EUROPEAN ATOMIC ENERGY COMMUNITY
EURATOM
THE COMMISSION

Documentation attached

to the

TENTH

General Report

on the

Activities of the Community

(March 1966 - February 1967)

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INDEX

DOCUMENT No. 1 PROVEN-TYPE REACTORS

I. Light-water reactors

The "nuclear break-through" in the American power reactor market, well on its way in 1965, showed a spectacular expansion in 1966. The pace and size of orders placed during the first two months of this year by American suppliers suggest that the output of nuclear electricity will be still greater than last year.

At the end of February 1967 the installed capacity of nuclear power plants in the United States — the majority of which will come on stream during the period 1971-73 — amounted to 32,000 MWe. The table below gives the breakdown of capacity as between the pressurized-water and boiling-water types on the one hand and the various manufacturers on the other.

Reactor type	Allis Chalmers	Babcock & Wilcox	Combustion Engineering	General Electric	Westinghouse	Total
Pressurized-water reactors	—	4,238	2,081	—	12,096	18,415
Boiling-water reactors	130	—	—	13,518	—	13,648
Total	130	4,238	2,081	13,518	12,096	32,063

Competition is very keen between the two reactor concepts, as will be seen from this table, which illustrates the dominant position of General Electric and Westinghouse on the American nuclear market.

Meanwhile in the Community there has been some slackening off. Apart from the construction programme slated under the French five-year plan, there have been no new orders for nuclear power units for the Community electricity network as a whole. However, Spain and Switzerland have in the past two years decided to build several plants with installed capacities of 656 and 1125 MWe respectively.

Clearly this situation inhibits development of a powerful nuclear industry in the Community. The backing provided by research contracts therefore continues to occupy an important role in enabling the industry to pursue the technological development which it would otherwise be unable to afford in present circumstances.

The European Atomic Energy Community is contributing to such development as far as the means available permit. The principal new activities initiated by the Commission and the main results achieved during the year under review are set out below.

1. *Joint Euratom/US Programme*

In 1966 the Joint Board gave the go-ahead for the negotiation of one contract in the Community and eight contracts — including five extensions — in the United States. This brings the number of contracts concluded since 1959 in Member States and the United States to 135 and 74 respectively, representing commitments totalling around 56 million u.a. for the Community and the United States together. No special difficulties were encountered in the mutual cooperation of the two parties, after their long practical experience, in this the eighth year of the ten-year Joint Programme. Owing to the limited personnel available, it has not been possible to back up that cooperation with adequate participation by Community engineers. Only two engineers were able to spend a few months on two particularly important programmes in the United States in the course of the year.

2. *Euratom's Own Programme*

Side by side with action under the Joint Euratom/US Programme, the Community supports a number of research projects carried out within its area. During the past year it has signed 12 contracts, including two extensions, representing commitments totalling 4.3 million u.a. Thus, by the last year but one of the second five-year research programme, 25 contracts representing total commitments of seven million u.a. were concluded with industrial concerns, specialist laboratories and universities in the Community.

The results obtained under these contracts are communicated to the Community as stipulated by the regulations in force.

3. *Symposia and Seminars*

The swift dissemination and the discussion of research carried out, whether under the Joint Euratom/US Programme or the Community Programme, are facilitated by the publication of numerous technical reports and also by means of specialist meetings to which are invited representatives from interested circles in Member States.

Euratom arranged five such meetings during the year under review, namely:

— Seminar on stress corrosion in cladding materials;

— Seminar on the thermohydrodynamics of steam/water mixtures (attended by specialists from the countries with which the Community has agreements for exchange of information in this field);

— Seminar on the development of ceramic fuel elements (co-sponsored by the USAEC under the Joint Programme);

— One-day seminar on the electroslag welding of high-gauge steel plate (co-sponsored by the Institut Belge de la Soudure);

— One-day conference on light-water reactor development in the Community.

In each case there were useful exchanges of views, contributing towards better coordination of similar work in hand in the various laboratories in the Community.

4. *European Variants of Light-Water Reactors*

These variants relate to the development of a twisted-tape fuel element assembly (Vortex) and to the design of a boiling-water reactor housed in a prestressed concrete vessel. Both were described in earlier reports, so that only the results are presented here.

A major step in developing the Vortex fuel element was taken when a prototype assembly was incorporated in the Kahl reactor. After four months' operation, there was no sign of any difficulty arising from its presence in the core of the plant. An initial examination is scheduled after it has been there for six months, when it will be possible to assess the in-pile behaviour of the system and more particularly its mechanical integrity and resistance to friction-induced corrosion.

Meanwhile AEG/SNECMA are continuing their joint optimization studies for a high specific power 600 MWe boiling-water plant design based on the Vortex fuel assembly. In close collaboration with the two companies, a big programme of fundamental research on the mechanism and positioning of the burn-out heat flux in the Vortex geometry is in hand at the Ispra Joint Research Centre.

At the same time, a preliminary reference design for a 1000 MWe boiling-water reactor with a prestressed concrete vessel has been completed in a joint study by SEEE (Société d'Etude et d'Equipement d'Entreprises) and General Electric. Economic assessments have shown that this system might prove cheaper than steel vessels for high-power plants, besides being safer. However, much remains to be done in developing suitable insulation and demonstrating experimentally the feasibility of the design before precise conclusions are reached as to this system, which draws largely on technology developed for other reactor concepts in the Community.

5. *Power Reactor Experiments*

The planned experimental programme on the Garigliano power plant was successfully carried out in 1966, having been the chief object of two contracts concluded by Euratom and the USAEC with ENEL and General Electric respectively.

Evaluation of the results still awaits completion but they show that, even in extreme operating conditions (void coefficient of the order of 50%), boiling water reactors remain remarkably stable. This finding confirms the possibility of raising the performance (in particular, the power per unit volume) of this reactor type and underlines the attractiveness of the Vortex fuel assembly. The programme has likewise demonstrated that data processors connected direct to the power plant constitute an effective and reliable means for the observation and prediction of conditions. It also pointed up the deficiencies in the performance and reliability of the in-pile instrumentation.

In addition, two research contracts have been entered into with ENEL and Fiat in connection with the programme of studies on the ENRICO FERMI pressurized-water power plant, announced in last year's report. Some initial series of measurements to shed light on changes in reactivity as a function of the pH value have been carried out and the results are now being analyzed.

During the shutdown scheduled for the beginning of the second quarter of 1967 for partial recharging of the core, the fuel assemblies and the various parts of the primary circuit will be subjected to detailed examination. Under a contract with the USAEC under the Joint Euratom/US Programme, Westinghouse will be associated with this work and will carry out a destructive analysis of a series of irradiated fuel assemblies.

Lastly, further series of experiments will be made over the next three years on the ENRICO FERMI power plant. Engineers from various industrial undertakings in the Community are taking a direct part in the programme by means of long-term postings.

6. *Nuclear Fuels and Materials*

Owing to the reductions in appropriations under the Community's second five-year research programme, the development work begun in previous years could not be pursued. During the last financial year, only one contract, relating to the design and fabrication of a prototype all-Zircaloy fuel assembly, was awarded to Fiat. This is a very disappointing state of affairs, in view of the cardinal importance of this sector of nuclear industry.

In the United States, work under the Joint Programme includes a contract with General Electric for the fabrication and irradiation of a number of fuel assemblies in the Big Rock Plant boiling-water reactor, where they will be subjected to a heat flux such that a fraction of the uranium oxide charge will be maintained in the molten state. Demonstration of the fuel's good performance during a long period of exposure (15,000 MWd/t mean) would mark a fresh advance towards exploiting the ultimate possibilities of uranium oxide.

To be noted also is the good in-pile performance of uranium oxide rods poisoned with boron carbide particles. Here, too, the results open up prospects for further increasing the maximum burn-up obtained by incorporating solid burnable poisons in the fuel.

At the same time, studies on the effect of irradiation on the corrosion of nuclear materials have proceeded. At the CEN, the effect of neutron and gamma rays on the electrochemical properties of metals in aqueous solutions has been demonstated; the part played by organic impurities stemming from ion exchange resins on the oxide-reducing properties of the irradiated solutions is preponderant.

Studies on stainless steel corrosion in water vapour are going ahead and the latest results are very promising. Parallel research work has pointed to the value of certain austeno-ferritic alloys, the remarkable protection conferred by surface chromizing, the part played by impurities in intergranular corrosion in steam and the need for appropriate surface treatment of the parts. Collaboration between the European and American programmes covered by the Euratom/US Agreement for Cooperation has enabled samples to be tested in General Electric loops. Here again, results were compared and discussed at a meeting attended by numerous Community scientists and technicians at St. Etienne, France.

Finally, studies carried out on steel corrosion in pressurized water at various temperatures, pH values and circulation rates, yielded data on the deposition mechanism of corrosion products circulating in soluble and insoluble form. The results of a study of this nature, presented at the Third International Congress on Corrosion (Moscow, May 1966) directly relate to such phenomena as the mass transfer of oxides and fuel element fouling in water reactors and the effect of the pH value on the reactivity.

7. *Plutonium Recycling*

The importance of this question for the overall economics of nuclear fuel management was once more confirmed at the symposium recently held by the International Atomic Energy Agency. Euratom, which has attached importance to the matter since its creation, is in a favourable position which should be turned to advantage by experimental demonstration in power reactors. Accordingly, the various research projects initiated previously under contract concluded with the CEN/Belgonucléaire Association and the CEA have been pursued.

Points to note include the incorporation in the BR-3/VULCAIN reactor, in November 1966, of a fuel assembly consisting of a mixture of UO_2-PuO_2 vibratory compacted powder. This assembly, fabricated by a new process developed by the CEN/Belgonucléaire Association, will be subjected to a mean burn-up of the order of 25,000 MWd/t. Also the Community's first neutron physics experiments on UO_2-PuO_2/light-water systems in a critical assembly will shortly be carried out in the VENUS plant.

Systematic studies on uranium/plutonium/graphite systems by the CEA continue and substitution experiments at a range of temperatures up to 500°C were carried out in the CESAR critical assembly in the course of the year.

