxygen formed by radiolytic decomposition of the water in the reactor. The off-gas system is provided with a "hold-up" line which ensures that the radioactivity of substances with a short half-life is considerably reduced before leaving the stack.

Loading and unloading of the fuel elements

In the fuel-element loading and unloading system, which is similar to that employed in swimming-pool reactors, water serves as shielding material. It includes a storage basin, located near the reactor, which can hold 250 fuel elements. The basin also has a space for the fuel element transport container, a space for the control rods and a machine for stripping and replacing the fuel-element channels.

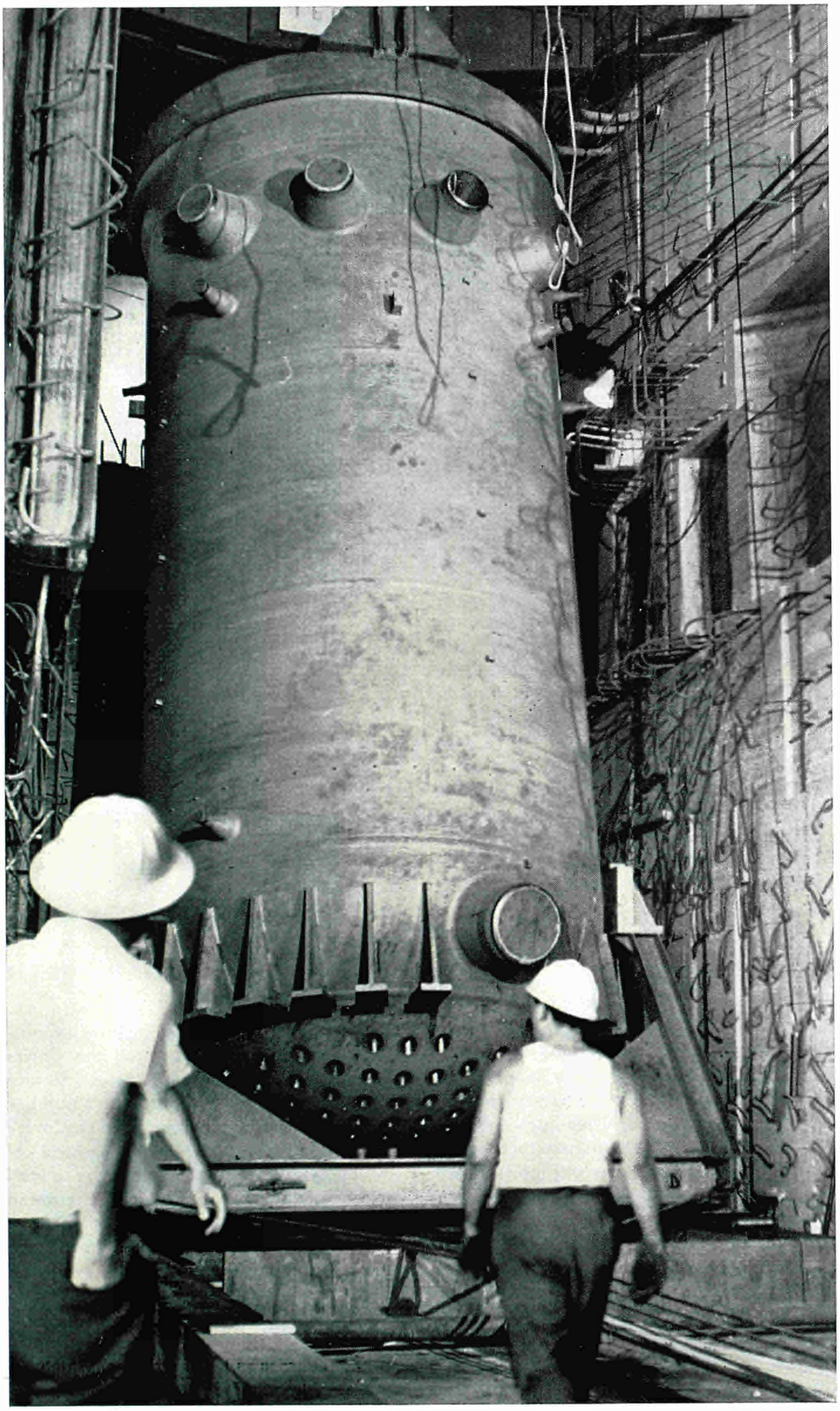
Water purification and waste processing

There are no less than four water-purification systems in the Garigliano plant.
The first system is purely conventional inasmuch as it is there to provide the make-up water necessary to offset the losses which are unavoidable in any steam-generating plant. The second system removes the dissolved or suspended matter present in the water coming from the condenser. As for the third, it prevents the accumulation of impurities in the primary circuit. It is a "clean-up" system, capable of reducing the impurity content to less than 0.5 parts per million. One of the essential objects of this third system is to reduce to a minimum the radiation level of the primary system resulting from the activation of solid products in the core. Chemical processing of radioactive waste is effected underground, outside the turbine house and containment shell. After holdup for decay, slightly radioactive liquids are diluted and discharged to the river. More active effluents undergo filtration, absorption or evaporation in order to reduce the volume of the activity carriers which are to be stored. The fourth demineraliser system is one of the installations used for the liquid effluent treatment.

Design development of the SENN project

The initial offer presented by International General Electric Company for the Garigliano plant was based on a design similar to that of the Dresden plant, with a number of modifications mainly related to the lower installed capacity (150 MWe instead of 180 MWe). However, during the development of the offer and later in the detail design stage, several major modifications were incorporated in order to keep pace with the continuous and rapid evolution of the boiling water reactor technique and to make the Garigliano plant as up-to-date as possible. Some of the modifications correspond to changes which in the meantime have also been realised in

Erection of reactor vessel



the Dresden plant; others are the fruits of the Dresden operating experience. Numerous examples could be given of the extent to which certain fundamental plant features were improved after the tender was presented and even after construction had started. This is in line with the present continuous evolution of nuclear technology and a good indication of the outstanding progress attained in this field in a matter of a few years.

It is known that new nuclear power stations of this type, now at the design stage, will incorporate further improvements such as will reduce the initial financial investment and, consequently, the cost of generated power. However, we feel it our duty to draw attention to the importance of the experience made available by the design and construction of the Garigliano plant, since only by actually coping with new problems is it possible to originate and achieve further possibilities of development. In particular, we should emphasise the experience acquired by all those who worked at the realisation of this project and, even more, the vital experience which will be acquired by a first-hand knowledge of the operational problems of a commercial nuclear power plant. The chance of acquiring information on the actual direct and indirect costs incurred with this type of plant, actual technical capability and maintenance problems; the chance of perfecting the juridical relations amongst operators, manufacturers and consultants in order to improve contract arrangements and guarantees on plant supply; the training of an adequate number of technicians and the know-how acquired by the national industry constitute for any nation, in our opinion, essential and irreplaceable means towards the full affirmation of this new source of energy.

Plant construction and testing

A schedule appears below which retraces the history of the plant from November 1959, when the first work was started, to June 1963, when the reactor first went critical. The extensive pre-operational test programme was started at the end of 1962, each vital component being carefully checked. In general, it may be stated that all the tests were performed with quite satisfactory results, which demonstrated the perfect working order of the various systems and components.

November 1959

Beginning of works related to land settlement and access roads.

February 1960

Completion of the piling for the containment vessel foundation.

July 1960

Completion of station building foundation piling.

July 1960

Completion of containment vessel foundation bowl, whose purpose is to transmit the weight of the containment vessel and internals (50,000 tons) to the piling.

October 1960

Beginning of the erection of the 18 colums, guyed to each other, which support the weight of the containment vessel plates (1500 tons). The erection of the sphere proceeds with the following sequence: equator course, lower hemisphere, upper hemisphere.

March 1961

Construction of the turbogenerator pedestal. The top slab of this structure, 1050 cubic metres in volume, was placed in one pour which continued uninterruptedly for 36 hours.

April 1961

Completion of the erection of the containment vessel plates; the welds were 100% X-rayed. Subsequently, the sphere was leak tested with excellent results: actually, the leakage rate at 26 pounds per square inch internal pressure over 24 hours was 0.02% of the contained air, a value which is definitely below the maximum permissible rate of 5%.

September 1961

Completion of the concrete pours for the station building and attached access and control building.

October 1961

Completion of the turbine crane erection and main condenser shell installation.

December 1961

Beginning of the mechanical installation with the transfer into the sphere and hoisting into place of the steam drum (diameter 2.3 m; length 20 m, weight 116 tons), performed in less than a day.

February 1962

Installation of switchyard equipment completed.

March 1962

Arrival at the site and installation of the two secondary steam generators.

April 1962

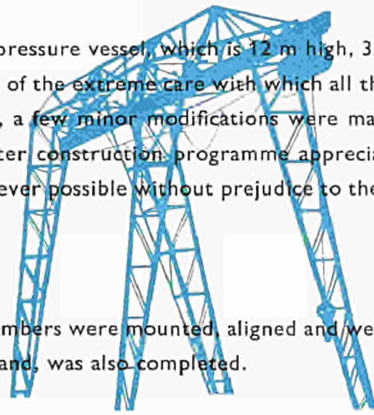
Completion of the 100 metre ventilation stack and beginning of the installation of components in the conventional loop, such as condensate extraction pumps, feedwater pumps, mechanical vacuum pump, ejectors, etc.

June 1962

Arrival at the site of the reactor pressure vessel and turbine components.The reactor pressure vessel, which is 12 m high, 3.8 m in diameter and weighs 190 tons, arrived with several months' delay over the schedule because of the extreme care with which all the fabrication and testing operations were performed. As a result of the extensive test programme, a few minor modifications were made to ensure perfect tightness. The delayed delivery of the pressure vessel did not affect the master construction programme appreciably as other works—mainly civil works inside the sphere—were carried out in the meanwhile wherever possible without prejudice to the rapid installation of the vessel at its arrival.

August 1962

The 89 thimbles for the control rod drives and the 20 guide tubes for the in-core chambers were mounted, aligned and welded in place. Installation of the thermal shield and lower core support plate, both fabricated in Holland, was also completed.



September 1962

Completion of the installation of all reactor internals. The primary and secondary steam piping and reactor auxiliaries piping were ready for chemical cleaning. In addition, the last pours were placed in the sphere and the large construction openings in the containment vessel were being closed.

December 1962

Construction of the plant was virtually complete and the pre-operational test programme had already been started. The main transformer was delivered at the site.

February 1963

Delivery at the site of the first fuel elements. The whole core (208 elements plus 10% spares) was transported by plane from New York to the Capodichino (Naples) airport in 10 flights at one week intervals. The shipping containers, each carrying two fuel elements, were transported to the site by means of trucks suitably outfitted for this purpose. It should be pointed out that fuel transportation by air freight has actually proved to be the most practical way. Transportation costs, inclusive of all related charges, from the General Electric shops at San Jose, California to New York and from there to the site totalled approximately $ 171,000, that is 3.4 $/kg U.

June 1963

On June 5, the plant went critical with a minimum of 8 fuel elements.

The Latina nuclear power plant

Reactor building—view of East side

P. MONTOIS, *Directorate General for Industry and Economy, Euratom, seconded to SIMEA*

The nuclear power plant at Latina, 70 kilometres south of Rome, is the first Italian plant for the production of electricity from nuclear fission to reach operation.
Work on the plant started during the autumn of 1958 and the reactor reached criticality on 27 December 1962; after completion of the nuclear tests at very low power at the end of March 1963, the power run-up was started in April 1963 and the first turbo-generator set was put on the grid on 12 May 1963.
The design of the nuclear part of the plant and the supply of the more specifically nuclear equipment were entrusted to the British NPPC group, who in the course of the work amalgamated with the AEI/John Thompson group, as a result of which The Nuclear Power Group was born. Whereas NPPC provides the overall guarantees on the commissioning and operating characteristics of the plant, the Italian Agip Nucleare was responsible for the design of the conventional part of the plant, the adaption of the project to local requirements, the placing of orders for equipment to be supplied by Italian manufacturers, and the general management of the work. Operation of the plant is in the hands of SIMEA (Società Italiana Meridionale Energia Atomica), now a member company of the ENI group, but which will be incorporated in the national enterprise ENEL under the recent Italian law on the nationalisation of the electricity supply industry.
On 22 December 1961 Euratom signed a contract with SIMEA whereby Euratom contributes to fuel costs up to a total of $ 4 million. A condition of this participation is that, once the initial 400 tons of fuel supplied by the United Kingdom Atomic Energy Authority have been used, SIMEA should use fuel manufactured within the Community.