In addition, Euratom has entrusted ENEL with an important study on plutonium recycling in the ENRICO FERMI (pressurized water) and Garigliano (boiling water) light-water power reactors. The programme, embracing a minimum critical configuration experiment (May 1968) and the irradiation of a dozen UO_2-PuO_2 fuel assemblies in the Garigliano reactor, will cover three years and a number of engineers and physicists from Community industrial undertakings are to take part.

The above-listed work witnesses to the extent of research carried out in this field with Euratom support and coordination.

Further, the studies entrusted by the Joint Board to the American companies of General Electric, General Atomic and Westinghouse are proceeding satisfactorily.

Under this heading, the subcritical assembly for the study of UO_2-PuO_2/light-water systems at high temperature constructed by General Electric has been operational since June 1966. It is being used for measuring various neutron parameters, in particular the fission rates of the various plutonium isotopes, conversion ratios and resonance absorption ratios within and on the surface of fuel rods and in the moderator. These data are measured at temperatures ranging up to 280°C in respect of several water/fuel ratios.

The plutonium recycling programme carried out by Westinghouse in the SAXTON reactor continues to yield a stream of high-quality information. Irradiation of nine assemblies consisting of 6% PuO_2-enriched UO_2 fuel was carried on successfully; at the end of 1966 the average burn-up was approximately 12,000 MWd/t and in the most highly stressed pellet 24,000 MWd/t.

The experimental determination of the spatial neutron flux distribution in UO_2-PuO_2/light-water systems by the time-of-flight method was put into the hands of General Atomic, the work being closely coordinated with that carried out by the CEN/Belgonucléaire Association.

8. *Thermodynamics and Hydrodynamics of Fluids*

Lack of funds has held up further progress in activities initiated by Euratom in previous years covering practically the whole range of fundamental and applied research conducted in specialist laboratories in the Community. This close coordination had led to the gradual development of close ties with American, British and Swedish experts. For the reason given above, activity in this field, which is of major importance for the development of light-water reactors, is now in abeyance.

9. *Structural Materials*

Studies on reactor vessel fabrication techniques have led to big advances on two major problems. One is concerned with the use of build-up welding or stainless steel plating for the internal protection of reactor vessels against corrosion. Two firms — Soudométal, using the "strip" process, and Reisholz, which employs a welding process with controlled-speed electrode wire — have estimated the potentialities of the respective methods for plating conditions deriving from new economic needs. These studies, while still in progress, have reached a very promising stage. In the same field, Reisholz has perfected a stainless plating process by hot-pressing which bridges a gap in the range of diameters of primary circuit pipework which do not lend themselves to internal plating by the usual techniques.

Problems connected with the brittle fracture of steel vessels are under active study, e.g., the techniques and methods required for investigating the embrittlement of heavy-gauge (200 mm) plates. These have led to the definition of the properties of the base metal, of the factors limiting weldability and the test criteria for heavy-gauge weldments. In addition, devices have been developed for evaluating the brittle fracture strength of such welded joints containing defects having known characteristics. A study is being carried out jointly by a number of German engineering works to determine the rupture behaviour of a large-scale model reactor vessel previously subjected to cyclical conditions of temperature and internal pressure, the vessel containing penetrations of different geometries. Again, in the search for criteria of brittle fracture resistance for reactor vessels, Oerlikon (Eisenberg) has initiated a study on the applicability of the Schnadt concepts and methods, which are far removed from classical thinking and test methods in this field.

Regarding other kinds of stresses to which reactor vessels are subjected, research into plastic fatigue and creep, conducted respectively by the CNRM and the Institut Battelle in Geneva, is nearing conclusion.

The work of the Roentgen Technische Dienst's research on evolving non-destructive inspection methods for heavy-gauge reactor vessels is all but completed and should result in the formulation of recommandations that are an improvement on today's methods.

Meanwhile, the present trend as to the size and properties of steel vessels lends added interest to the multilayer fabrication process under study at Krupp's, which is developing well.

10. *Miscellaneous Research*

In recent years, Euratom has handed the task of drawing up nuclear codes for light-water reactors to a number of bodies within the Community, such as Alsthom, CEA, Fiat and SNAM. These work in collaboration with the European Scientific Data Processing Centre (CETIS) at the Ispra establishment of the Joint Research Centre, where several improved codes for calculating changes in reactivity, thermal-neutron coupling and so on have been added to the nuclear code library. These codes are available to Community industries and design offices as a whole.

Finally, mention should be made of the work being done by AEG and General Electric on the development of two different designs of improved performance steam/water separator. These researches form the subject of contracts entered into by Euratom and the USAEC respectively under the Joint Euratom/US Programme.

II. Graphite reactors

The Latina plant continued to operate in 1966 under extremely satisfactory conditions at a high load factor, particularly during periods of heavy demand from the grid. EDF-1 and EDF-2 helped to supply the French grid and EDF-3 went critical in the spring of 1966. Incidents which occurred during the autumn in the steam generators and the burst slug detection gear of the last-mentioned reactor will delay its entry into service as part of the electricity supply system.

Pursuing its development programme by way of contracts, Euratom concentrated on solving a limited number of problems so as to draw maximum benefit from the expenditure incurred and focus attention on worth-while solutions to the chief problems presented by the development of this type of reactor.

1. *Development of Fuel Elements*

The development programme on ternary uranium alloys carried out over a number of years by the CNEN and SNAM brought little in the way of fresh results during the period under review. There were considerable hold-ups and activity was limited to the preparation of samples to be irradiated in the CAMEN Centre reactor at Pisa from the beginning of 1967 onwards.

Following completion of the work on the fabrication of Latina-type fuel elements with a ternary uranium alloy, it was decided not to proceed with the study for fabrication of tubular elements (hollow rods sealed at both ends) already fully developed by some manufacturers in the Community.

Research on a metal bond between the magnesium canning and uranium metal fuel led to the choice of titanium. The results which determined this choice have proved to be faulty and it has been found that bonding between titanium and magnesium cannot be effected on an industrial scale.

In the programme for developing a process for the casting of magnesium alloy "herringbone" cans, the high-pressure technique used has not given satisfactory results, the cans not being helium-tight. Distinctly better results have been yielded by the process of atmospheric-pressure casting in a sealed metal mould, under study by Karl Schmidt. This process would seem suitable for the industrial production of parts meeting the specifications laid down for fuel element cans. However, the fin profile selected in 1963 is no longer representative of the profiles subsequently developed. It appears doubtful whether known casting techniques can be employed to make fins as fine and closely spaced as those which are used in the latest reactors and can easily by produced by machining.

Backing up the programme on the feasibility of machining very long herringbone monobloc cans, which has fully demonstrated the advantages of the process both from the fabrication angle and from that of the thermal and aerodynamic characteristics, with heat transfer gains of 15-30% compared with the present cans used at Latina, the Messier company has costed the series production of this type of can. Their utilization in the Latina graphite-gas reactor may be expected.

2. *Heat Transfer*

Under the programme in hand at Jülich nuclear research centre, in association with the CEA and SNECMA, an initial series of calibration tests on standard EDF-2 cans has been made. While results tally with those obtained in France, the tests have revealed the influence of certain secondary parameters such as the heating method and the length of the heated can. On this basis the subsequent programme has been laid down, to include tests on cans having more sophisticated profiles and in particular with external and internal cooling.

Knowledge of the natural convection of carbon dioxide under pressure is of considerable value for developing thermal insulation systems for prestressed concrete reactor vessels, and advanced research into the subject has been carried out by Bertin. Although the investigations were all carried out in a CO_2 atmosphere, the results are also of considerable importance for reactors using other coolants.

The provisional formula evolved in 1965 has been taken further and its field of application extended to cavities formed by and filled with gas. It will be further extended in 1967 to cavities containing materials such as fibreglass, of which radiation-resistant varieties now exist.

The Sud-Aviation "honeycomb" metal-cell insulation system has been successfully tried out at laboratory level, thereby warranting further investigation in a plant of suitably representative scale.

An initial series of tests of the "water screen" system was carried out in the installation designed and constructed for the purpose by the Deutsche Babcock and Wilcox and Indatom association. The tests demonstrated the validity of the system and a second series will be made early in 1967. They also confirmed the feasibility of a "gas screen" variant, the advantages of which are self-evident for gas-cooled reactors in terms of safety and simplified circuitry.

3. *Structural Materials*

Some delay has occured in installing in the BR-2 reactor the loop constructed by Deutsche Babcock and Wilcox for studying the radiation-induced corrosion of graphite by CO_2 and the first trials are now scheduled for February 1967. The irradiation programme has been extended to cover 15 test sections instead of six. Close liaison has been maintained between this programme and other experimental work in the Community.

The concrete irradiation test rigs built by SNAM were installed in the CAMEN reactor at Pisa at the end of 1966. They will carry further a series of out-of-pile measurements which pointed to the advantages of certain concrete compositions. In particular, a Portland cement concrete has apparently been found which stands up satisfactorily to high temperature.

In other tests undertaken by Bredero in the HFR reactor at Petten, fast neutron doses of up to 10^{18} n/cm^2 were shown to be insufficient to cause appreciable deterioration of the mechanical properties of the concrete. A fresh series of tests up to doses of 10^{20} n/cm^2 has been commenced to determine the effect of more intense irradiation.

Also in this field, a contract was signed in 1966 with CEA-Saclay for the definition and development of insulating concretes consisting solely of materials — whether binders or aggregates — which are readily and cheaply obtainable and which can be prepared by conventional methods. It is hoped thus to bring about substantial savings in the use of heat-insulating concretes as against the cost of existing methods.

4. *Reactor Technology*

In connection with the study of the "loft" method for unloading fuel elements, the CEA has carried out materials tests to provide information additional to the data already obtained; satisfactory solutions have been found. The Delle laboratories have also carried out pressure and temperature testing on one and three-chain control rods. These control devices have the advantage of being easily housed in a thin concrete slab such as that forming the floor of the loft.

Fundamental research on materials and components, as well as calculations and plans for the construction by Krupp's of a mock-up of a prestressed concrete reactor vessel, are now completed and the mock-up is now being built. Technical progress has led to the inclusion of new methods of thermal insulation using ceramics and of draining the water contained in the concrete, thus giving it better mechanical properties.