General features of the plant

The plant, which has a net electrical capacity of 200 MW, is equipped with a natural-uranium, graphite-moderated, carbon-dioxide cooled reactor, six heat-exchangers and three turbo-alternator sets. The working principle of the installation is shown in Figure 1. The project was based on the design used for the Bradwell power plant in England, and the principal elements of the two plants are identical. It has, however, been possible to step up the power to 200 MW, as compared with 150 MW per reactor at Bradwell, by increasing the absolute pressure of the coolant from 10.5 to 13.8 atmospheres without any appreciable change in the dimensions or the other operating parameters.
The reactor is housed in a spherical steel vessel about 20 m in diameter and with a thickness of 9 cm, except at the top, which carries the reinforcements for the standpipes, and in the region of the supporting columns, where the thickness is 11 cm. As the coolant enters the sphere from below and moves upwards through the core, the walls of the sphere are exposed to relatively low temperatures at its base and to high temperatures at the top. In order to obtain an even temperature distribution throughout the vessel and, consequently, a substantial reduction in the thermal stresses, insulation has been applied internally in the upper part and externally in the lower part. In normal operation, the maximum and minimum temperatures of the steel are 215 and 180°C respect vely. The vertical graphite stack is 14.20 m in diameter and 9.40 m high. It contains 2,929 fuel-element channels and 108 control rod channels and consists of vertical blocks keyed together in such a way that the dimensional variations occurring as a function of temperature and irradiation do not affect the linearity of the channels. The fuel elements, of which there are 8 in each channel, are rods of natural uranium clad with a magnesium alloy (Magnox). The cladding is provided with spiral fins and longitudinal "splitters", which serve both to stiffen the element and to improve the heat-exchange coefficient (polyzonal system). The respective maximum permissible temperatures are 480°C at the cladding and 620°C at the centre of the rod. The average burn-up envisaged is 3,000 MWd/ton.
One of the problems which the designers of any type of reactor have to cope with is the problem of "flux-flattening". If no measures are taken to "flatten" the flux, a peak occurs in the central part of the core. If we bear in mind the limitations on fuel-element temperature which have just been mentioned, this would imply that maximum possible heat output would be confined to the central part of the core, with a marked tailing-off as the distance from the centre becomes greater. In the Latina reactor flux-flattening is achieved by inserting steel absorbers into the cen-

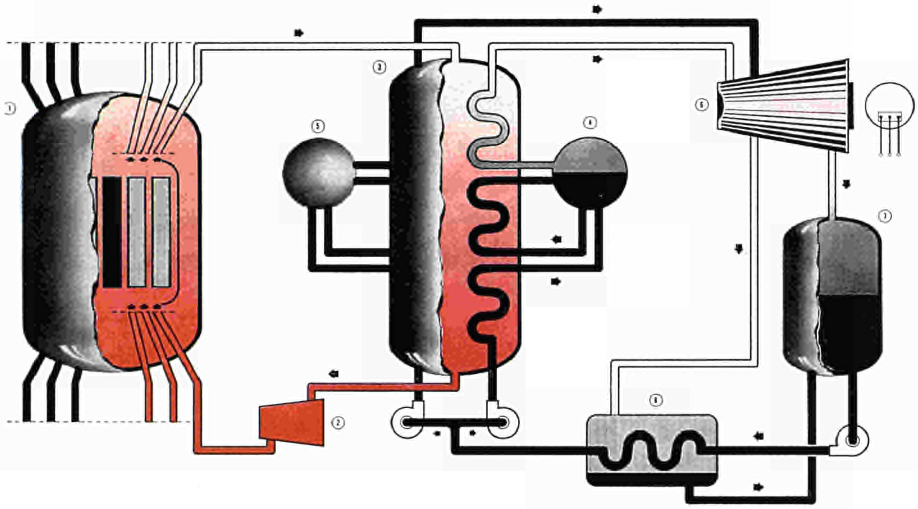


Figure 1—Schematic flow-diagram (gas-cooled graphite-moderated reactor)
1 Reactor
2 CO_2 blower
3 Steam generator
4 High pressure steam drum
5 Low pressure steam drum
6 Turbo-generator
7 Condenser
8 Feed-water heaters

tral zone. As they are inserted in interstitial channels, there has been no need to reduce the number of channels in the lattice which are available for the fuel and for control purposes (see Fig. 2).
The reactor is automatically controlled by sectors. Four rods in the central sector and two rods in each of the eight peripheral sections are actuated by the temperature variations measured in the sector concerned. As the temperature of the coolant in a particular region of the core depends directly on the neutron flux in that region, two functions are thus performed: the gas temperature at the channel outlet is maintained constant and the spatial stability of the flux is ensured.
Apart from these control rods, which make fine adjustments and maintain the overall stability of the reactor, irrespective of the power level at which it is operating, there are the so-called "bulk rods" which are arranged in two groups of 46 and 22 rods respectively. The first group is used to adjust the power output of the reactor according to requirements (controls the shut-down negative reactivity and the temperature effect on reactivity), while the second is used to compensate the "poison" effect of the fission products which accumulate within the fuel-elements. There are also 12 safety rods which are normally kept fully extracted from the core, even in shut-down conditions, and are inserted by gravity in case of emergency.

The control system, which is completely automatic, is designed to enable the plant to operate at between 20% and 100% of its maximum power.
Fuel-element loading and unloading are effected during operation by a single machine which travels on the pile cap and is capable of performing all the necessary operations. It enables the fuel of about 7 channels to be renewed in a day. A second machine is provided as a stand-by.
The heat exchangers have been slightly modified with respect to those at Bradwell. Although having a 33% higher heat-exchange capacity, they are slightly smaller, the improvement being obtained by the use of finned tubes for the superheaters.
The secondary cycle comprises two steam circuits, a high-pressure circuit (53.2 atm.) and a low-pressure circuit (13.8 atm).
The six axial gas blowers are driven by electric motors fed at variable frequency by auxiliary turbo-generators. Furthermore, emergency electric motors fed by diesel generator sets enable the blowers to continue operating in the event of a general electrical failure, in order to ensure an adequate supply of coolant to evacuate the residual heat of the reactor after a shut-down.

Principal construction stages

Work on the site started in November 1958. The foundations of the reactor building were laid between February and July 1959. The "Goliath" crane covering the entire reactor building, which was to serve for the erection of the containment shell and the heat-exchangers, was erected during the same period. At the end of the summer of 1959 the first pouring of concrete took place for the reactor's biological shield, which reached the level of the pile cap in September 1960.
The first plates for the pressure vessel arrived on the site in August 1959. The assembly, welding and stress-relieving op-
(*continued on page 16*)

Reactor building—putting fittings into position on the reactor core support floor

Participation by Community Industries in Design and Construction

The Latina power plant was constructed under a contract for co-operation in the field of graphite-gas reactors concluded between Agip Nucleare and the Nuclear Power Plant Company in August 1958. Although the purpose of the contract is to promote the continual growth of the nuclear industrial potential of the Italian partner, so that ultimately collaboration should be on a 50/50 basis, the far greater experience of the British at the time the Latina plant was built resulted in the studies and the main supplies being undertaken by the NPPC and the companies forming this group.

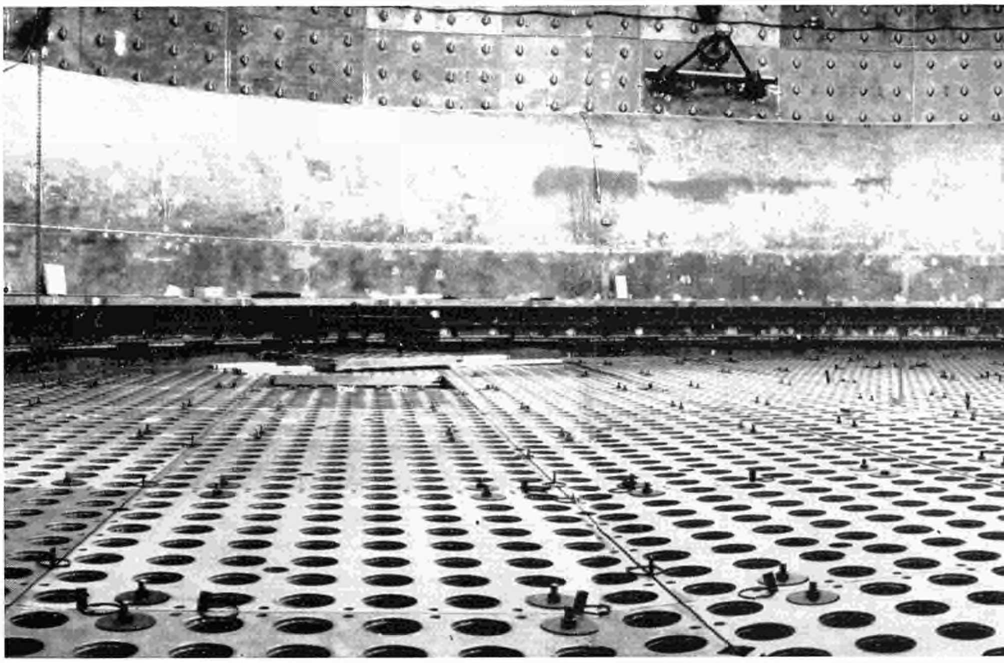
Italian participation was, however, also active at the time the design studies for the plant were carried out and during construction and commissioning.
At the design stage, all the NPPC studies were checked by Agip Nucleare, which put forward certain original solutions, such as the keyed graphite block design. Agip Nucleare also carried out the civil engineering studies, together with the detailed studies relating to the installation of the equipment not covered by the NPPC contract, a list of which is given on this page.
At the construction stage, Agip Nucleare was responsible for the following:
— levelling of site and access roads,
— supplying of site labour (with the exception of a number of specialists supplied by the NPPC and its associates),
— general site services,
— civil engineering works,
— supply and installation of equipment not included in the NPPC contract,
— co-ordination and supervision of the work.

At the testing and start-up stages, all the operations drawn up by the NPPC were first discussed and approved by Agip Nucleare, SIMEA and the Comitato Nazionale per l'Energia Nucleare (CNEN). The tests were carried out by the SIMEA operating staff under the supervision of the NPPC test engineers and the designers.
Mention should be made of the special care devoted to the training of the SIMEA operating personnel. The entire staff of the plant followed training courses of varying duration, either in the NPPC design offices and laboratories or at Calder Hall or Bradwell.

(Non-Italian enterprises are marked by a letter in parentheses: D = German, F = French).

Civil Engineering	Impresa Torno ICOS CIA Tabellini
Mechanical Installations	SAIPEM
Sea-water Inlet and Coolant Water Outlet Equipment	Fincosit Riva Bonna Passavant (D) Junker
Handling	
Goliath crane	Ceretti and Tanfani
Travelling cranes	Zerbinati
Lifts	Falconi
Main CO_2 ducts	Nuovo Pignone
Blowers	
Main and auxiliary motors	Marelli
Heat-exchangers	
Casings, internal cradles, drums, collectors	Nuovo Pignone
Circulation pumps	KSB (D)
Feed pumps	KSB (D)
Feed-pump motors	TIBB
Water/Steam Circuits	
Pipes	Dalmine
Valves	Babcock & Wilcox (D)
Heat Insulation	Riva e Mariani Guadalupi
Main Groups	
Condensers	Franco Tosi
Auxiliary Groups	
Turbines	Ansaldo
Alternators	Ansaldo S. Giorgio
Overpressure Suppressor	Balcke (D)
Biological Protection Cooling Circuit	
Ventilators	SITE
Ventilator Motors	OET
Protective Posts	Italglass
Make-up Water Preparation Unit	
Purging unit	De Bartolomeis
Demineralisation unit	Rossetti
Air-Conditioning and Ventilation	COGET
Transformers	
Main transformers	Marelli
150/220 kV transformers	IEL
Auxiliary transformers	Marelli IEL Trafo
Power Lead-Off Unit	
Framework	SEN
Cut-out switches	TIBB
Disconnecting switches	Galileo
Stand-By Network	
Diesel groups	FIAT
Convertor groups	OET
Rectifier-transformers	Marelli
Batteries	Hensemberger
Instrumentation and Control	
Consoles and leads in tubes	CIELM
Temperature scanner	Olivetti
Telecommunications	Siemens

Reactor building—graphite support grid



erations were completed 15 months later in December 1960.
Hydraulic testing was carried out in February 1961, external insulation between March and April 1961 and internal insulation between September and October 1961. From then on the inside of the pressure vessel was maintained under clean conditions control for both the personnel and material.
Stacking of the graphite started on 19 February 1962 and was completed at the beginning of June, the time taken being determined by the phasing of graphite deliveries and not by the actual erection work. The summer of 1962 saw the installation of the equipment located on the upper face of the stack, such as thermocouples for measuring the gas temperature at the outlet of the channels, piping for the detection of cladding ruptures, etc.
Installation of the first fuel-element loading and unloading machine started on 20 May 1962 and was completed in September of the same year; that of the second machine started in February 1963 and was completed in April 1963.
Erection of the heat-exchanger shells was carried out between March and September 1960. This was followed by the internal assembly work and installation of the tube-banks, which were completed at the beginning of 1962. Installation of the main piping for the gas circuit took from March 1960 to August 1962.