In the same field, studies on a preliminary model of a concrete containment prestressed by means of a hydraulic jack were completed by the firm of CITE. Although leaktight layers of neoprene could doubtless be used for the jack provided great care is taken, a compartmented steel jack was used for the 1/10th scale mock-up. It is planned to carry out numerous measurements for different loads in order to study the distribution of the stresses, the temperature and the deformations.

The comparative study undertaken by AEG-Alsthom, from the standpoint both of ease of construction and performance, of different types of steam cycle associated with a graphite power reactor, has been completed. The results make it possible to select the cycle, and hence the conventional part of the plant, which is the most economical, on the basis of the reactor characteristics. They also enable optimum values of the independent parameters of the conventional part to be determined. However, the effect on the cost per kWh is very slight.

5. *Reactor Physics*

ENEL has an important programme in hand at Latina for experimentally determining the reactivity curve as a function of fuel irradiation and comparing it with theoretical values. To that end, two calibration measurements of control rods and some ten anti-reactivity measurements of absorbers have been made since the programme began. Routine measurements are taken of temperature coefficients. Recording and processing of the data is by a specially designed data logger. The measurements as a whole show the reactivity to be greater than that calculated theoretically. Further work in 1967 will enable the codes to be rectified as needed. It is also hoped to check the accuracy of calculations aimed at proving that burn-ups can be increased to 5000 MWd/t in this type of power plant.

The purpose of another programme, which is being carried out by SNAM, is the theoretical study of the zero reactivity method (PCTR) on the basis of experimental results obtained previously. This programme is devoted to the study of spectral and heterogeneity effects. It has pointed up the improvements and simplifications to be introduced in the experimental procedure which make the PCTR method even more attractive as compared with traditional critical and subcritical methods.

A new method for determining the distribution of power densities is currently being developed by GAAA. Direct treatment of the problem of neutron flux distribution in three-dimensional geometry by an analytical method is envisaged. The method is a three-dimensional generalization using an axial harmonic development of the Nordheim Scalettar theory. Its main advantages are that it offers a satisfactory representation of perturbations caused by the control rods at varying degrees of insertion together with savings in computer time.

DOCUMENT No. 2

HEAVY-WATER AND ORGANIC-LIQUID REACTORS

A. THE ORGEL PROJECT

I. Activities under the ORGEL and heavy-water reactor programme

1. *ORGEL Design*

In view of the advantage of a high specific power version of the ORGEL reactor (HSP variant) and the present status of the ORGEL programme, already highlighted at the symposium held at Ispra on 26-28 October 1965, which was attended by 102 representatives from various Community bodies and industries, the ORGEL project directorate focussed the group's activities in 1966 on problems involved in the construction of a high specific power ORGEL prototype.

The latter's power has been raised to 250 MWe in order to bring it more into line with a competitive prototype, this decision being based on the fact that the financial loss incurred during operation of a prototype reactor is largely unrelated to the size in the 100-300 MWe range, coupled with the increased confidence in the design which should result from operation of the WR-1 and ESSOR reactors.

A file has been prepared in respect of an invitation to tender issued in 1967 with the aim of obtaining detailed draft designs together with firm bids for the construction of such an ORGEL prototype by Community industry.

The necessary technical information has been collected and the decisions made in 1962 with regard to the building of a 250 MWe power plant by the Belgonucléaire Indatom-Siemens group have been revised in the light of the studies carried out and the results obtained in the meantime.

A slight degree of enrichment and a greater breakdown of the UC-SAP fuel element (19 pins instead of 7) are recommended in order to obtain a high specific power prototype; a hot-pressure-tube gas-insulation channel is retained as the reference channel. The neutron, thermal, design and economic problems inherent in such a core have been subjected to detailed static and dynamic studies. Thus the dynamic behaviour of a complete 250 MWe power plant equipped with a core of this kind, which is intrinsically unstable in its present design, has been investigated on an analog computer, thus enabling a satisfactory control programme to be drawn up; similarly, a very powerful code (CRAYON), adjusted on the basis of the Canadian irradiation results, has been developed and put into operation in order to forecast the behaviour of the fuel elements in such a reactor and determine the operating conditions for various in-pile experiments. Alongside this, the THESEE code has been developed and used to obtain the temperature profile in the cluster.

The optimization studies and the studies on the economic prospects have been continued and suggest a trend towards heavy fuel sections for each channel; a 500 MWe reference design study has been undertaken, partly from this standpoint and partly with a view to the possible construction of a plant that would be profitable and would meet safety requirements, in which respect certain major accident studies have been carried out. A comparative survey of the economic advantages of various methods for reprocessing spent organic coolant has shown that the reprocessing cost could be halved by making the make-up terphenyl from benzene on the plant site.

The value of the ORGEL design as regards the desalination of water has been borne out by specific studies demonstrating the considerable flexibility of a concept which enables the coolant to be selected so as to suit the desired local conditions (high-temperature coolant if electricity requirements are heavy, low-temperature coolant if they are low).

Finally, the status of the work on the construction of the ESSOR reactor is such that an experimental programme for this reactor has been drawn up and the ground prepared for it, with the cooperation of the competent departments of the Ispra establishment.

2. *Studies in Connection with Other Heavy-Water Reactor Variants*

The project in hand under the association with the CNEN has been pursued in close collaboration with the CISE, which is engaged on a study of a boiling-light-water-cooled heavy-water-moderated version of the reactor called CIRENE.

The design, construction and installation in the ESSOR reactor of the power-channel test loop for this type has been continued, with the ORGEL project lending constant assistance. A preliminary safety examination on this loop was started and the necessary equipment for the zero-power neutron tests ordered.

II. ORGEL reactor physics

1. *Theoretical Studies*

The following codes were completed in 1966: PLUTHARCO, intended for the simplified calculation of heavy-water lattices, and PROCOPE, used for calculating collision probabilities in clusters. Version 4 of the PINOCCHIO code was tested on nearly all the experiments with natural-uranium/heavy-water lattices carried out in the world (including ORGEL lattices). The second part of the year was devoted to revision of the code for design calculation purposes and to its improvement.

The models used in PINOCCHIO for calculation of Pu-239 were tested on the French plutonium lattice measurements (AQUILON). The critical analysis of methods for calculating Pu-240 absorption in heterogeneous media was completed, as well as the studies of the effect of fission products.

In addition, the three series of ORGEL heterogeneous core measurements made in ECO with the PLUTHARCO + TRIHET codes were interpreted. The analysis is at present being extended by means of PINOCCHIO + SOS.

The thorium cycle in an ORGEL reactor with U-235 make-up was studied for two fuel elements, i.e., 19 and 37 oxide pins. The cycles were studied with the aid of the GAFFEE programme for continuous loading and unloading with or without reprocessing. One-dimensional burn-up calculations were carried out with the MAFIA programme for the purpose of studying the initial period of operation of the 250 MWe ORGEL prototype. In reactor dynamics, calculations for the ORGEL 500 reactor project were made by means of the COSTANZA code for cases of serious accidents. In addition, a check was carried out on ESSOR's stability with respect to axial or radial xenon oscillations. Work was also performed on the preparation of methods and a first series of calculations for analyzing serious accidents which might possibly occur during the first start-up of ESSOR.

As regards the neutron part of ESSOR, methods were developed for calculating the TRIHET and SOS input parameters from the lattice calculation results (PLUTHARCO and PINOCCHIO).

The core configurations laid down in the ESSOR critical experiment programme were evaluated using PLUTHARCO + TRIHET.

2. *Experimental Studies*

The year 1966 was marked by measurement of the neutron parameters for certain types of ORGEL fuel elements and by preparations for the ESSOR start-up experiments.

The EXPO subcritical installation was used to perform a number of measurements, in particular those on buckling.

Other neutron parameters for reactor fuel elements were determined with the aid of the ISPRA-1 and ECO reactors.

The preparations for the ESSOR zero-power experiments are in the course of evaluation. All the experimental equipment has been designed, some of it already being available and some of it in production. An analog method for calibrating reactivity was developed for the ESSOR experiments and was successfully tested in EXPO, ECO and ISPRA-1. Detailed reports and manuals have been prepared in respect of the ESSOR start-up experiments.

III. Fuel material

Uranium monocarbide fabrication has reached a highly satisfactory stage of industrial development. Hopes of reducing the price of this carbide appreciably have been duly fulfilled. Through pilot-scale fabrication it has been possible to supply Ispra JRC with:

— about 1700 kg of natural carbide for use in the preparation of fuel elements for ESSOR and ECO;

— 200 kg of 3%-enriched carbide, used for the fabrication of a fuel element to be irradiated in the WR-1 reactor.

Further progress has been made with the study of the properties of uranium carbide. The aim of this research is to demonstrate the influence of the composition on a number of properties, such as the corrosion resistance and the mechanical and structural properties of the carbide.

Among the various projects, results have been achieved in the field of thermal properties — dilatometry, thermal conductivity, structural changes — and also in the study of corrosion caused by air and humidity.

IV. Structural materials

1. *SAP (Sintered Aluminium Powder)*

The study of SAP alumina transformations was carried further in 1966 with the aim of throwing light on any influence which these may have on the mechanical properties in the hot state. In addition, the influence of various heat treatments — at high temperatures and over long periods — on the creep behaviour has been investigated. Research on the effect of various types of mechanical transformation (swaging, drawing, rolling, etc.) is in progress.

Stress-relief measurements to explain the abnormal creep behaviour of SAP have revealed the presence of stress-relaxation with constant deformation at up to 40% of the load initially applied. The hypothesis that the high flow limit is due to the high density of the dislocations has been proved correct.

The structure of the SAP defects during rolling and the annealing process were studied by means of electrical resistance measurements. Two annealing stages were found, corresponding to the interaction between the dislocations and to the grain growth, the main annealing taking place during recrystallization.

Activity under the ISML contract proceeded according to plan, consisting of studies on new powders, technological studies, development of non-destructive testing techniques and theoretical studies of a SAP model.

Work on the Montecatini contract likewise continued smoothly as regards the supplying of finished products for ESSOR (claddings, pressure tubes, rods).

A large number of terphenyl corrosion tests were carried out on quite a wide variety of materials, i.e., Al, Mg, Zr alloys, surface deposits, metallic bondings, etc. Further progress was made with investigation of the compatibility between fuel and cladding material, also in the presence of a liquid seal.

2. *Zirconium Alloys*

Further research was carried out to find an alloy whose mechanical characteristics and compatibility with terphenyl at 400°C are sufficient for the purpose of making pressure tubes for ORGEL reactors.

The parameters influencing the corrosion of zirconium alloys in organic (oxidation and hydride-forming rates) are the temperature, the exposure time, the chlorine concentration and the quantity of water in the organic. The most critical parameter is the chlorine concentration.

Work on this project in 1966 was carried out in two stages. By means of statistical analysis followed by medium-term corrosion experiments using a regression equation, on the basis of the experiments carried out with SNAM, these alloys were found to be resistant to water and chlorine attack at 400°C if the chlorine concentration does not exceed 0.5 ppm (normal concentration in the WR-1 reactor).

In the meantime, optimization tests on the heat treatment of the alloys selected have been started. Preparations have been made for long-time corrosion tests and corrosion tests under irradiation are to be performed in the KID loop installed in the Ispra-1 reactor. The alloys in question will therefore be subjected to corrosion tests in terphenyl at 480°C (under contract) with a view to their use as fuel cladding in an ORGEL reactor. The mechanical characteristics of the alloys in question will likewise be studied.

For the basic studies on zirconium oxide (resistivity of the oxide), the influence of the contact metals (Pt, Ag, Au, Pd) on the oxidation kinetics was measured. Calculations of the activation energies for oxygen diffusion in a rigid zirconium oxide lattice were completed.

3. *Impregnated Graphite*

The impregnation alloys, mainly magnesium-based, were perfected and large pieces (15 cm in diameter) impregnated entirely homogeneously.

The immersion method was successfully tried out with lead and tin. It should on the one hand make the operation more industrially viable and on the other facilitate the impregnation of intricate structures. A system was developed for carrying out impregnation after assembly of the components, with subsequent welding.

Two irradiations of small impregnated graphite cylinders were carried out in the HFR reactor at Petten.

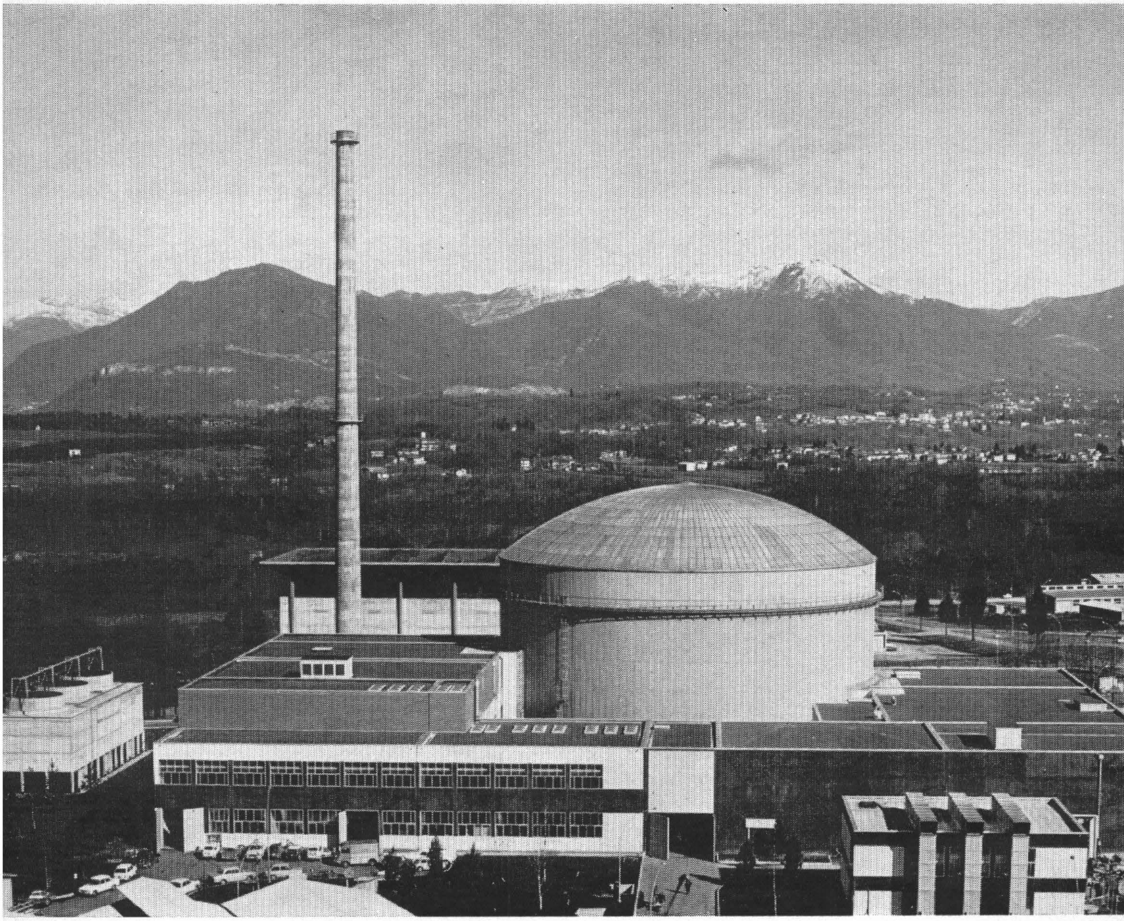
4. *Magnesium*

Further studies were made on magnesium alloys and on corrosion inhibitors which enable them to be used in contact with terphenyls, more particularly with a view to employing magnesium as a graphite-impregnation material.

The long-time tests have borne out the previous results and reveal a long-term reduction in the oxidation rate.

5. *Installations*

Considerable efforts have been devoted to the irradiation of materials in ISPRA-1 and in HFR (Petten), and a number of devices have been built. A hot 10 equiv. curie cell was put into operation.



ISPRA (Italy) — OUTSIDE VIEW OF ESSOR TEST REACTOR

(See other side of page for caption)

The ESSOR test reactor is housed in a leaktight containment 45 m in diameter and 45 m high, 12 m of this being below ground level. The stack is 80 m high. The buildings around the containment contain the hot laboratories, workshops and conventional laboratories.

V. Organic coolant

Intensive study of the coolants was continued — the main accent being on technological research — with the aim of determining the specifications for the virgin and decomposed liquids.

The activities of the organic analysis group were directed for the most part to various determinations on behalf of the Centre's scientific departments.

Besides OM2 — the ORGEL liquid — decomposition and compatibility research was carried out on Thermip (fluid for flushing secondary circuits) and the eutectic OMD (ESSOR primary fluid).

In addition, a fully automatic device — for assaying benzene and terphenyl decomposition products — has been built and calibrated and is to be installed in the ESSOR reactor.

In order to complete the fine analysis of certain hydrocarbon fractions present in the decomposed liquid, a technique has been developed and perfected which permits the combined use of chromatography and mass-spectrometry. Particular attention has been devoted to determining the oxygen in decomposed liquids at contents of below 10 ppm.

The dechlorination studies on organic fluids resulted in determination of the operating conditions in which the chlorine content can be reduced to less than 0.2 ppm. This is now being done on a semi-industrial scale.

In order to define still more accurately the specifications for the coolants for ESSOR and the prototype, a large number of physical determinations were made.

A searching study was carried out with object of pinpointing the mechanism governing the self-ignition of organic coolants in the various thermal insulants.

VI. Fuel elements and irradiations

1. *Prototype Fuel Elements*

The Metallurgy Department's activity consisted mainly in the design and construction of the following three types of element:

— elements for physics experiments;

— element for ESSOR or WR-1;

— element for the ORGEL group.

In addition, two G6-type fuel elements have been supplied to WR-1 (four times six pins round a central rod). One was instrumented with a core thermocouple, and the other was not. Both elements, however, had adequate instrumentation for measuring the cladding temperatures, the instantaneous flux, the instantaneous integrated flux and the integrated flux.

This activity, bearing as it does on the design, control, fabrication and instrumentation of the fuel elements, has made it possible to develop an appropriate fabrication process and to extend the techniques to other fields.

In particular, the non-destructive tests can be applied in the checking of cladding and fuel rods from the standpoints of both metrology and defectoscopy.

The assembly and subassembly tests have been applied on a large scale, using conventional techniques (mechanical tests) and photoelastic methods for studying stresses.

The accent in the field of instrumentation was on the study of thermocouples, it being necessary to revise the design of leaktight penetrations in the light of recent experience.

Welding activity, too, was particularly intense, efforts being directed to finding a substitute for electron bombardment welding, which had been used hitherto but was at first sight unadaptable to small diameters. Results have been achieved with welding by diffusion, vibration and drawing, the last-named forming the subject of a development contract with a non-Community research centre (CERCA).

SET's studies on ORGEL heat exchange during 1966 were concentrated mainly on parallel rod bundles. The aim was not only to obtain accurate data for a specific configuration (seven-pin cluster, finned SAP cladding) but also to secure results which could be interpreted from a physics standpoint and extrapolated to other geometries.

As regards the theoretical aspects, the following research was carried out: a study on the temperature and flux distribution in a pin; a study on the process for evaluating the thermal performance of a cluster; and a study on the hydrodynamics and heat exchange of smooth rod bundles.

Experimental investigations into the influence of the geometry were directed to the mixing process between the subchannels making up a finned cluster, the heat-exchange coefficient distribution in a finned cluster (still in progress) and the effect of artificial roughness on thermal performance.

The thermal phenomena affected by the coolant properties were studied in organic circuits. The following studies were carried out during the year: determination of the exchange coefficient in annular flow conditions with roughnesses on the lower tube and studies in annular test sections containing a SAP rod with indirect heating.

In addition, the organic circuits scheduled to be used for heat exchange and fouling studies were employed simultaneously in long-time tests to study the corrosion (by the organic coolant at 400°C) of various coatings designed to protect the SAP and Zircaloy.

A large number of routine measurements were performed in connection with the physical properties of organic coolants. Several new devices were developed for measurements necessary for ESSOR.

Hydraulic and thermomechanical studies were carried out on various fuel element models by the Technology Department.