Construction of the turbine house was carried out concurrently with that of the reactor building. Installation of the main turbo-alternator sets and their auxiliaries started in June 1960 and was finished in July 1962.
The construction work proper was completed on 1 November 1962 with the exception of the pool for the storage of irradiated fuel elements and the processing of radioactive waste, which was ready at the beginning of 1963, and of the finishing operations.

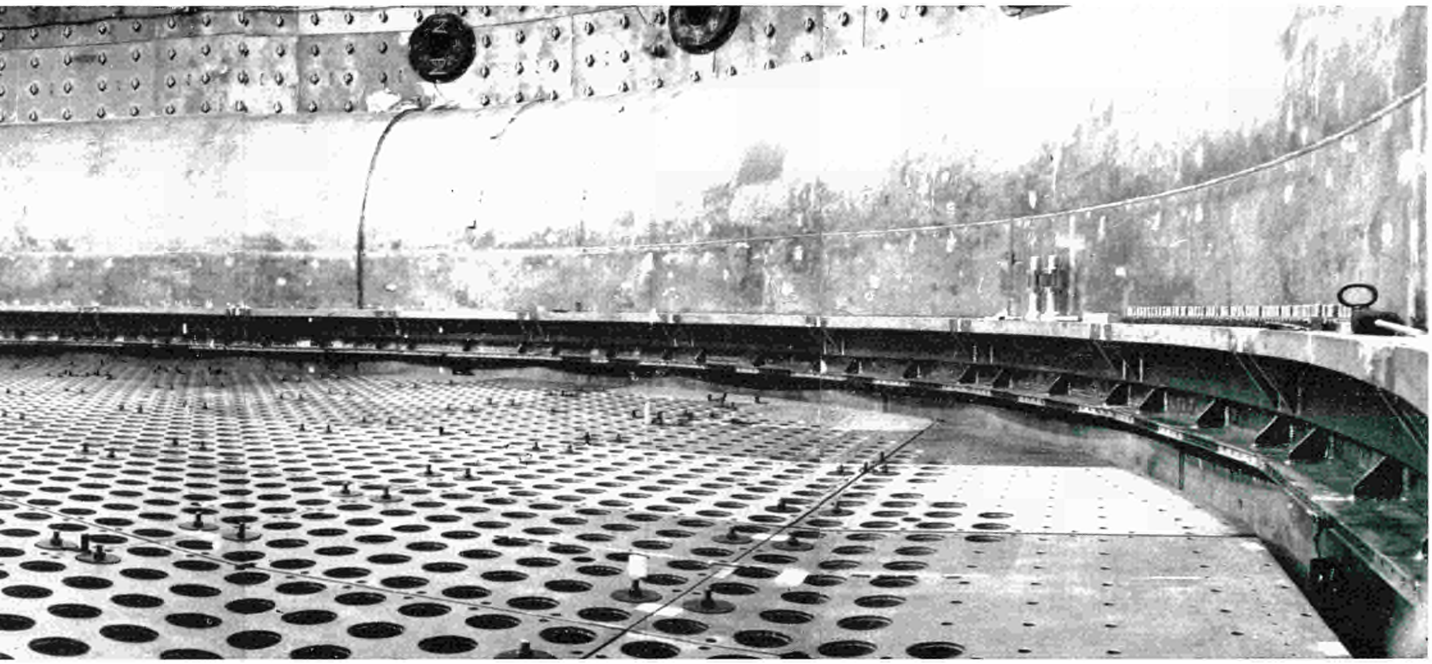
The first fuel-supply contract has been concluded with the United Kingdom Atomic Energy Authority. It provides for 400 tons as the initial charge, one and a half year's consumption, and a reserve of 30 tons. Between 1 August and 15 December 1962, 300 tons were delivered to the site.

Unit tests

As assembly work on the various items of equipment reached completion, individual tests were carried out in order to ensure that the assembly work had been performed in accordance with the specifications of the contract, to effect the necessary adjustments, and to guarantee that each piece of equipment was capable of fulfilling its function.
This phase of testing naturally commenced well before completion of the construction work. As a result it was possible to detect two weak points and to carry out the necessary modifications before start-up of the reactor.

Combined tests before loading of the fuel

These tests are carried out when the various units and circuits required for the functioning of the reactor have been completed and individually tested. Their purpose is to confirm, before the fuel is loaded, that the plant is capable of operating under load. They constitute the transition



stage between the construction work and the start-up proper and provide the operating personnel with initial training in the operation of the plant.

These tests, which were successfully carried out between 1 November and 8 December 1962, consisted mainly in the following activities:

— leak-tightness testing of the entire gas circuit with compressed air at 15.5 kg/cm² gauge. The various sections of the circuit had previously been tested with air at 19 kg/cm² gauge (equivalent to one and a half times the nominal pressure). The leakage rate was measured at the nominal operating pressure.

— preliminary testing, in cold air and at the operating pressure, of the various elements: blowers, valves and auxiliaries of the primary circuit, control-rod actuation mechanisms and circuits, apparatus for flux measurement and the detection of cladding ruptures, safety circuits, and CO_2 blow-down system.

— drying of the graphite by blowing air which had been heated and dried in a provisional drying installation.

— filling of the circuit with CO_2

— A second CO_2 test programme, in the hot state and at operating pressure, on the various elements listed above plus the fuel-element loading and unloading machine

— the blow-down, vacuum test and purge with air of the primary circuit, to which access was thus possible for the loading of the first charge of fuel by hand.

This test phase, which had been scheduled to take 6 weeks, was actually completed in slightly less time, thanks to the introduction of a number of simplifications as compared with the original programme.

Fuel loading

The loading of the first charge of fuel into the reactor differs considerably from the normal fuel replacement procedure by means of the operating equipment. It consists in fact in loading the reactor with 24,000 new fuel elements in the least possible time, whereas at the rate permitted by the fuel element charge/discharge machine this operation would have taken several months. The initial loading was therefore carried out chiefly by hand.

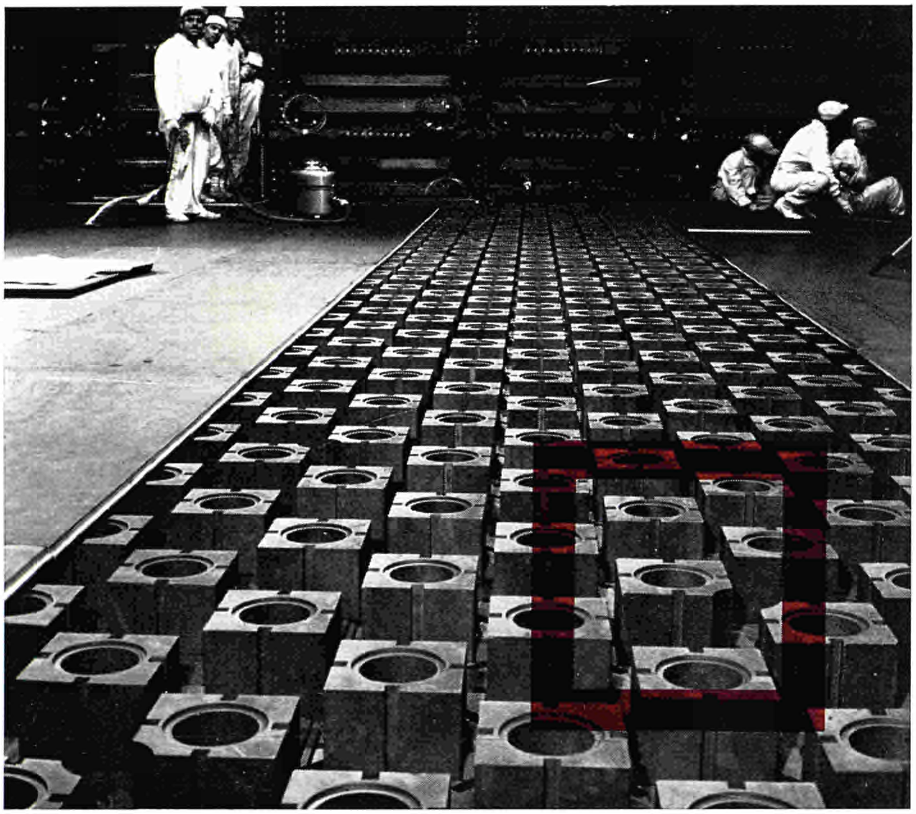
Loading started on 24 December 1962 and was completed on 14 January 1963. It was done in two stages. The critical size was obtained after the loading of 420 channels, and a preliminary series of measurements was carried out with 432 channels loaded. This first phase of the loading took 55 hours, including the stoppages for measurements in the course of loading. The loading of 2,497 channels to bring the small pile up to full size was then effected in less than 10 days. Altogether, 10,5 channels were loaded on an average per hour, the work being carried out continuously by shifts of 26 men.

Final measurements before power run-up

Now that the pile was loaded to full scale, final measurements were made. This vital phase, which precedes the actual power run-up, is perhaps the most anxious one for the designers of the reactor core inasmuch as it is a test of the accuracy of their calculations. At the same time the last fine adjustments can be made.

First of all, the *built-in reactivity* of the pile was determined.

It was then possible to draw up *flux distri-*



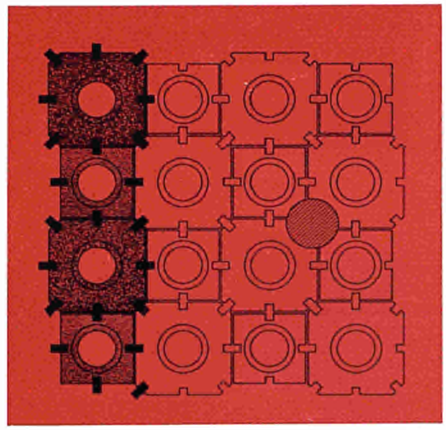


Figure 2—*First layer of graphite blocks for the Latina reactor. It can be seen that the blocks of this first layer are of two different heights, which means that by stacking blocks of equal height above them, an interlocking layer arrangement will be obtained throughout the pile. This arrangement and the fact that the blocks are keyed together ensure that expansion and contraction phenomena caused by temperature changes do not affect the linearity of the channels.*

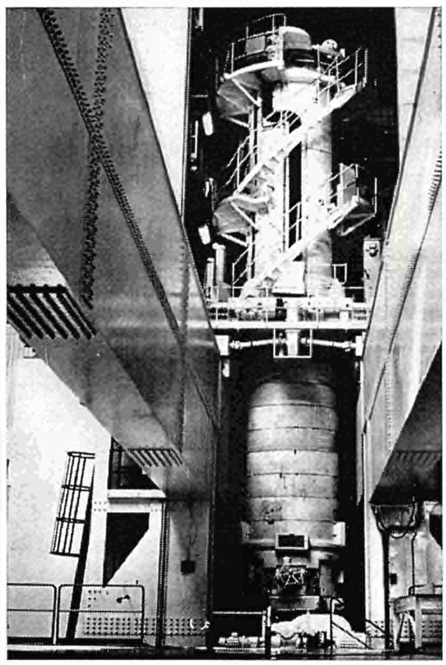
The hached space on the diagram represents one of the interstitial channels in which steel neutron-absorbers can be inserted for flux-flattening purposes.

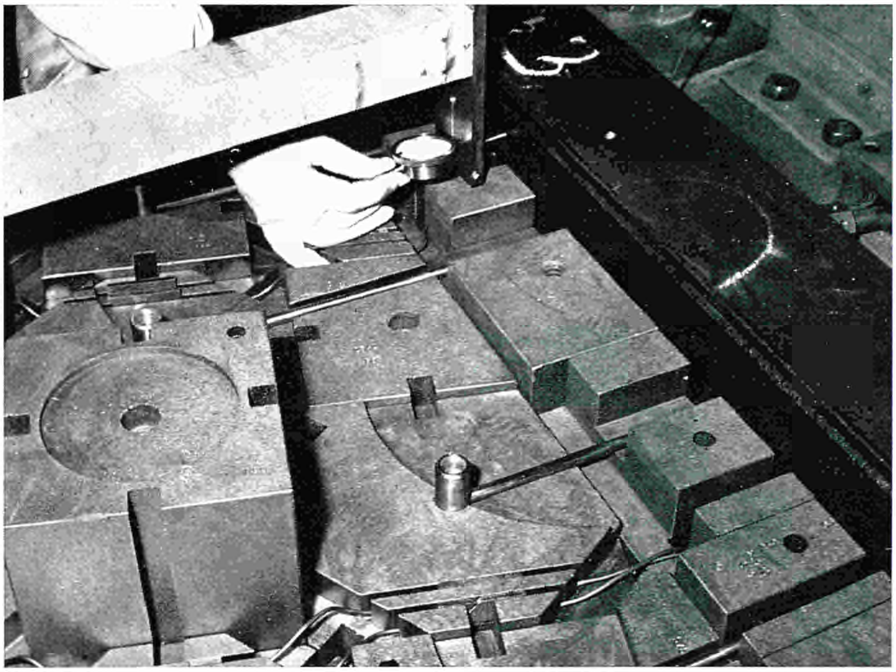
bution charts, giving an accurate picture of the core's behaviour, down to the smallest deformations of the flux in the vicinity of irregularities: empty channels, absorbers, control rods.