The hydraulic investigations were concerned with the analysis of pressure drops and hydrodynamic forces for various types of element (influence of fins, grids and supporting structure, inlet effects). By means of radioactive tracers, studies were made of the residence times of particles of the fluid in the annular space present in certain element types (skirt or matrix) in order to evaluate any risks of radiolysis or pyrolysis of the organic for various random misalignments of the elements in the channel.

Studies are in hand on evaluation of the amplitudes and frequencies of the hydrodynamic vibrations at high flow-rates, particularly in the case of lower-diameter fuel pins, which are advantageous for specific high power fuel elements (clusters of 18 or 19 pins).

The emphasis in the thermomechanical studies was on measurement of the thermal deformations of a finned can when subjected to circumferential temperature gradients, and also on analysis of the effects of thermal and mechanical stresses on rupture and thermal cycling fatigue.

2. *Irradiations*

As in the previous year, the in-pile behaviour of uranium was studied:

a) In the SILOE and El-3 reactors under a contract with the CEA. The first samples were removed from the reactor in the autumn;

b) In the HFR reactor at Petten, where irradiation of a new capsule filled with UC pellets is due to start in the near future;

c) In the DIRCE loop of the ISPRA-1 reactor. The trial period for this loop having ended in October, start-up was effected with an instrumented UC/SAP fuel pin. Following a leakage of coolant between the pressure tube and the calandria tube, the in-pile section was unloaded. A new in-pile section has been designed and will be built early next year.

The proposal submitted in 1965 for the irradiation of a fuel element in the Canadian WR-1 reactor was approved by AECL. Two fuel elements were fabricated at Ispra and duly dispatched. The irradiations are scheduled to take about a year. Meanwhile one of these elements, after developing a fault during irradiation, has had to be unloaded from the reactor.

The bulk of the work in the medium-activity laboratory consisted in the calibration of the cell equipment. This has been slowed down by lack of technical staff.

The metallography chain (five cells) is nearing the operational stage. The safety report has been drawn up.

VII. Coolant channel

1. *Introduction*

The channel project was continued with the aim of ascertaining the most satisfactory operating conditions for the reference channel (SAP hot pressure tube, gas insulant, Zircaloy calandria tube) and studying the use of a zirconium alloy for the hot pressure tube.

Further progress was achieved in the study of more advanced solutions, the work being limited to the application of a cold pressure tube. These studies, an assessment of which was made during the year, were directed to the construction of various test sections, which were tried out by simulating the most critical operating conditions for this type of channel.

2. *SAP Channels*

The SAP tube series (110 tubes) fabricated for the purposes of selecting tubes to be installed in the ESSOR channels was used, on the one hand, to conduct research into the material's quality characteristics (tolerances, defects) and, on the other hand, to collect statistical data on the creep rupture strength with the aim of determining safety coefficients such as to permit the use of these tubes in the reactor. Already significant statistics have been obtained on the tubes currently being produced, which has led to a rough idea of the permissible stress values at operating temperature. Work has been started on the creep notch sensitivity and should provide information on the harmfulness of the defects in the case of protracted stresses.

Twelve complete channels have been prepared for irradiation in ESSOR (Fig. 1), and ten of them have been inserted in the reactor.

The tests on joints were aimed mainly at determination of the lifetime and the safety coefficient of the ESSOR-type SAP/stainless steel bonds.

On a series of sections of this type, pressure tests were carried out with thermal cyclings and shocks to reproduce reactor scram, the residual deformations and the leakage pattern being observed. The value of the leakages measured in the test conditions was invariably far below 10 mg/hr of organic vapour equivalent under rated conditions. The organic leakages were therefore also measured directly on an installation assembled on a loop, the measured values decreasing as a function of the operating time.

In the study of a metal bond to ensure completely leaktight joints, the aim was to determine the choice of the bonding material (titanium) and the out-of-pile diffusion characteristics. The tube fabrication studies were commenced.

A channel taken from the ESSOR fabrication chain with a C2 fuel element (ESSOR power) was retested in the loop. This also provided an opportunity for testing the entire instrumentation system, which is typical of that used in ESSOR.

3. *Zircaloy Channels*

The programme concerning the prevention of hydride-formation by means of an aluminium layer has advanced as far as the construction of mock-ups with end-joints (Zr-steel). The main line of development followed by the programme during the year was the solution of the technological problems involved in the construction of plated channels, together with their joints.

On the basis of the experimental results currently available in respect of hydrogen pick-up, it is planned to insert one or two Zr2.5%Nb channels in ESSOR by the end of 1967.

VIII. Reactor components

1. *Fuel Handling*

The equipment for performing fuel handling tests was got ready and a first series of tests at room temperature was carried out on a device for unloading through the bottom of the channel. Draft design studies were conducted on various possible handling methods, with the organic liquid circulating up through the channel, and for a G18-type fuel element.

2. *Primary Circuit Components*

A second series of tests was performed on the ESSOR primary circuit valves, as well as tests on prototype measuring instruments for use in the same circuit in order to check their characteristics (lifetime, response time, measuring stability). Statistical lifetime tests of mechanical pump packings for organic liquids were directed to the choice of the best combinations of materials.

3. *Pressure Tube Bursts*

A series of experiments was carried out to evaluate the damage caused by the bursting of pressure tubes, with or without failure of the calandria tube, allowances being made for the presence of the fuel element. The results, subject to certain hypotheses which will have to be verified, can be used for extrapolation to the analysis of such an accident in an industrial-scale reactor.

IX. ESSOR test reactor

1. *Construction*

The year 1966 was given over to shop fabrication and field assembly of the bulk of the mechanical and drive-control equipment for ESSOR. All these operations went according to plan. The position as regards the various subassemblies may be summarized as follows:

In the case of the reactor bloc, the vessel was in position at the end of 1965. Assembly of the core components and installation of the piping in the upper and lower chambers continued throughout the year. The fitting of the organic circuits in the appropriate chambers is nearing completion. Assembly of the heavy-water circuits has been completed and acceptance tests on them have started. A heavy-water and organic analysis laboratory and an office building have been added to the bloc.

The working fluid and ventilation systems have been completed and are now being tested.

Shop assembly of the loading machinery is to be continued. The tests on the feeder zone machine have been duly performed, and assembly on site is scheduled for the early part of 1967. Work on fitting up the handling gear went on throughout the year. The cooling pond and the necessary equipment were completed.

Work at the manufacturer's on the drive controls lasted the entire year; field assembly and connecting up likewise continued non-stop, with an increase in activity in the second half of the year.

The acceptance tests for the stand-by diesel power unit were performed and the distribution and lighting installations have to all intents and purposes been completed.

2. *Criticality Preparations*

The design and fabrication of special equipment are going ahead. The first set of feeder elements was delivered on site in December.

3. *Setting-up of Operations Team*

Recruitment is proceeding at a steady pace. By the end of the year, the ESSOR staff numbered about 150, more than a third of whom formed the technical section. The latter has been given the responsibility of preparing the equipment and methods for reactor maintenance and operation, in close cooperation with the ESSOR construction department, the bulk of whose personnel has, in fact, been loaned to the operating team.

As things stand at present, the team is capable of operating the reactor up to 16 hours a day for the period of the physics tests, or a small part of the plant continuously for 24 hours a day; such a system of limited-scale continuous operation has actually been applied since the end of November 1966 in the case of certain subassemblies as and when their acceptance tests were carried out.

The hot-work section, a vital one for reliable operation of the reactor, has been cut down owing to lack of budgetary slots.

Most of the ESSOR personnel who had been seconded to the JRC departments were recalled during the latter half of the year. Training continued in the form of loan schemes and reactor operating courses. Thirteen operator's certificates were issued.

B. THE PRO PROJECT

In the field of organic-moderated and -cooled reactors, research was carried further by the Ispra Establishment in conjunction with the CNEN and certain Italian research bodies on the following items:

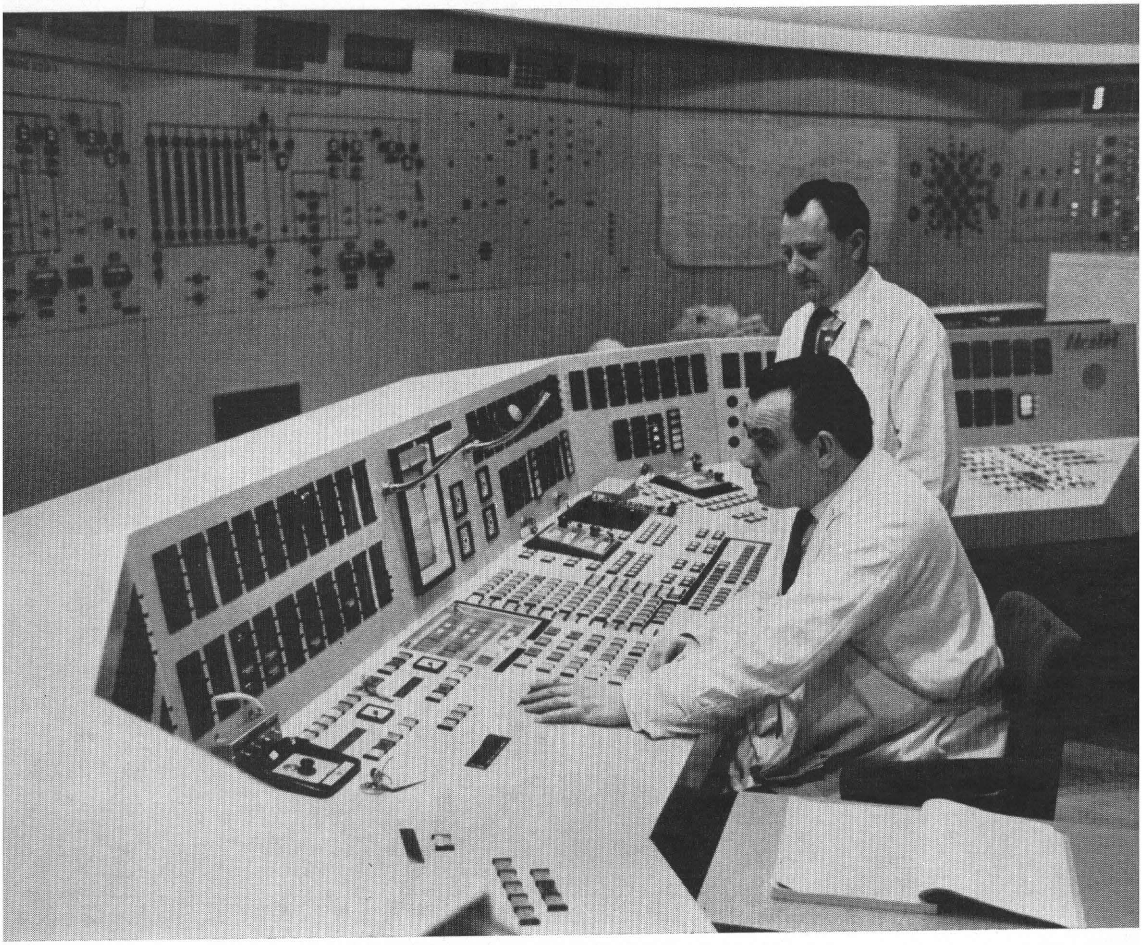
— CIRO irradiation loop: for safety reasons, irradiation of the first test section, consisting of a cluster of three stainless-steel-clad UO_2 rods, could not be started until the end of 1966. The aim of this operation, which occupied the whole of the first quarter of 1967, and of most of the irradiations to be carried out subsequently, is to study the influence of the density and dimensions of the UO_2 grains, the cladding/pellet clearance, impurities, etc., on the irradiation behaviour. In the spring of 1967, a test section consisting of natural uranium carbide with a cladding of graphite rendered impermeable by light-metal impregnation was inserted in CIRO. The second UO_2 test section has been prepared and is to be inserted in the reactor around mid-1967.