There followed the *measurement and adjustment of the gas coolant flow in each channel*. This adjustment was carried out in cold air at atmospheric pressure, with the six blowers rotating at their nominal speed. It was carried out by successive approximations, the flow at the channel outlet being measured by means of anemometers and the necessary alterations being made to the adjustable orifices with which each channel is equipped. The adjustment of the total number of fuel channels was finally obtained with a maximum deviation of 0.5% from the required value as calculated, the operation having taken a total of 19 days.

The calibration of the control rods is another delicate operation, as an accurate knowledge of the way in which each rod alters the reactivity of the core is essential, not only from the safety point of view, but when it comes to keeping an exact control of the output of the reactor. The control-rod calibrations gave satisfactory results

Reactor building; view of the fuel-element charge/discharge machine





Mounting the control rods ▲

Reactor building—laying the core graphite ▶

which were in good agreement with the calculated values. They took a total of 20 days.

Finally the *sensitivity of the cladding burst detection system* was determined. It is indeed important, when the reactor is operating, to be able to locate a burst fuel element quickly in order to remove it. Otherwise the fission products which it releases could eventually contaminate the primary circuit above permissible levels. The determination was effected by loading the reactor at different points with non-clad sheets of an enriched uranium/aluminium alloy and maintaining the reactor at a constant power of 100 KW for ten hours. This had the effect of raising the level of radioactivity abnormally at these points and thus reproducing conditions similar to those which attend the release of fission products. In this way, it was possible to demonstrate the correct operation of the measuring equipment and to determine its sensitivity.

The nuclear tests at very low power in air were completed at the end of March, that is to say three months after first criticality. In general, all the test proceeded in accordance with a programme which had been very carefully drawn up by NPPC. Each test was the subject of a procedure which was checked down to the last detail and approved before execution of the test by the operator and the inspection authorities. This method proved to be extremely efficient, the planned programme being carried out in its entirety within the time schedule.

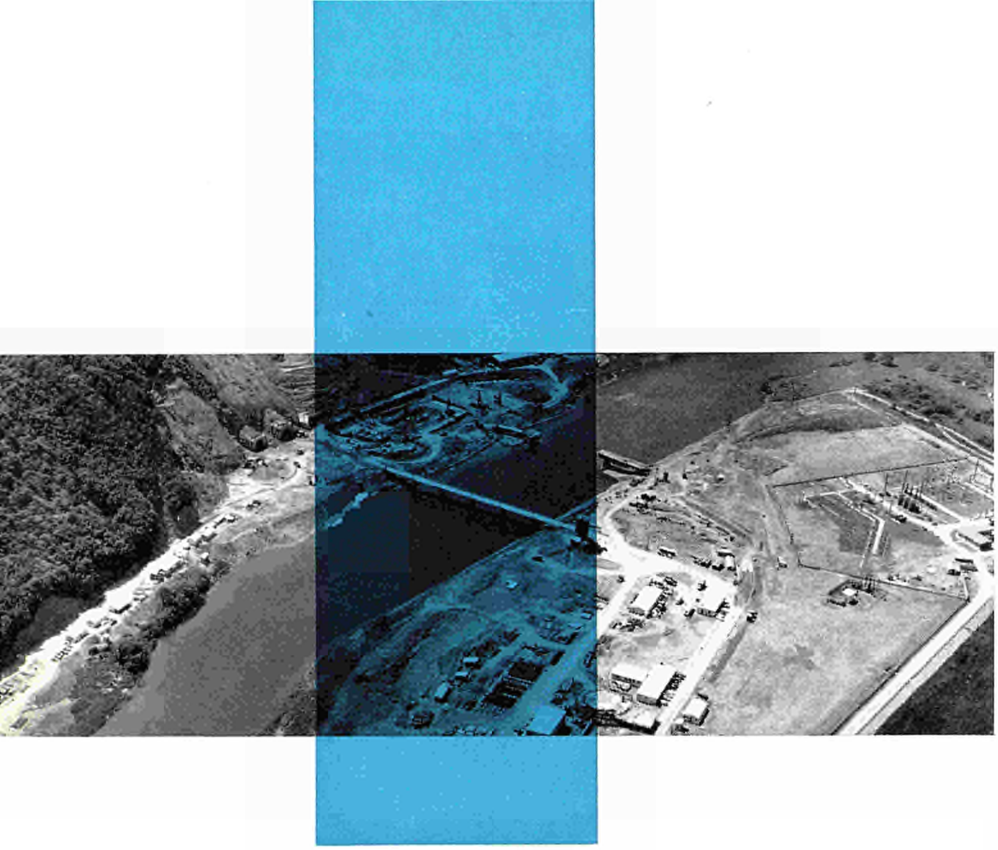
The power run-up

This last phase commenced on 2nd April. It was carried out in a number of stages and, at the beginning of August, power levels were 670 MW thermal and 180 MW electrical. At each stage a record was made of the operating stable conditions of the reactor: gas and fuel temperature distribution, heat balance, reactivity balance, radiation survey, etc. . . Tests were carried out on the charge-discharge machine and the flux scanning equipment.

During this first power operation period, fuel temperatures were kept below the maximum operating limits. These limits will only be reached when the procedure of reactor temperature survey is definitely settled.

On the whole, power raising was performed with only minor troubles generally not due to the reactor and which were rapidly corrected.

At the 15th of August, the net electrical production since the beginning was 172 million kWh.



The Ardennes nuclear power plant

J. EHRENTREICH AND W. KAUT, *Directorate General for Industry and Economy, Euratom*

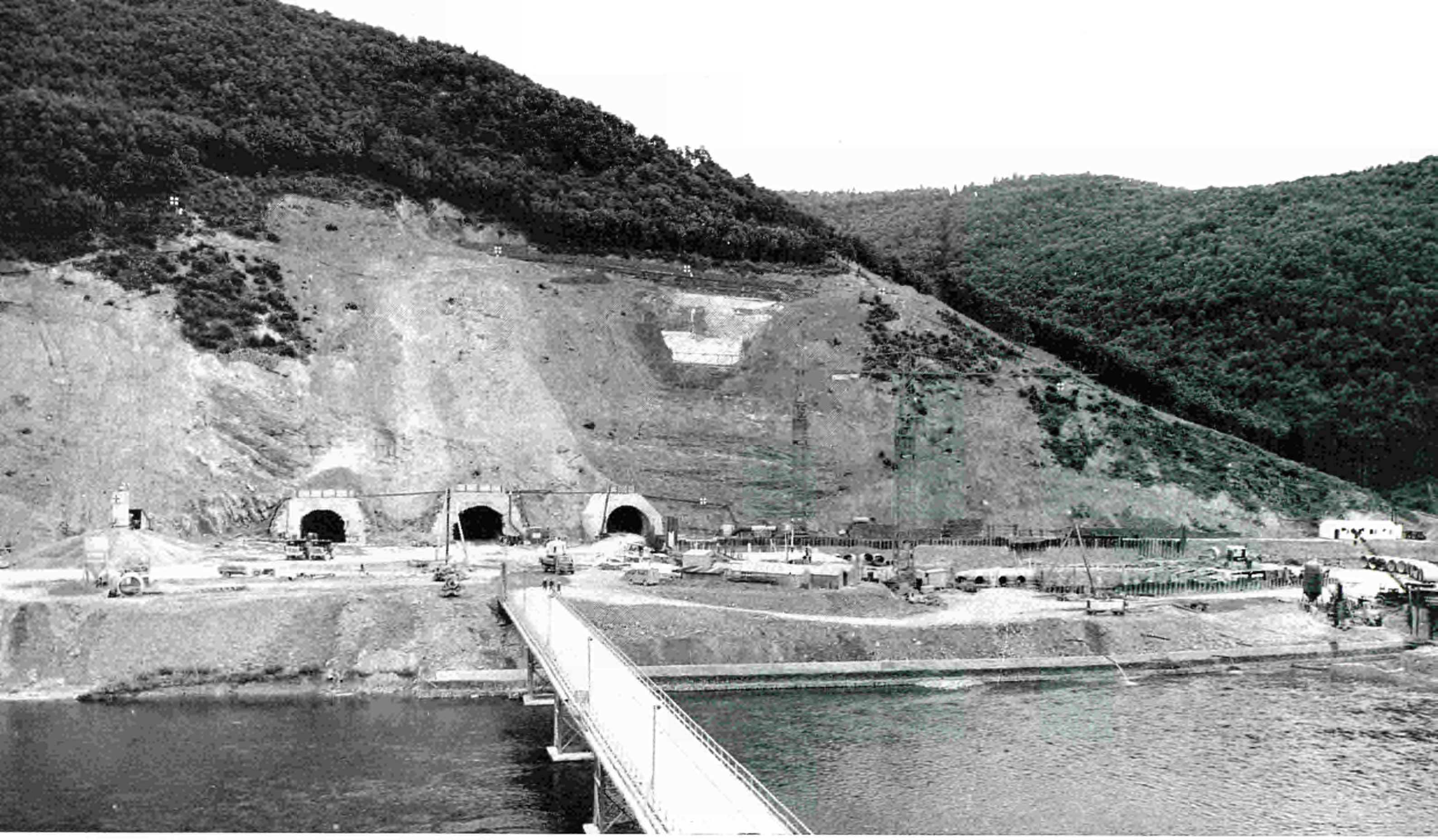
In January 1962, work started on the site of the Ardennes nuclear power plant on the banks of the river Meuse near the village of Chooz in France. To trace the origin of this project, we have to go back several years to a time when the need was felt, both in France and in Belgium, for experience in the construction and operation of a type of reactor not hitherto developed in Europe. France and Belgium accordingly pooled their resources for the realisation of a power plant equipped with a reactor of American type, using enriched uranium fuel and pressurised water both as moderator and coolant (PWR). This led to the formation of the "Société d'énergie nucléaire franco-belge des Ardennes" (SENA) by "Electricité de France", the French electricity production corporation, and "Centre et Sud", a group of Belgian utility undertakings[1]. The plant is being built in the framework of the US/Euratom Agreement of co-operation, of which one of the provisions guarantees the supply of the necessary enriched uranium. Apart from this, Euratom decided to include the SENA project in its Participation Programme, undertaking to participate in the extra start-up costs which could occur in the course of the first three years of operation and in the cost of the second fuel charge, on condition that the fuel elements be manufactured by Community industries.

The design of the nuclear power plant and the manufacture of its equipment are being handled by the A.F.W. constructor group, which includes Ateliers de Constructions Electriques de Charleroi (A.C.E.C.), Framatome and Westinghouse Electric Corporation. Besides the firms which constitute Framatome in France the Belgian firms Cockerill-Ougrée, Seraing and Métallurgie et Mécanique Nucléaires (M.M.N.), Brussels, are also members of the group.

Siting of the plant

As can be seen from the aerial photograph, the South bank of the river Meuse, at the location selected, rises steeply while

1. Member companies of "Centre et Sud" are:
Société d'Electricité de Sambre-et-Meuse des Ardennes et du Luxembourg (Esmalux),
Union Intercommunale des Centrales Electriques du Brabant (Interbrabant),
Sociétés Réunies d'Energie du Bassin de l'Escaut Ebes),
Société Intercommunale Belge de Gaz et d'Electricité (Intercom).
This group represents practically all electricity production and distribution enterprises in Belgium.



General view of the site on the South bank of the Meuse

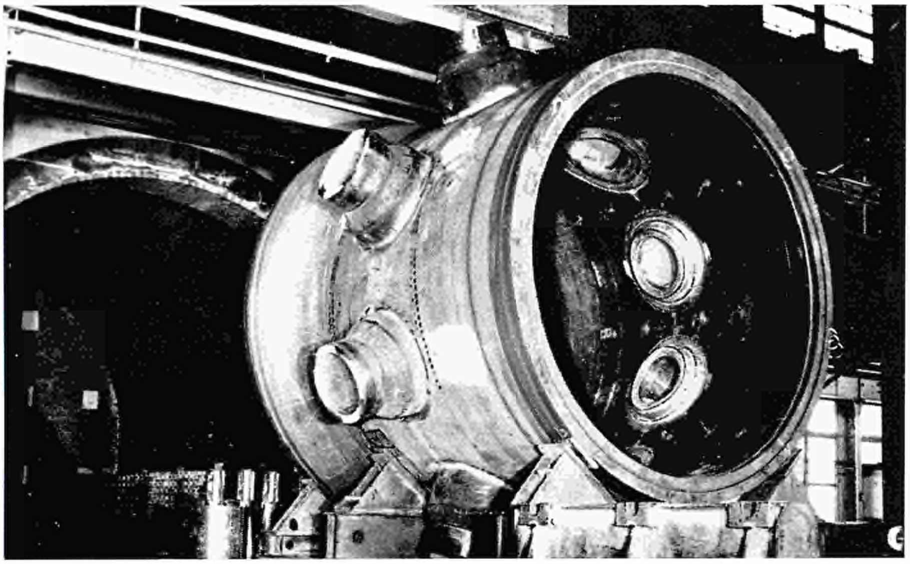
the North bank is relatively level.
It was originally envisaged to site the whole plant in the open. Later a solution lying at the other extreme, and which meant housing practically all parts of the installation inside the cliff, was considered. In the end a compromise solution was adopted. Broadly speaking the reactor proper and its cooling circuits along with a number of auxiliaries will be housed in two caves excavated out of the hillside, the rock thus constituting an adequate biological shield, while the turbo-alternator hall, the electrical plant building, the control room, the administrative block etc. will be erected in the open on level ground.
The contract with the A.F.W. constructor group for the plant design and the manufacture of equipment was signed in September 1961. The various mechanical and electrical parts of the plant are now being built in the manufacturers' workshops in Belgium and France.
The contract for the civil-engineering work was concluded in January 1962 and at the same time the on-site construction work was started. The South bank of the Meuse was prepared first, so that work could begin on the excavation of the galleries leading to the two caves. The problem of landslides from the mountain-side above the gallery entrances had to be overcome before excavation was possible. As loose boulders made excavation itself difficult, it was necessary to line the gallery entrances with concrete and to prop the excavated sections. Excavation of the galleries has now been completed and that of the caves is being continued, but the work is still very difficult.
Construction of the machine house and of the building for the electrical plant is proceeding and concreting of the bridge over the Meuse has been completed.
However, civil engineering work as a whole was held up by the extremely cold winter of 1962/1963.
The erection of the mechanical and electrical parts will start in mid-1964, and the start-up of the plant is scheduled for the end of 1965.

The reactor and its working principle

The nuclear part of the plant consists primarily of a large pressurised water reactor of advanced design. The plant capacity is 905 MWth (266 MWe net).
The core of the reactor is housed in a pressure vessel and bathes in the demineralised water which acts as moderator and primary coolant. This primary water, the average temperature of which is 284°C, is prevented from boiling through pressurisation to 140 atmospheres. After flowing through the vessel, it divides into four loops, each of which includes a steam-generator in which the heat is used to produce saturated steam in a secondary circuit at a pressure of 35 atmospheres. The steam flows to a *single* turbo-generator unit which has four casings, one high-pressure and three low-pressure.

Reactor core

The design of the reactor core has not yet been finalised, but it will contain about 40 tons of slightly enriched uranium (approximately 3.5%) in the shape of 120 fuel elements, each containing some 200 stainless steel clad fuel rods.
The rods in each fuel assembly are held in place within the lattice by spacer grids located at intervals along the assembly. Spring clips will prevent lateral movement of the rods, while permitting them to expand axially. Nozzles at the top and



Reactor vessel. Annealing of the upper part after welding of the eight sleeves

SENA Figure 1—Schematic flow-diagram (pressurised water reactor)
1 Reactor vessel
2 Pressuriser
3 Heat-exchanger
4 Turbine (high-pressure casing)
5 Water separator
6 Reheater
7 Turbine (low-pressure casings)
8 Condenser
9 Feed-water heaters

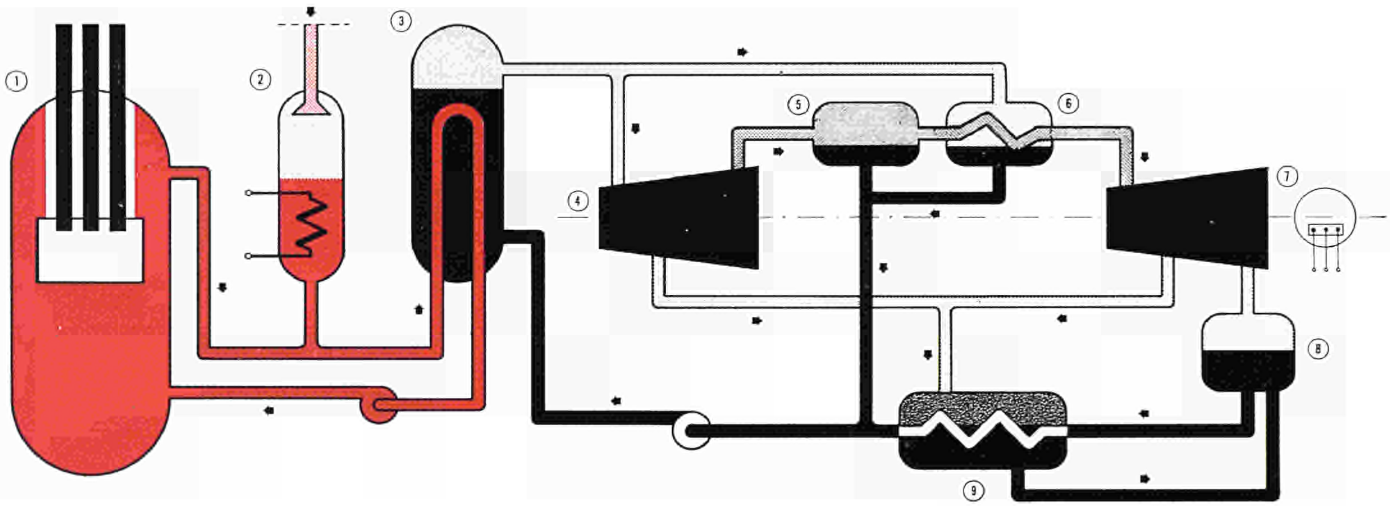
bottom of the bundle and a perforated stainless-steel can welded to the grids and surrounding the bundle complete the assembly. Portions of the outer rows of fuel rods will be omitted at the corners of the bundle to form slots for the blades of the cruciform control rods (see Fig. 2). The core is provided with a form-fitting austenitic stainless-steel baffle which will surround the cluster of assemblies and confine the coolant flow to the fuel-containing region.

Reactor cooling system

The whole primary cooling system is located in the reactor cave. The four identical heat-transfer loops of which it consists are connected in parallel to the reactor vessel and each contains a circulating pump and a steam generator. An important item of equipment included in the system is the pressuriser, which keeps the pressure of the primary system constant.
The reactor vessel, which contains the core, is a welded cylindrical container with a hemispherical bottom-head and a flanged and gasketed removable top-head. The main cooling water enters the reactor vessel assembly through 4 inlet nozzles and leaves through 4 outlet nozzles. The inside surfaces of the vessel are clad with stainless steel in order to bring down to a minimum the formation of corrosion products in the primary circuit.
The four steam-generators are vertical shells filled with U-tubes through which the reactor coolant flows. The steam is generated in the shell and flows upwards through moisture separators to the outlet nozzles. Here again, all surfaces which are in contact with the primary fluid are either made of stainless steel, as in the case of the heat transfer tubes, or clad with stainless steel.

The pressuriser

One of the vital parts of the primary system is the pressuriser, which controls the pressure of the fluid and prevents deviations from 140 atmospheres. Its main component is a vessel which is connected to one of the primary loops (see Fig. 1) and in which water and steam are maintained in equilibrium. Should the pressure of the primary system tend to drop, steam is generated



by electric heaters inserted through the wall of the vessel near the bottom head. Conversely, if the pressure tends to rise, a spray nozzle located at the top of the pressuriser comes into operation. The pressuriser is equipped with safety and relief valves which connect it to a relief tank. Thus, should the pressure rise steeply, steam is discharged into the tank where it is condensed.

Chemical and volume control

During the operation of the plant, reactor coolant is continuously withdrawn from the cold leg of one of the heat-exchange loops into the chemical and volume control system and then returned to the cold legs of two of the other loops.

The chemical and volume control system has a multiplicity of functions: it maintains the proper *water inventory* in the reactor coolant system, reduces the quantity of *fission- and corrosion-product impurities*, and maintains the proper concentration of *corrosion-inhibiting chemicals* in the reactor coolant. To a certain degree, and this is a novel feature, it also permits *reactivity control*.

The water entering the system, after being cooled and depressurised, is passed through demineralisers, which *remove ionic impurities*. It is then collected in the volume control tank, which acts as a kind of buffer tank for the primary circuit as a whole. It will indeed be realised that, as the output of the reactor varies, the temperature of the cooling circuit will fluctuate, and, consequently, that the volume of the *water inventory* will expand and contract. It is not desirable that oxygen should enter into solution with the primary coolant as its presence would promote corrosion. The atmosphere of the volume control tank is therefore hydrogen. The tank is to be vented at various intervals in order to ensure the *removal of the fission gases* which may be released into the primary circuit by burst fuel elements.

Provision is made in the chemical and volume control system for the addition of *corrosion resistant chemicals*, according to needs. However, the most unusual feature is perhaps the provision for the injection of boric acid into the reactor coolant, and the adjustment of its concentration for *reactor control* purposes. The boron, which is thus in solution in the primary circuit, does a duty which, in most other reactors in existence, is fulfilled by control rods earmarked for the compensation of the "poison" or neutron-absorbing effect of fission products. When the core is fresh, the boric acid concentration will be at its highest level, but as irradiation proceeds and therefore fission products accumulate, the concentration will be decreased. One of the advantages of this solution is that less control rod openings are necessary in the reactor vessel.

Reactor control system

The presence of boric acid in the coolant is not the only feature of the SENA reactor's control system which is novel. The control rods, which are actuated from the top of the reactor, do not consist simply of a neutron-absorbing material. They are in fact made up of two sections, one of which is an absorber section made of silver-indium-cadmium, the other being a fuel-bearing "follower" consisting of stainless steel tubes filled with uranium oxide pellets. Thus when a control-rod is withdrawn, the absorber section is replaced by a fuel-bearing section. This has the effect of avoiding flux-peaking and making the core's power production more homogene-

Floor preparation for concreting in the auxiliary access gallery (February 1962) ▶

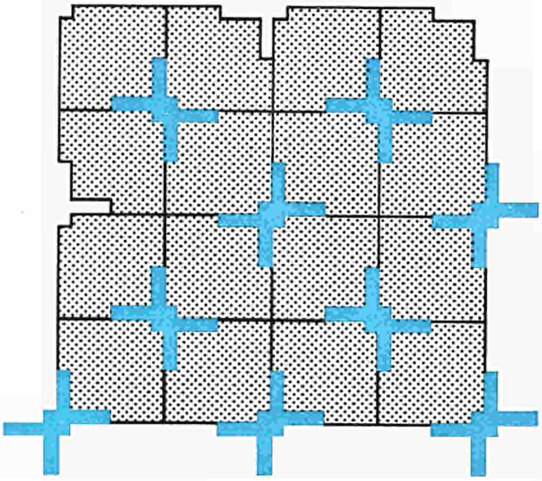


Figure 2
Horizontal cross-section of part of the core showing arrangement of fuel elements and cruciform control rods

ous. As in most water-reactors, the control rods are cruciform but are slightly offset to fit between the fuel assemblies according to a certain pattern (see Fig. 2).
The control-rod drive mechanism is of an electrical type, in which magnetic fields set up by coils are the motive force. The mechanism also provides a signal indicating the position of the control rod.
The reactor will normally be operated by an automatic control system at power levels in excess of approximately 10% of full power.

The necessary design and construction studies for the plant are being carried out for S.E.N.A. by:

B.E.N. (Bureau d'Etudes Nucléaires) Sofina Electrobel Traction Electricité	in Belgium
Région d'Equipement Thermique No. 1 de l'EDF Région d'Equipement Thermique Nucléaire de l'EDF	in France

The manufacture of parts will be equally distributed between Belgian and French companies. Some of the main parts and their manufacturers are listed below.