  In addition, the acquisition and installation of the post-irradiation examination equipment have been completed — equipment for dismantling, visual and dimensional examinations, fission gas assay, burn-up analysis, etc.

— Terphenyl purification: a study was started on the elimination by reduction (hydrogenation) of the oxygen in oxygenated compounds present in therphenyl, the presence of such compounds apparently being a contributory factor in the fouling of heating surfaces by decomposed terphenyls. Systematic studies of catalysts have served to demonstrate the efficiency of palladium deposited on alumina, with which the oxygen content can be reduced considerably while keeping down terphenyl hydrogenation. Continuous purification by this process will be tested out in a pilot installation which is now under construction and will be operational in 1968.

— Zirconium alloys for use in an organic medium: the aim of the work is to develop zirconium alloys with a view to using them as structural materials (guide tubes, claddings) in contact with hot organic. The alloys adopted have been selected for their good corrosion strength when in contact with superheated steam. Determinations are being made of both their resistance to hydride-formation in an organic medium and their mechanical properties in the hot state.

— Improvement of SAP technology: further progress was made with the research, in hand since 1964, aimed partly at improving the characteristics of the starting powder and investigating the admixture of aluminium powders with powders of materials other than alumina, and partly at improving the



ISPRA (Italy) — CONTROL ROOM OF THE ESSOR REACTOR

(See other side of page for caption)

The operator at the reactor control console is actuating one of the remote-control devices for the control rods with his left hand. The black screens in front of him are observation panels showing the various operating states of the installation.

dimensional qualities of the finished products by special plastic processing.

— Zirconium-steel metal joints: activity under this head is directed at perfecting a process for welding zirconium-alloy tubes to steel tubes or plugs by hot-swaging. The results obtained fully warrant continuation of the work along these lines.

DOCUMENT No. 3 HOMOGENEOUS REACTORS

In the suspension reactor project, on which Kema has been engaged for some years, the year 1966 was spent in revising the suspension fuel concept. The capsule irradiation tests, even at very limited burn-ups, revealed that as well as the colloidally stable suspension of 5μ particles, other fuels, ranging from colloidal suspensions to particles of considerably greater diameter, had to be studied.

The caking problems involved with colloidal suspensions were tackled and, as regards large particles, several alternative coatings were investigated.

DOCUMENT No. 4 FOG-COOLED REACTORS CIRENE PROGRAMME

It was announced in the Ninth General Report that the comparative study of the two reactor versions using the two types of fuel originally envisaged for a CIRENE reactor had led, at the outset of 1966, to the choice of the natural UO_2 fuel.

Following on this decision, all work was centred on this reactor formula. The object, as set out in the contract of association with the CNEN signed in 1965, was to study a reference design for a high-capacity power plant and draw up a preliminary design for a fairly high-power prototype reactor. At the CNEN's request a special effort was put into the latter task, with the result that the CNEN and the ENEL have decided to build a CIRENE prototype on the Latina power station site at the end of 1967.

1. *Design Studies for a Reference Power Plant*

The principal characteristics of the 500 MWe reference power plant adopted in consequence of the foregoing comparative study are as follows: vertical reactor axis; upward circulation of coolant (light water in phase change) in the channels; coolant slightly subcooled at channel inlets; direct steam cycle; hot pressure tubes and calandria tubes in Zr-2; fuel in clusters of 19 UO_2 pins with thin collapsed Zr-2 cladding; on-load fuel-handling and two-directional movement with single loading machine beneath the core.

During the past year, the 500 MWe plant optimization calculations were resumed to allow for the effect of the spatial distribution of the coolant density on the power-generation distribution and *vice versa,* to determine more precisely the optimum coolant pressure in the reactor, and to take account of the recent experimental findings on critical power and coolant density. The feasibility of admitting a coolant with a positive steam quality at the power channel inlets was also examined. The reactor start-up problem was gone into and it was decided to inject auxiliary steam at the channel inlets to offset the reactivity deficit when starting up with channels full of light water. Lastly, certain mechanisms of the fuel-handling machine were considered in further detail.

2. *Research and Development Programme*

a. *Thermal and hydrodynamic balances*

The transfer from Genoa to Piacenza of the large-scale heat transfer test loop and the alterations to the loop to raise the heating capacity to 6 MW were completed. An initial series of critical power measurements effected on a cluster of seven heating rods did not produce the same results as had been obtained under identical test conditions prior to the transfer of the loop. The discrepancy is attributed to fouling of the heating surfaces in the Piacenza loop; this theory is being checked at present.

The significant effect on the critical power of the spacing between the heating rods in a cluster and of the axial power distribution along the rods was shown up by analysis of experimental data. The equation for predicting the critical power was adjusted accordingly.

An initial study of the effect on the critical power of spacers between the heating pins and the guide tube was conducted on a nuclear test station with a central heating rod. The results suggest that the spacers have a favourable effect for high qualities of the water/steam mixture entering the test section.

As regards density measurements on the water/steam mixtures in heating channels, special mention should be made of the development of the "rapid valve-closing" method of measuring, which has proved extremely accurate. The first tests, effected on heating tubes, confirmed that, all other conditions remaining the same, the existence of a heat flux has a relatively negligible effect on the coolant density in a heating channel. The new measuring method will be applied to rod-cluster test sections and to the determination of the coolant density during transient conditions, e.g., in the case of accidental coolant loss.

b. *Neutron balance*

Work continued on developing and improving computer codes for predicting the neutron balance of CIRENE lattices and its curve as a function of burn-up. In particular, a code named PROCELLA was drawn up to calculate the cell parameters and the neutron balance of UO_2 lattices. For the case of small reactors like that of the CIRENE prototype, heterogeneous calculating methods were used.

For the optimization calculations, the MOICANO code was developed to find the coherence conditions between the spatial distribution of the coolant density and that of the power in the channels.

On the experimental side, flux measurements were made in the TOPLESS subcritical assembly mentioned in last year's report, which is equipped with a central fuel rod submerged in heavy water and fed by a uniform peripheral neutron source. These tests were intended to provide experimental values for the heterogeneous parameters to be used in an analytical model.

Lastly, it is worth noting the preparation of a series of measurements, to be carried out in the Bologna RB-1 reactor, on the infinite multiplication coefficient of CIRENE UO_2 lattices; these measurements will begin in the spring of 1967.

c. *Fuel*

Work continued on schedule on the construction of the CART circuit for CIRENE channel irradiation tests in ESSOR. Assembly of the main circuit components started at the beginning of 1967. The test section for the zero-power physics measurements was likewise prepared. The CNEN started fabrication at Saluggia of the first fuel clusters for irradiation. A second edition of the safety report was published and submitted to the responsible departments at the Ispra Centre. The consequences of a possible rupture of the CART channel in ESSOR will be assessed by means of burst tests in the Ispra Centre's BETULLA facility.

The designing of a loop for test irradiations of single fuel pins, to be installed in a swimming pool reactor, was finished and orders have been placed for certain components.

The main fuel development problem is that of devising, for reasons of neutron economy, a thin cladding collapsed on to the fuel by the effect of the coolant pressure. A set of hot and cold collapsing tests were carried out on dummy fuel pins to define the conditions that will obviate permanent creasing of the clads and axial bending of the clad during the collapsing process. The cladding's resistance to fatigue as a result of thermal cycling of the fuel will be tested in an assembly now being built.

The problem of pressure tube fretting corrosion was approached analytically, by means of partial tests, before going on to large-scale overall tests under typical operating conditions. Experimental studies were made of the mode of vibration of the fuel pins in relation to their connection to the end grids. The contact between the end grids and the pressure tube under vibration conditions was also determined in relation to the coupling force between the fuel clusters of a given channel. The study of grid deformations due to stresses was begun.

d. *Channel*

Tests were conducted to study the leaktightness of the packings on the channel plugs under typical operating conditions. The coupling between the channel ends and the tip of the loading-machine was also tested for leaktightness.

A mock-up of a complete channel is being constructed for use in overall feasibliity tests.

e. *Dynamics, controls and start-up problems*

At the experimental level, a circuit has been built for testing a system of "two-phase" control rods; in these rods, the neutron capture of a borated gas/water mixture is varied by regulating the gas flow. The first results indicate that the reaction rate of such a system is compatible with the control requirements for a CIRENE reactor. The radiolysis of the absorbent fluid will be studied in special tests.