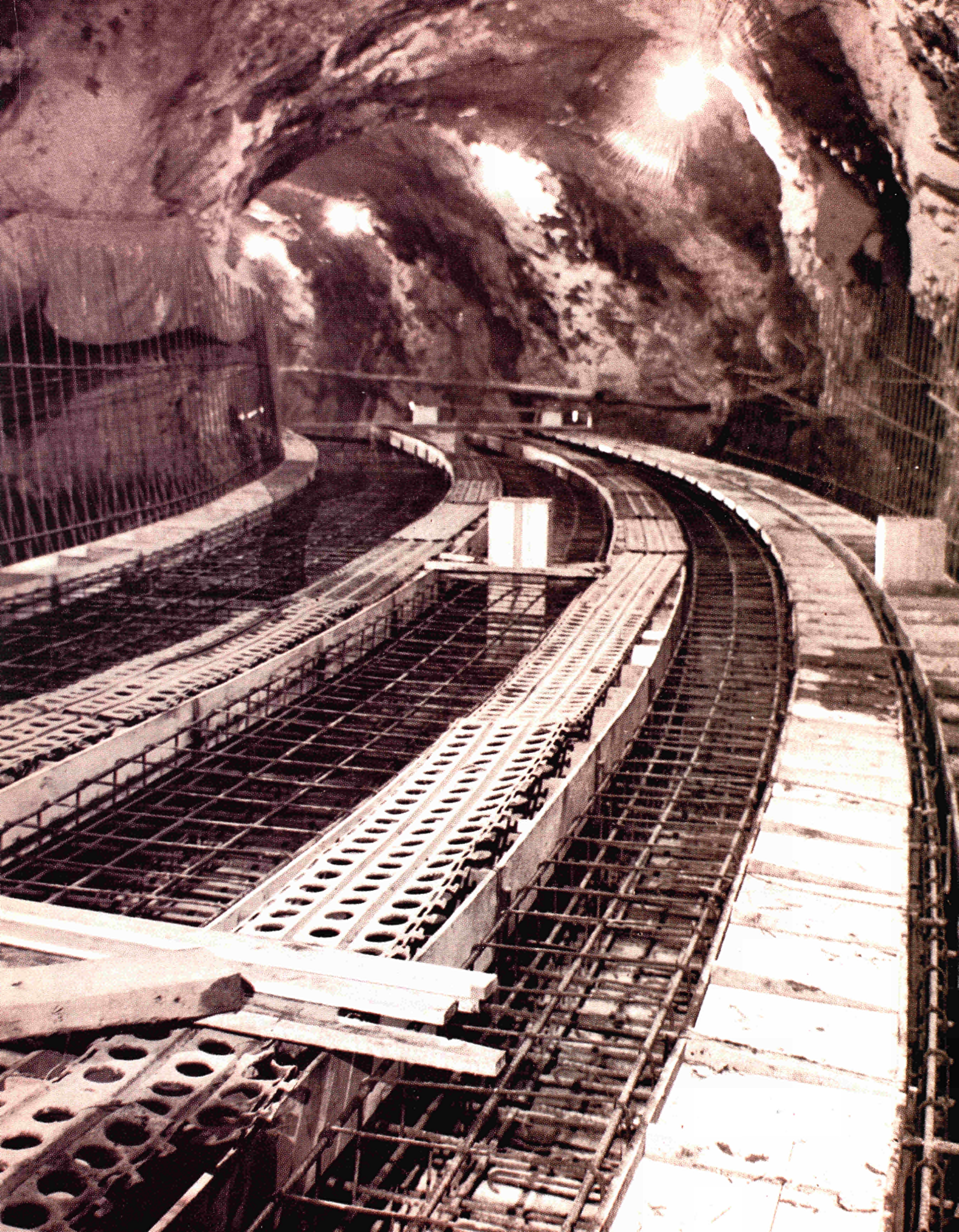
Reactor pressure vessel	Société des Forges et Ateliers du Creusot (S.F.A.C.)
Pressuriser	S.F.A.C.
Primary pipes	S.F.A.C.
Primary valves	Ateliers de Constructions Electriques de Charleroi (A.C.E.C.)
Primary pumps	A.C.E.C. Forges et Ateliers de Constructions Electriques de Jeumont (F.A.C.E.J.)
Steam generators	Cockerill—Ougrée
Turbine	S.F.A.C., Rateau, Cockerill—Ougrée
Alternator	A.C.E.C.
Condenser	Le Matériel Electrique SW, Paris (SW) Cockerill Ougrée
Control rods	Westinghouse Electric Corp.
Control-rod drive mechanisms	A.C.E.C., SW
Fuel elements:	
First charge	Westinghouse Electric Corp.
Subsequent charges	Métallurgie et Mécanique Nucléaires, Bruxelles (M.M.N.) and Compagnie d'Etudes et de Recherches de Combustibles Atomiques (C.E.R.C.A.)

Neutron shield system

The plant is equipped with radiation shielding wherever it is necessary to provide biological protection for the operating personnel. As in many other types of reactor a primary concrete shield surrounds the reactor vessel, leaving an annular space which is filled with water. In addition, an unpressurised water container, the "neutron shield tank", fits inside this annular space around the central part of the vessel, i.e. around the core. An unusual feature of the SENA neutron shield system is that this tank comprises a set of heat-exchangers for cooling purposes. One of the reasons for this is that the chambers to be used for operational neutron-flux measurements are located in the neutron shield tank and must be held at temperatures not exceeding 80°C.

Secondary circuit and turbo-generator

As already mentioned, the plant includes a single turbo-alternator set with a gross output of 288 MW.
The turbine, which runs on dry saturated steam at a pressure of 35 atmospheres and at a speed of 3000 r.p.m., is a four-casing unit with one high-pressure and three low-pressure casings. Provision is made, not only for extracting the water present in the steam between the high- and low-pressure casings, but for slight reheating by live steam taken directly from the steam-generators (see Fig. 1).
The SENA plant is the only plant figuring in the Euratom Participation Programme which is equipped with a pressurised water reactor. As we have briefly shown, the reactor is of advanced type and the design incorporates a number of novel features. The project will undoubtedly face those involved in the construction and, in due course, the operation of the plant with many new problems, and grappling with them will entail the acquisition of new experience. Thanks to the incorporation of the project in the Euratom Participation Programme, the fruits of this experience will be made available on a European scale.



The Gundremmingen nuclear power plant

J. DESFOSSES, W. KAUT AND J. S. TERPSTRA, *Directorate General for Industry and Economy, Euratom*

After participating in the construction of the Latina (SIMEA) and Garigliano (SENN) nuclear power plants in Italy, and the Franco-Belgian Ardennes plant (SENA), Euratom signed on 29 March 1963 an agreement to take part in the construction of the Gundremmingen nuclear power plant in Germany. The other contracting party and constructor of the installation is the Kernkraftwerk RWE/Bayernwerk GmbH (KRB) of Gundremmingen, Kreis Günzburg in Bavaria.

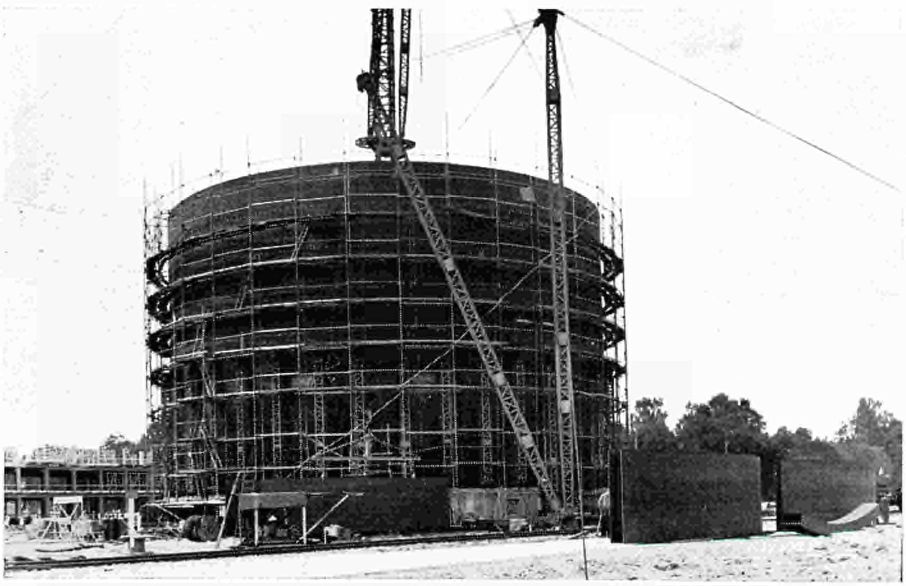
The main supplier is a group of firms consisting of International General Electric Operations Ltd. (IGEOSA), Geneva, Switzerland, Allgemeine Elektricitäts-Gesellschaft (AEG), Frankfurt/Main, and Hochtief AG, Essen. The plant figures in the Joint US/Euratom Nuclear Power Plant Programme under the terms of which it is to be commissioned by 30 December 1965 at the latest.
Euratom will contribute to the costs up to a maximum of 8 mil ion dollar. In return, apart from receiving the information specified in the agreement, Euratom has also the right to assign to KRB a limited number of persons who will work together with KRB personnel on the design, construction and operation of the plant.
The plant has a rated power of 801 MWth and a net electric power of 237 MW. The boiling-water reactor is light-water cooled and moderated, with forced circulation and a double direct cycle; the fuel is enriched uranium dioxide.

The plant will be built in Gundremmingen on the Danube, which will supply the water required as coolant.
The reactor building, a cylinder of about 30 m diameter and height 60 m, will accomodate the whole nuclear steam generating plant with its auxiliary systems, and the fuel storage tank. Adjacent to it are the turbine-house and the operations building.

The design of the reactor core has not yet been finalised, but it is expected it will contain some 368 fuel elements each of 36 rods, with a total uranium weight of approximately 45 t. A non-uniform uranium diameter for the fuel element rods was chosen with the aim of flattening out peaks in the flux distribution; thus for each element in the first core the diameter will be 12.17 mm in 31 rods and 11.15 mm in the remaining 5. Enrichment of the fuel is 2.17% and zircaloy is the cladding material. A high burn-up is guaranteed (16.500 MWd/t as compared with 13.000 MWd/t in the case of SENN).
The chosen power density of 40.9 kW/litre represents a notable advance on the corresponding figures for the Dresden and SENN plants which are 28.9 kW/litre and 28.6 kW/litre respectively. A further difference from these plants is that the steam is separated from the primary water coolant inside the reactor pressure vessel and not in a steam-drum (see fig. 1).

The turbine has an output of 250 MWe at 1500 rpm. For this it requires a supply of fresh steam of about 1025 t/hr at 70.3 atm. abs. direct from the reactor, and a secondary supply of about 450 t/hr at 32.7 atm. abs. from the secondary steam-generators, which is fed into the turbine at an intermediate stage. As in all installations using saturated (i.e. non-superheated) steam, particular attention must be paid to water drainage from the turbine. The water separated during expansion in the wet steam range is removed from the turbine at six points together with the steam extracted for the preheating of the feed water. In addition, water-separators are mounted in the change-over lines

View of the Gundremmingen site



between the high-pressure and the low-pressure sections.

Present status of activities

The contract for the construction and commissioning of the RWE/Bayernwerk nuclear power plant was confirmed by the contractors, AEG, IGEOSA and Hochtief AG, in November 1962, while work has already started on the site preparation in October of the same year. The bottoms of the construction pits had been provided with complete frost protection before the onset of the bad weather so that the work on the foundations could be resumed as soon as the warmer weather returned in March. The frost merely caused an initial six-week delay with the construction of the reactor building, but this was partly offset by extra shifts in the erection of the containment shell and it will probably be possible to make up for the delay entirely.
Of the heavy plant components, orders have been placed for the reactor building containment shell, the reactor pressure vessel, the circulation pumps, the heat exchangers and the large transformers: these items are now being manufactured. Wherever necessary, the approval of the "Technischer Überwachungsverein", the expert body acting for the licensing authorities, has been obtained for these. The orders are about to be placed for most of the other components of the primary and secondary circuits.
Work on the detailed design has been started, partly in conjunction with the manufacturers alone and partly in collaboration with the "Technischer Überwachungsverein". Instances of items already being dealt with are: problems relating to the selection of appropriate materials, the capacity and construction of the waste processing installation, power consumption, measurement and control, regulation systems and procedures, reactor shielding, lighting, etc. The turbine design has been more or less settled.