The loop for testing a liquid safety-rod system has been completed at the Ispra Centre. Insertion of the poisoned water into the reactor will probably be by means of a combined gravity and gas-pressure system. The results obtained from operation of the circuit confirmed that the pre-insertion times and the rod insertion velocity are sufficient for the needs of a CIRENE reactor.

The method of starting up a reactor by injecting auxiliary steam into the channel inlets was tested on a special scaled-down circuit. It was ascertained that the coolant flow conditions in the channels remain stable during start-up of the reactor and the power run-up.

As regards design, it was ascertained by analysis that by maintaining a certain degree of boiling in the moderator of a CIRENE reactor under steady-state conditions, the intrinsic stability and dynamic behaviour of the assembly are improved.

Safety work included further preparation of digital computer codes for a CIRENE power plant and experimental measurement of the time required to dump the coolant from a heating channel by the "fast-closing valve" method.

f. *Chemistry and physical chemistry*

The dynamic corrosion tests on Zr-2 samples in the AVOGADRO pile at Saluggia were continued in an attempt to determine the influence of the presence of ammonia in the coolant; this influence proved to be negligible for the accumulated short exposure times.

At the same time, out-of-pile tests were performed in various loops to measure the thermal degradation of the ammonia, the formation of nitrites and the distribution of the ammonia between the liquid and vapour phases of a separator.

The poison adopted for the liquid safety rods underwent tests for deposition on the internal walls of steel tubes. The results showed up the necessity of washing the rods after a reactor shut-down.

3. *Design for a Prototype Power Reactor*

At the request of the CNEN, the dimensioning of the CIRENE prototype was pegged to the credits regarded as available for building a facility of this type in Italy. The outcome was a reactor of about 35 MWe, equipped with sixty power channels identical, except as to height, with the channels studied for the reference power plant. The fuel is natural UO_2, with thin ZR-2 cans. The reactivity available with this fuel will not suffice, however, to achieve the burn-up envisaged for a large power plant. On-load charging and discharging is planned. The steam pressure in the separators will be 50 atm. The coolant is slightly subsaturated at the channel inlets, and the steam cycle is direct.

The first safety report has been made out and submitted to the competent Italian authorities. As mentioned in the introduction, the CNEN and the ENEL have announced their decision to build such a prototype on the site of the Latina power plant.

DOCUMENT No. 5 ADVANCED GAS REACTORS

I. DRAGON Project

1. *Operation of the Reactor*

The reactor experiment, which went critical in August 1964 and reached half its rated power in August 1965, was at full power by April 1966. Between then and the end of August 1966, the reactor operated at capacity with an availability which was always higher than 90%. During full-power operation the fission product release rates consistently maintained a level of 10^{-4} to 10^{-5} and the activity in the primary circuit remained steady around 200 mC. The burn-ups achieved by the end of August 1966, i.e., at the end of the first core load irradiation, ranged between 15,000 and 28,000 MWd/t, depending on the fertile/fissile ratio and the position of the element in the core.

The element which reached a burn-up of 28,000 MWd/t was one consisting of fuel and pellets which had been irradiated for the THTR project. The elements with burn-ups of 15,000 MWd/t are long-life elements, irradiation being continued during operation of the reactor with successive loads. These elements are expected to reach a burn-up of 60,000 MWd/t by the end of 1967. During full-power operation, the temperature of the coolant at the core outlet was 830 °C, the maximum fuel temperature being 1250 °C and the maximum temperature of the graphite 930 °C. The reactor operated and behaved very flexibly and caused no trouble of any kind. The total level of chemical impurities in the primary circuit remained constant, being of the order of 4 vpm. The non-recoverable helium leak-rates were of the order of 6 kg/month.

Between September and December 1966, the first core load was discharged and the second inserted, with the exception of the long-life elements already mentioned, which are to be kept in the reactor throughout the irradiation of the subsequent charges.

Routine inspection work on the major reactor components was carried out during the four months' shutdown.

Post-irradiation examination of the discharged fuel elements was begun.

In accordance with the procedure for the periodical inspection of the main reactor components, one of the primary circuit blowers was removed from the circuit, together with its heat exchanger. The operation went off without difficulty on account of the low activity in these components. The heat exchanger, which is the coldest part of the primary circuit and hence tends to attract non-gaseous fission products, showed an activity due to such contamination of less than 10 mC. The total activity was of the order of 30 mC, over 20 of which were attributable to neutron activation.

With regard to the post-irradiation examination of the discharged fuel elements, the irradiated elements showed no signs of damage of any kind and had retained their shape. Contraction of the graphite was in line with what had been predicted; no cracking or corrosion of the structural graphite had occurred.

Post-irradiation examination of the cartridges of the coated fuel particles confirmed the average release rate for gaseous fission products as determined during operation of the reactor.

Diffusion of the non-gaseous fission products was also found to be particularly low. The structural graphite used in the fuel elements (tubes and contamination rate.

The contamination due to non-gaseous fission products measured at the hottest points in the structural graphite was 0.6 mC/g graphite.

An interesting experiment was conducted at Windscale on a cartridge of an irradiated U/Th fuel element. This was oxidized at a temperature of 1430 °C by a stream of CO_2. The cartridge was completely disintegrated by the combustion, but the layer of silicon carbide around the coated particles was not attacked. This layer served to retain the fission products inside the coated particles. It was not possible to identify the fission products in the vicinity of the points where combustion occurred or in the filter through which the combustion gas passed. The conclusion to be drawn is that this kind of treatment has no adverse effect on the coated particles' properties with regard to the retention of fission prodcuts.

At the beginning of January 1967, full-power operation commenced with the second charge. The reactor is now operating entirely satisfactorily and the initial data concerning the behaviour of the second charge are highly encouraging. The total activity of the primary circuit is of the order of 200 mC. This value must be regarded as extremely low, bearing in mind that the second charge consists of non-vented fuel. Furthermore, one of the fuel elements has a structure in which the fuel cartridges are cooled directly by the gas without the help of a graphite layer. The structure of this type of fuel is very similar to that which would be used in a power reactor.

2. *Study of a Prototype Power Reactor*

The evaluation studies on a 528 MWe prototype are virtually completed and work is now in progress on the final report.

With regard to the capital cost involved, the study has shown that a prototype of the size mentioned could be built for a tender price of the order of 130 u.a./kWe. Assuming about 20% of it is borne by the client, the total capital cost comes to approximately 152 u.a./kWe.

As regards the fuel cycle, an assessment of the economic outlook for the fuel cycle using low-enriched uranium was carried out under the DRAGON project concomitantly with the thorium cycle evaluation. It is particularly interesting to note that the low-enriched uranium cycle (3% enrichment of the make-up fuel), despite being the one that gives the highest cycle cost, is already an extremely attractive proposition, the total cost of a cycle being of the order of 1.05 mills/kWh, divided up as follows:

— fuel inventory cost 0.13 mills/kWh.

— proportional cost 0.92 mills/kWh;

The particularly low inventory cost is due to the high specific power of the HTGR reactor (about 47 MWth/t), which gives a first charge cost of the order of 9.9 u.a./kWe. This represents an improvement of about 30 u.a./kWe on the capital cost of the first charge in comparison with an equivalent AGR.

3. *Research Programme*

Alongside intensive work by those in charge of the research programme on assessment of the fuel irradiated in the DRAGON reactor, various jobs were continued in 1966 in an attempt to obtain a better understanding of the irradiation behaviour of the graphite and the fuel, as also were studies of various types of new fuels.

Graphite irradiations of a more basic nature performed in collaboration with the THTR Association were continued. Particularly interesting results were obtained from the creep experiments, which indicated that, at the operational temperatures of the graphite pieces making up the reactor core, the irradiation creep might cause an appreciable drop in the differential stresses in these pieces.

Work on the development of a plutonium-base fuel, which was begun in 1965, went further ahead in 1966 and resulted in the fabrication of particles which gave a release rate of the order of 10^{-6} during irradiation in the Studsvik reactor in Sweden. These extremely favourable findings led to the decision to introduce two tubes of fuel containing plutonium oxide in the second DRAGON charge.

Fuel reprocessing studies were pursued by British and Italian contractors, these techniques being shown to be an economic proposition by the results of the dissolving and reprocessing operations. The Italian work on fuel refabrication will not be finished before the beginning of 1967.

Work continued on the deposition of carbon on steels used in heat exchangers. By careful selection of the material used in the heat exchanger and by means of suitable heat treatment, it appears possible to form an oxide layer on the surface of the material to prevent carbon deposition during in-pile operation.

II. THTR Association

The development of a pebble-bed reactor running on thorium was pursued under a contract of association signed in 1964 between the Community, the Kernforschungsanlage des Landes Nordrhein-Westfalen and the Brown-Boveri/Krupp company, with indirect financial backing from the West German Ministry for Scientific Research.

1. *Research and Development Programme*

a. *Fissile and fertile fuel elements, with irradiation tests and post-irradiation examinations*

The first US-made AVR elements were delivered during 1966, as a result of which the AVR reactor went critical on 26 August 1966.

The general specifications for the make-up fuel to be fabricated in the Community were drawn up by the THTR Association and are very similar to those for the American first charge, which was tested in the Oak Ridge reactors. Tenders were invited both in and outside the Community. Comparison of the various bids submitted showed that the supply of the make-up fuel could be undertaken by a European firm. The definitive contract is now being drawn up.

Particular stress was placed on the irradiation stability of the graphite used for the fuel spheres and of the pyrocarbon surrounding the fuel particles, since it must enable the expected life-time of the AVR elements to be achieved with an extremely low fission product release.

A certain guarantee as to the irradiation stability of the graphite was obtained by systematically irradiating various graphites fabricated inside and outside the Community in the BR-2, Petten and DRAGON reactors. Several graphites show excellent behaviour under irradiation; selection will be made on the basis of cost and mechanical resistance to the 4 m drop test.

The development and comparative study of various fuel geometries resulted in a proposal that so-called "Tapeten" fuel should be used as make-up fuel for the AVR reactor. A characteristic of this fuel is that the coated particles adhere to the inside of the hollow graphite sphere thus ensuring that they are as close to the coolant as possible.