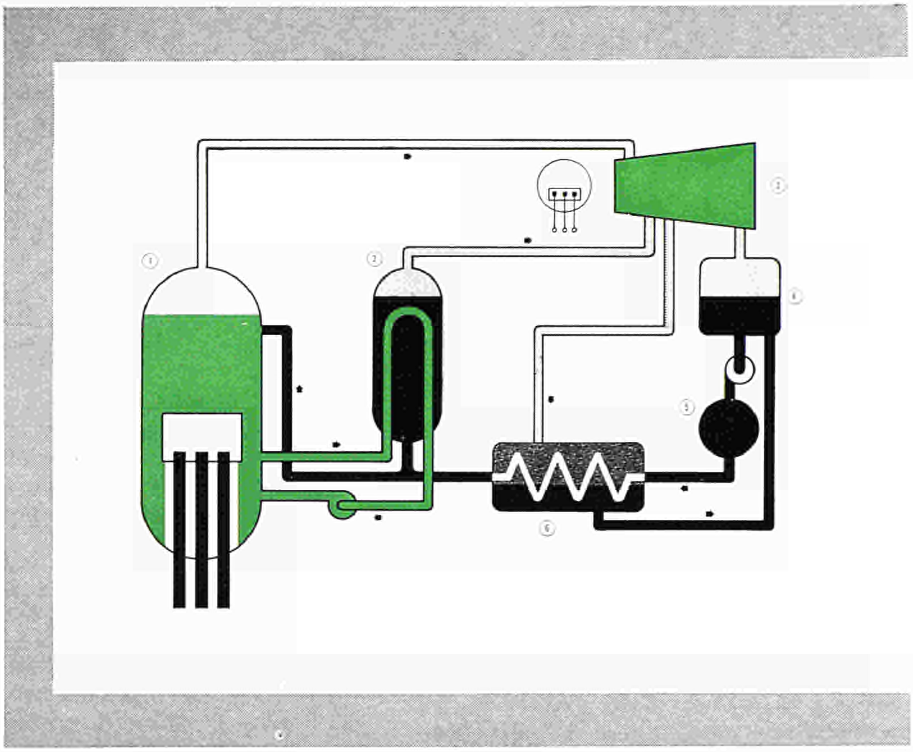


Figure 1—Schematic flow-diagram (forced circulation dual cycle boiling water reactor)
1 Reactor vessel
2 Secondary steam-generator
3 Turbo-generator
4 Condenser
5 Demineraliser
6 Feed-water heaters

Furthermore, the sponsors of the project are carrying out on their own account preliminary work connected with environmental radioactivity monitoring. The monitoring system must be functioning, in line with the principle of "demonstrable safety", before the beginning of zero-power operation. For this purpose, orders have been placed for an observation tower 118 metres high, as well as for a considerable proportion of the metering devices required for the recording of local weather conditions and for monitoring environmental radioactivity.
The authorities have been provided with a provisional safety report dealing mainly, in line with the status of the planning work, with the fundamental design criteria and aimed at the granting of a construction license under the licensing procedure governed by nuclear legislation. The description of the individual pieces of equipment and circuits with which the design requirements are to be fulfilled, which must be provided before the operating license is granted, will be supplied as the detailed design work progresses.
The "Technischer Überwachungsverein" and the Reactor Safety Commission are still in the process of studying the provisional safety report before issuing the expertise requested by the licensing authorities. The study has not yet progressed sufficiently for a definitive and formal construction license to be granted under the Atom Law. To date, no factors have emerged according to which the design of the structures would appear inadequate.

The Dutch nuclear power plant project

J. S. TERPSTRA, *Directorate General for Industry and Economy, Euratom*

The contract between Euratom and Samenwerkende Electriciteits Productiebedrijven (S.E.P.) of Arnhem was signed at Brussels on Tuesday, 2 April 1963. This contract governs Euratom's participation in the construction and operation of a nuclear power plant to be built by S.E.P. This nuclear power plant, the first in the Netherlands, will presumably be situated in the municipality of Doodewaard in the Betuwe district, where S.E.P. has an option on a site in the unembanked alluvial land along the right bank of the river Waal (see location map). Among the many advantages which this location offers are the certainty of a constant supply of cooling water, good building land, a central position in relation to the Dutch national grid, moderate population density, etc. It is hoped that operation of the plant can be commenced in the spring of 1968. The design of the nuclear part of the plant is being carried out, with the assistance of S.E.P., by IGEOSA (International General Electric Operations S.A.) of Geneva, with whom the relevant contract has already been concluded. One of the main stipulations of this contract is that both Dutch firms and the nuclear industry of the Euratom countries shall be allowed to collaborate on a large scale in the construction of the plant and the manufacture of its components, including the fuel elements and control rods. S.E.P. itself will thus be acting as a structural engineering enterprise and will obtain from General Electric only the necessary know-how for the design and start-up.
The signing of these contracts means that the plans for the building of an atomic power plant, which have been under study at S.E.P. for many years, have finally taken on a highly promising concrete form.

Purpose

As already stated, the express desire of S.E.P. in embarking upon this project is to stimulate the initiative of the European nuclear energy industry. Furthermore, the reactor core will be equipped with a large number of additional measuring instruments in order to enable extensive experiments to be carried out in the fields of nuclear physics and hydraulics. Thus, besides the parameters which are customarily measured in a reactor of this type, a constant watch will be kept on the neutron-flux distribution, the energy spectrum of the neutrons and the kinetic/hydraulic behaviour of the coolant. All these measurements are directed in particular toward the development of better and cheaper fuel elements with a high burn-up rate.
Moreover, by carrying out the entire construction itself, S.E.P. will obtain an excellent overall view of the cost breakdown among the various reactor components.

Reactor

The main element of the plant is a single cycle boiling-water reactor with a thermal capacity of 165 MW. This heat is removed by light boiling water which circulates through the fuel elements by natural convection. The saturated steam thus produced (at a pressure of 70 atm. abs.) is led into a turbine which drives a 50 MWe generator. The exhaust steam which condenses in the condenser is preheated to 125°C as feed water and pumped back into the reactor. The quantity of steam produced is 256 tons/hour. Of the electricity generated, 2.5 MW is used for driving the auxiliary machinery, so that the remaining 47.5 MW can be fed into the national grid.

The core is made up of 156 fuel elements, each of which comprises 36 fuel rods. Four of these elements are equipped with the instruments mentioned above. The fuel rods consist of slightly enriched (2.2 to 2.5%) uranium dioxide pellets with a stainless-steel or Zircaloy cladding. The cooling water also serves as a moderator and reflector for the neutrons. All the fuel elements are provided with a "chimney" to promote circulation of the coolant. The core also contains 37 cruciform control rods of stainless steel, inside which are 60 neutron-absorption tubes packed with boron carbide granules. One of the control rods will be equipped with a special drive, enabling oscillating movements for the study of the transient behaviour of the reactor. The total weight of uranium in the core is 13,000 kg and the specific power is 30 kW per litre of core volume. The estimated average burn-up rate of the fissile material is 13,000 MWd per ton of uranium.
The cylindrical reactor vessel has an internal diameter of 3 m, a length of 11 m and a wall thickness of 10 cm. In addition, the inner wall is lined with a stainless-steel jacket 12 mm thick. The weight of the vessel, including the cover, is 120 tons. Besides the actual reactor core, together with its supporting structure, the vessel also contains a steam/water separator and a steam drier. The reactor building is equipped with a pressure-suppression system, which in the event of an accident condenses any steam escaping from the reactor.

Euratom—S.E.P. contract

The construction cost of the power plant is estimated by S.E.P. at 95,000,000 florins.

The maximum share of Euratom in the construction and operating costs will be 18,100,000 florins, the break-down of which is as follows:
— 1,400,000 florins as an allowance towards the losses incurred during the three-year initial operating period;
— 12,000,000 florins for reactor components manufactured in the European Community;
— 4,700,000 florins for the fuel elements, insofar as they are manufactured by European firms within the European Community.
In return for this financial aid S.E.P. will place at Euratom's disposal the knowledge acquired during construction and operation of the plant. Furthermore, Euratom has the right to second to S.E.P. members of its own staff and any third parties it wishes to invite. A liaison committee will also be set up in which Euratom and other interested parties will discuss the technical and economic aspects of the project with S.E.P. experts.

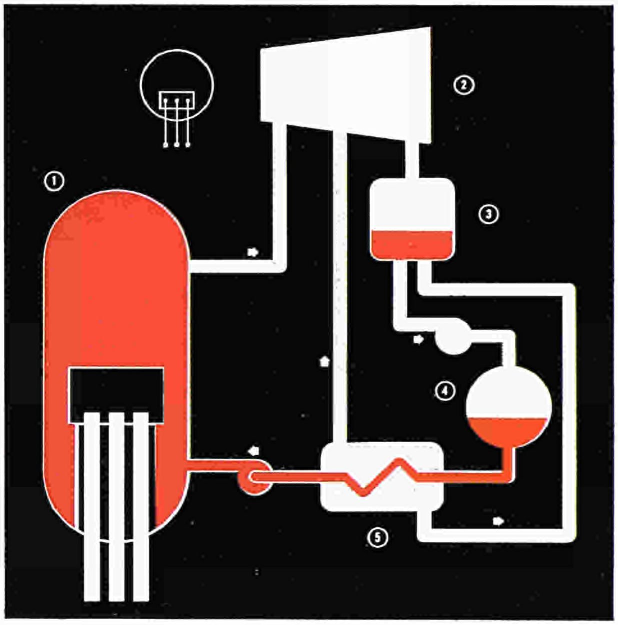
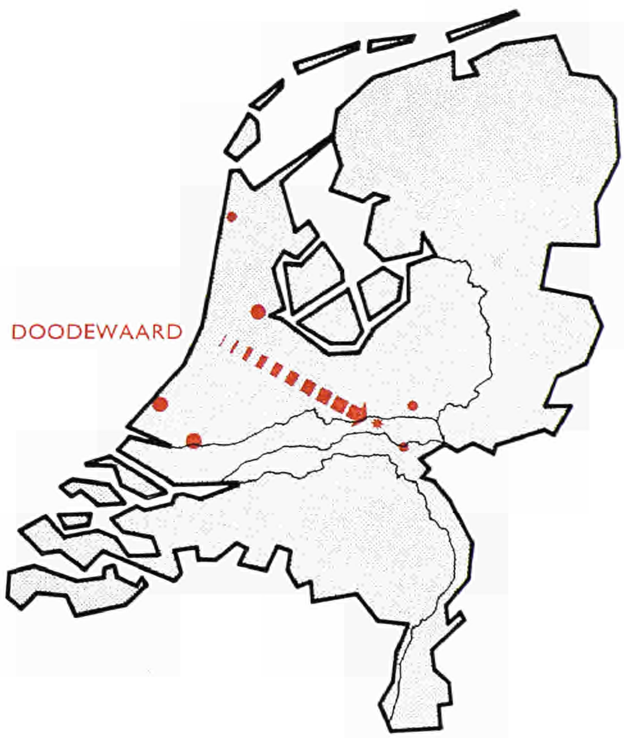


Figure 1—Schematic flow-diagram (single cycle natural circulation boiling water reactor)
1 Reactor vessel
2 Turbo-alternator
3 Condenser
4 Demineraliser
5 Feed-water heaters

Current progress

The project has been divided into three phases, after each of which a decision is made whether to continue or not.
The first phase, comprising the study of the preliminary project, has already been terminated. During the second phase, which is now being carried out, a detailed study of the plant will be made. Phase three comprises the construction period. Following the signing of the contracts with General Electric and Euratom, S.E.P. has made a vigorous start on the solution of the technical problems which are to be cleared during the second phase. These problems concern for example:
— the cladding of the fuel elements
— the pressure vessel
— the steam separating and drying devices
— the charge and discharge machine
— the shieldings
— the design of the station buildings
In San José, California, a team of S.E.P. engineers is at present working with the engineers of General Electric on the further elaboration of the nuclear part of the power plant. Another scene of great activity is the SEP/KEMA head office at Arnhem, where every effort is being made on the finalisation of the plans.



EURATOM NEWS

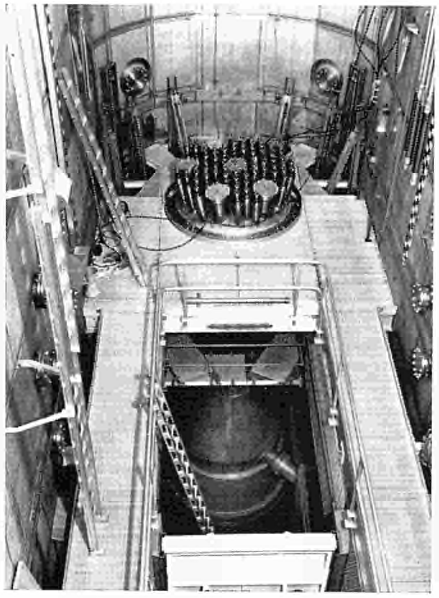
The BR 2 reactor breaks a world record

The BR2 materials testing reactor at Mol, which is run jointly by the Centre d'étude de l'énergie nucléaire (CEN) and Euratom, has just completed a series of tests in which its specific rating was stepped up 50% over and above the output for which it was designed.

At this increased rating, which was reached on 24 September, the heat flux on the surface of the uranium slugs totalled 600 watt/cm², the world's highest for this type of slug. The total power was 40 MW. The actual thermal neutron flux (of energy lower than 0.5 eV) attained in the uranium plates was 10^{15} neutrons/cm². sec–higher, with one or two exceptions, than that of any other in the world and by far the highest in Western Europe. The fast neutron flux of energy higher than 2 MeV reached 3.10^{14} neutrons/cm². sec, which is also regarded as the world's highest.

Once the reactor was running at high power, cooling was deliberately interrupted in an abrupt manner; measurements which were carried out indicated that the reactor had suffered no damage from such drastic action. It was thus shown that a false manoeuvre or an incident resulting in a coolant loss could have no adverse effect on the plant.

The tests were carried out by a truly international team of technicians, including, in addition to staff members of the Belgian Centre and Euratom, representatives of the United Kingdom Atomic Energy Authority (UKAEA) and of the Institute for Atomic Physics of the Rumanian Academy of Sciences.



BR2 materials testing reactor (Mol, Belgium) – end fittings for loading fuel elements

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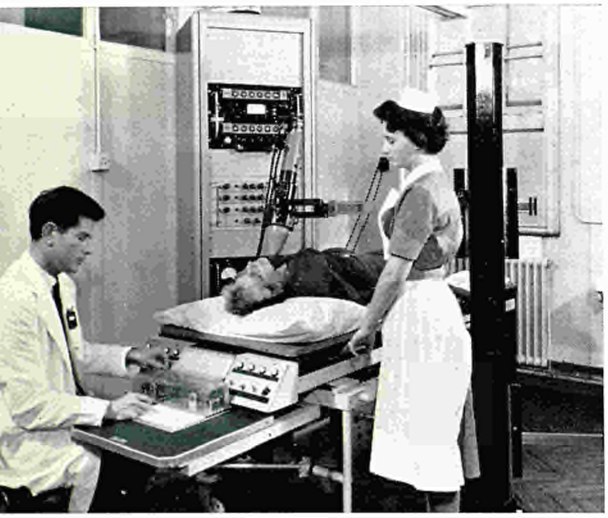
Research on new medical uses for the atom



Diagnostic test to assess the position, size and shape of the thyroid gland

A three-year contract of association was recently concluded between Euratom, the Free University of Brussels and the University of Pisa. The purpose of the contract is to devise novel methods of diagnosis and therapy involving the use of nuclear energy and its by-products. Attention will be centred on the diagnosis and treatment of such diseases as diabetes, cancer and hypertension, as well as affections of the kidneys, heart and thyroid.

Although a number of methods based on the use of certain radioisotopes have now become common practice in medicine, it is acknowledged that nuclear energy opens up numerous possibilities which have not yet been turned to advantage. Little use is as yet made, for instance, of activation analysis. This process consists in taking a sample of tissue from an organ, subjecting the sample to a neutron flux in a reactor and then obtaining, by counting the induced radioactivity, an exact measurement of the quantity of elements such as sodium, potassium, etc., present in the sample.

Apart from activation analysis, the study will cover the possibilities of using various heavy radioisotopes and certain new marked molecules.

A committee made up of representatives of the three parties involved will direct the research programme to be carried out under this contract of association.

USAEC signs with Euratom Supply Agency a contract concerning the supply of nuclear fuel for the Italian SELNI power reactor

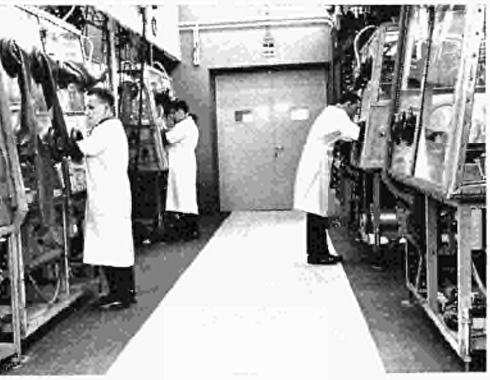
On 25 September 1963, a contract concerning the supply of nuclear fuel to the Community for the power reactor of the Società Elettronucleare Italiana (SELNI) was signed between the U.S. Atomic Energy Commission and the Supply Agency of the European Atomic Energy Community. A second contract was signed between the Agency and SELNI covering the use and consumption of the fuel. The value of the fuel will be approximately $ 73 million; it is to be delivered and paid over a 20-year period.

The contracts were signed at Brussels. They are in conformity with the Euratom Treaty which lays down the principles that the Community retains ownership over all special fissile materials in the Community and that the Agency shall have the exclusive right to conclude contracts for the supply of special fissile materials produced in or imported into the Community. The Agency also has the right of option on special fissile materials produced in the Community.

Development of nuclear industry in the Community up to 1980 theme of Amsterdam Conference

The constantly growing power requirements of the six Community countries make it essential that nuclear energy be used in the years to come. At the present moment, however, the nuclear power plant construction industries do not yet have a sufficiently large market to enable them to bear the costs involved in the implementation of new techniques. This is the main problem which was examined by about 50 heads of nuclear construction companies in the six Community countries, who met in Amsterdam on 26 and 27 September 1963 at the invitation of the Euratom Commission. A total installed nuclear power of 40,000 MWe is planned for 1980, amounting to orders to the tune of ten thousand million dollars. The creation and development of a nuclear market was covered by an exchange of views at this meeting, which was presided over by Messrs. De Groote and Krekeler, members of the Euratom Commission.

A plutonium recycling experiment at Mol



Under a research contract between Euratom and the Association BelgoNucléaire/CEN, a first irradiation experiment involving three capsules of plutonium-enriched fuel was carried out in the BR2 high-flux reactor at Mol. The fuel is mixed uranium oxide/plutonium oxide (UO_2-PuO_2) with a 3% PuO_2 content. A burn-up of about 1000 megawatt days per ton was reached with a specific power of 350 watts per centimeter. The success of this experiment led to the decision to insert 9 rods made of this fuel in the BR3 reactor at Mol. It will be recalled that this is a prototype pressurised water power reactor which normally uses slightly enriched uranium oxide as fuel. Advantage was taken of a reactor shut-down in October to insert these 9 rods; they will remain there for a year and it is expected that a burn-up of 5000 MWd/ton will be reached.

It is the first time within the Community that plutonium-enriched fuel elements have been introduced into a power reactor.

Part of the Plutonium Laboratory of the Association BelgoNucléaire/CEN at Mol (Belgium)

EURATOM NEWS

European symposium on the use of radioactive tracers to track the movement of solids in water

A symposium on the use of radioisotopes and radiations for determining the movements of solids in water was held at Euratom headquarters from 2 to 4 October 1963. The meeting, organised by the Eurisotop Bureau was attended by about forty experts from the Member States of the European Community.

The discussions underlined the growing importance of radioactive tracers in the study of sanding and silting-up processes in rivers, harbours and lakes, and consequently in the improvement of counter-measures; in the study of sediment-migration in rivers during the construction of hydroelectric plants, with the aim of affording optimum turbine protection; in the perfection of methods of purifying effluents and drinking water; in coastal protection; even in solving glacier problems. Radioactive substances can also help in detecting faults in existing hydraulic structures and thus in discovering how to husband water supplies and to avoid accidents.

The most widely used nuclear techniques in this specialised field are based chiefly on the addition of small quantities of certain radioactive products to mud, sand or gravel, or on the activation in a reactor of samples from the medium which it is desired to observe. It is thought, however, that there are some prospects for the process which consists in activating substances *in situ* by means of particle accelerators.

It was recognised that present working methods could be considerably improved and that co-operation between the various specialist groups, which until now have tended to work independently, would be bound to be advantageous. Some ten resolutions were therefore drafted, dealing with well-defined fields such as the production of the necessary marked substances, the standardisation of measuring methods and the pooling of documentation.

The Eurisotop Bureau, in consultation with the experts, will now have the task of setting out these resolutions in greater detail. They will then serve as a basis for a programme of development on the European plane.

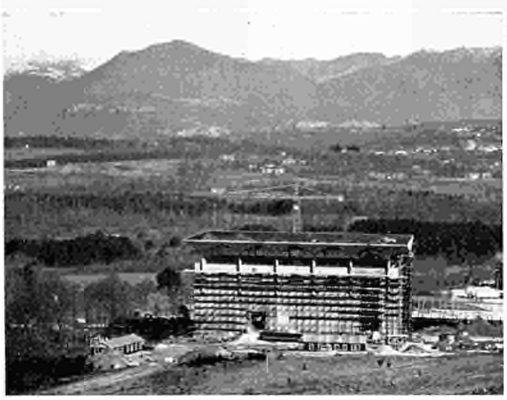
Meeting on medical supervision held in Tours

A restricted meeting on the medical supervision of workers exposed to ionising radiations, organised by the Euratom Commission, was held at Tours (France) on 7, 8 and 9 October 1963.

The meeting was attended by about 70 medical practitioners responsible for medical supervision in the main nuclear centres of the Community, industrial physicians and public health officers, as well as by members of the Group of Experts set up pursuant to Article 31 of the Euratom Treaty for fixing the Basic Standards for the Protection of the Health of Workers and the General Public Against the Dangers Arising from Ionising Radiations.

The principal items on the agenda were a) liaison between the medical services and the physical control services and public authorities and b) the problems involved in the specialist training of medical practitioners approved as medical supervision officers.

Over seven tons of uranium carbide for ECO



ECO rough structure (Ispra, Italy)

Construction of ECO (Orgel critical experiment) is nearing completion at the Ispra establishment of Euratom's Joint Research Centre. Completion of this critical assembly constitutes an important milestone in the Orgel programme, aimed as it is at the development of an organic-cooled, heavy-water-moderated power reactor.

Orgel's intended fuel, the ceramic compound uranium carbide (UC), has not yet been used very widely, and the setting up of the ECO installation necessitated the fabrication of this material on an almost industrial scale for the first time. A total of 7,400 kg of UC, in the form of rods, was manufactured by arc-melting from uranium oxide powder by the process described by the formula: $UO_2 + 3C \rightarrow UC + 2CO$.

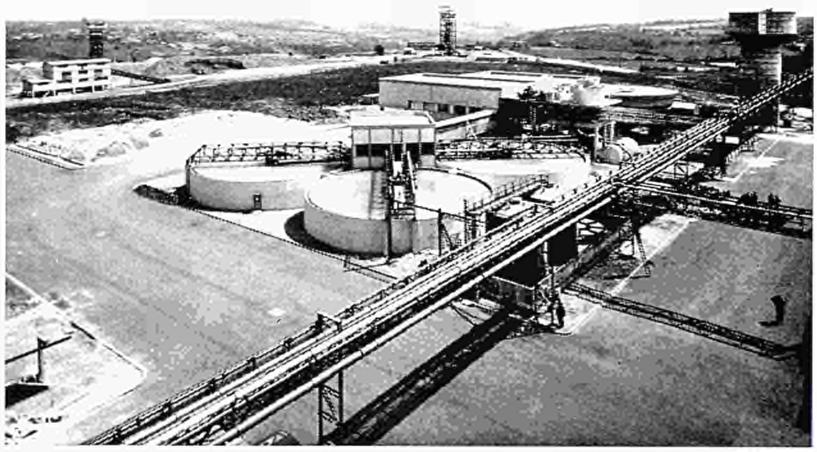
Euratom had concluded research contracts with one German (NUKEM) and one French (CICAF) firm for the development of an industrial process for the fabrication of this relatively novel nuclear fuel, as well as for the manufacture of the quantities required.

Euratom report on long-term uranium outlook

On 24 October 1963 a Euratom report on "The Problem of Uranium Resources and the Long-Term Supply Position" was published. This report was drawn up by the Consultative Committee of the Community's Supply Agency.
The report concludes that while in the present or next decade the industrial use of nuclear energy will not be hampered by insufficient supplies of uranium, the position over the longer term must from now on engage the attention of all concerned. Present production capacity exceeds immediate needs. This is resulting in a decline in activity in the uranium industry and a perceptible decrease in prosperity for new deposits; yet a rapid increase in demand is expected during the next decade.
If suitable measures are not taken in time the mines might, by the end of the period under consideration, no longer be able to produce sufficient uranium at advantageous prices. The Community must therefore adopt appropriate measures and a joint policy if the necessary uranium is to be obtained on favourable terms. This conclusion moreover takes account of the development of breeder reactors, which will result in a tremendous improvement in the efficiency with which the available uranium resources are used. A common policy should contribute to the stepping up of prospecting activities and the opening up of new workings in parts of the world likely to contain new deposits on which the Community will have to draw in view of the lack of adequate resources on its own territory.
The Euratom Commission and the Supply Agency are at present considering the policy which should be pursued in this field.

Euratom budget for 1964 - decision of Council of Ministers

At a meeting held on 14 October 1963, the Council of Ministers approved the draft Euratom research and investment budget. The budgetary commitments for the financial year 1964 are estimated at just under 95 million EMA u.a., or almost the same amount as under the 1963 budget.
The Council's decision will also enable the Commission to raise to about 2,400 the total number of staff employed under the research and investment budget.



Uranium ore concentration plant at l'Escarpière, Vendée (France)

Setting up of a "communication" procedure

Under the Treaty establishing the European Atomic Energy Community, the Euratom Commission is required to convey to the persons and undertakings operating within the Community the information stemming from the implementation of its own programmes as well as that which it obtains from other sources and of which it may dispose as it thinks fit.
Some of this information has already been circulated through the publication of scientific and technical reports, the insertion of articles in specialised periodicals or public announcements.
As a result of these methods of dissemination, however, the information in question does not remain confined to the Community's industries. For this reason, the Commission has decided to transmit data of industrial value only in the form of confidential information and to communicate it only to persons and undertakings within the Community, in order to give them the first opportunity of taking advantage of it.
The Commission will carry out the distribution of such information:

- by issuing documents designated as "communications" via six national correspondents;

- by organising technical meetings, conferences, symposia, exchanges of staff, contacts between research workers and representatives of industry, etc. restricted to persons and undertakings of the Community.

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