In an attempt to obtain certain data on the stability of the graphites planned for use in the THTR fuel, a contract was signed with the UKAEA for the irradiation of graphites with doses of first $6 \cdot 10^{21}$ and subsequently 2 to $3 \cdot 10^{22}$ in the DFR reactor (Dounreay Fast Reactor). These irradiations will also be used for determining the radiation stability of the graphite powder mixtures contemplated for use in the fabrication of synthetic fuel elements.

Development of the coated particles continued successfully, as was shown by their irradiation in reactors inside and outside the Community. It would appear that by incorporating high-density pyrocarbon and inserting layers of porous carbon between the fuel kernels and the layers of pyrolytic carbon, molten fuel kernels might be used satisfactorily even for protracted irradiation periods. The influence of high fast-neutron doses can be estimated by means of irradiations in the BR-2 reactor and in the Dounreay reactor. Various irradiation stability models have been developed in the United States at Oak Ridge laboratory and some of the irradiation experiments planned by the THTR for 1966 and 1967 will be aimed at assessing the validity of this model for particles developed in Europe. Particular importance will attach to checking the creep properties of various pyrocarbons deposited on the fuel kernels.

Comparative studies were carried out on methods of fabricating powders by metallurgy and by the sol-gel technique. For the production of small quantities, the dry methods offer a certain advantage, but beyond a certain production volume the sol-gel technique or the emulsion method would seem to have the economic edge.

As regards the THTR reactor, there would appear at present to be only two geometries offering a fuel element fabrication cost which could compete with that of other reactors:

— A fuel consisting of coated particles packed freely in a slit made by the lost-wax process before the fuel sphere is graphitized;

— A synthetic fuel obtained by pressing coated particles set in a graphite matrix which contains certain graphite-free materials. Some graphite matrix samples have been irradiated at Petten and have yielded favourable results with regard to dimensional variations. As was pointed out above, similar samples are now being irradiated in the Dounreay reactor; the results obtained will be used to assess the dimensional and mechanical stability of fuel pellets fabricated from these materials.

The majority of development work on these fuels is carried out by Nukem, under contract to the Association.

In the field of synthetic fuels, it is particularly important that the pellets should have a fairly high crushing strength, since tests carried out at Jülich have revealed a correlation between this characteristic and the impact strength when the control rods are inserted straight into the pebble bed.

b. *Reactor physics*

Following on the neutron calculations carried out to cover the various possible ways of loading the fuel, it was decided to conduct detailed studies on the solution involving direct insertion of the control rods in the pebble bed without the use of graphite or metal guide tubes. In this way 25 control rods could be inserted to regulate operation of the reactor. It was also decided to study, by way of a back-up solution, a method by which graphite tubes would be inserted in the pebble bed up to a height of about two metres measured from the upper surface of the pebble bed. As a result, the rods could be dropped rapidly without any resistance. No final choice has been made so far and the programmes are being continued.

c. *Reactor technology*

Loading/unloading circuit problem

Work is still in progress on studies bearing on a problem of vital importance where pebble bed reactors are concerned, namely, that of developing a method for checking the nature of the various fuel spheres at the reactor outlet. The method proposed is to use a low-power homogeneous reactor for selection purposes. Installation of this reactor was completed by the end of 1966 and results are expected in the course of the 1967 programme.

The studies on the loading/unloading circuit were conducted in close collaboration with the departments responsible for the development of the prestressed concrete vessel in order to ensure that sufficient volume is available for selecting the various fuel spheres at the bottom of the reactor and also in order to be able to reintroduce the spheres in two parallel circuits, each consisting of eight different loops, so that each sphere falls into the most favourable position from the standpoint of neutron economy.

A milestone was reached in the designing of a pneumatic brake, the main purpose of which is to cut down the height from which the pellets must drop at the top of the reactor from 4 m (AVR value) to about 2 m. Successful application of this method will reduce the mechanical stresses to which the pellets are subjected.

Prestressed concrete reactor vessel

The studies being performed by a group consisting of Indatom/ENEL and Krupp proceeded throughout 1966 and culminated in a complete assessment of the tendon configurations necessary to allow for the various penetrations in the prestressed concrete vessel which are required for installing the heat exchangers, the blowers, a certain number of thermocouples and the pellet circuits.

Heat exchangers

Studies were continued on various geometric configurations for the tubes on the basis of calculations and tests in the aerodynamic loop at Jülich. The influence of the use of finned tubes in the economizer is now being evaluated, with a view to ultimately reducing the height of the heat exchanger, which at the moment is fixed at 14 m.

A major problem with regard to the heat exchangers is that of the penetrations at the top of the reactor used for passing the steam from the exchanger to the turbine. For safety reasons, it will probably be necessary to install a double wall over certain sections of this pipework in order to avoid any risk of gaseous contamination being released into the atmosphere in the reactor building.

Blowers

Several contracts have been awarded to firms to the design of oil-bearing blowers with various methods of positioning the electric motor. The use of gas bearings is still being considered with some interest.

d. *Reactor chemistry*

As a result of the work carried out on the corrosion of various pellets in line with a specification drawn up for the AVR but extended to cover a period of 50 hours, different graphites were short-listed for the AVR and THTR fuel elements. These findings showed that in order to avoid localized corrosion it is essential to use high-purity graphites.

The work on the chemical purification of helium was continued in order to determine accurately the kinetics of reactions for low concentrations of absorbed gases. Over the short term, it was decided to use conventional methods for the THTR reference design.

There was close collaboration with the DRAGON project in the work on the deposition of carbon in the exchangers. The results obtained are given above. It is planned to continue the programme using shop-made tube exchangers in order to confirm the results obtained on laboratory samples.

2. *Prototype Design*

Further work was conducted on the assessment and design of a 300 MWe prototype in close collaboration with a number of industrial firms which had been asked to design certain major components of the reactor, factoring in the results obtained under the research programme.

No major modification has been made since last year and the findings of the basic assessment study will be available in early 1967. The results of the detailed financial evaluation are expected for the end of 1967 or early 1968.

As things stand at present, there would appear to be no major obstacle to the development of the pebble-bed reactor.

3. *Utilization of AVR Reactor*

a. *Criticality of AVR reactor*

The reactor went critical on 26 August 1966 with a mixture of 17,000 fuel pellets and 44,800 graphite pellets.

Before the reactor core was loaded with the fuel elements, an extensive programme of operational checks was carried out on various parts of the reactor, notably the control rods, the nuclear instrumentation, the safety couplings, the loading/unloading system, the blowers and the temperature, pressure and activity monitoring circuits.

Certain discrepancies were noticed between the practical results and the theoretical calculations. These were accounted for by the influence of the space between the core and the upper reflector from the neutron leakage standpoint since this space is obviously more important at criticality and at full power. The second reason for the discrepancies in the calculations was the fact that air was used when the reactor went critical instead of helium.

b. *Reactor construction*

Construction work on the reactor was held up owing to certain bugs picked up during the acceptance tests, notably:

— the loading/unloading machine, in whose circuits certain defects were revealed;

— certain primary circuit valves, whose helium leaktightness was inadequate;

— the control rods, all of which had to be replaced owing to jamming which manifested itself after long-time bench tests. A makeshift solution based on the use of a special oil proved of no avail owing to the high temperature of the rod during operation, namely, about 160 °C, which causes the oil to evaporate. There was found to be no choice but to adopt a new design based on a ball-bearing system, work on which had been conducted concurrently. Replacement of the rods, which was started in 1966, will not be finished before the spring of 1967.

DOCUMENT No. 6 FAST NEUTRON REACTORS

1. *Euratom/CEA Association*

Completion or commissioning of the large installations RAPSODIE, MASURCA and HARMONIE went off more or less on schedule:

— HARMONIE, which first went critical in August 1965, has been operating non-stop since the beginning of 1966; in particular, it has been employed permanently for calibrating the instrumentation for use in RAPSODIE and MASURCA, for experimental studies on the biological shielding and for preparing pulsed experiments;

— MASURCA is now finished and went critical on 15 November 1966, the bulk of the fissile material in the core consisting of plutonium;

— RAPSODIE was completed at the end of 1966. The tests prior to start-up were unfortunately hampered by minor incidents which held up criticality by several weeks. All these incidents — rupture of a feed line and ejection of sodium at the plug, jamming of certain pump bearings — were overcome without any great difficulty and the reactor went critical on 28 January 1967.

The 5 MW Grand-Quévilly loop for steam generation studies, which went into service in mid-1965, was used non-stop during 1966. New test sections have been ordered.

The studies on large sodium-cooled reactors, which had led to the conceptual design of a 1000 MWe unit, were continued with work on a less ambitious prototype reactor (about 250 MWe) and detailed studies on physics and kinetics, fuel and structural material development and component development. The detailed draft design of the prototype reactor (PHENIX) will be ready for the end of 1967, construction possibly beginning in 1969.

2. *Euratom/GfK Association*

The situation with regard to the major installations covered by the association is as follows:

STARK went critical in mid-1964. Operation proceeded normally, the facility mainly being used for perfecting the noise analysis method with three successive subcritical fast cores. At the end of 1966 STARK had to be shut down for a brief period owing to the lack of enriched uranium for SNEAK.

SUAK, which went into operation in the autumn of 1965, was used for analyzing subcritical U-235 assemblies; it, too, had to be shut down owing to the lack of enriched uranium. New experiments, in collaboration with the Euratom/CEA Association, are to begin around mid-1967.

Construction work on SNEAK was delayed by a fire on the site, which damaged certain electrical conductors. SNEAK went critical on 15 November 1966 with an enriched-uranium core; a plutonium core is to be used subsequently.

The 3 MW steam loop (Loeffler cycle) was used regularly.

The work on large reactors in 1966 was mainly directed at a 1000 MWe steam-cooled draft design after economic and safety studies had revealed the attractiveness of such a type. The sodium reactor conceptual studies were also continued on the NA-1 (1000 MWe) concept, which was completed in 1965. As under the Euratom/CEA Association, these conceptual studies underlie all the research and development work in the various fields.

3. *Euratom/CNEN Association*

During the last six months covered by the contract of association, the experimental work was chiefly devoted to the development of vented fuels (in which the fission gases can be passed off during irradiation) and studies on sodium in the boiling state; the results obtained are to be employed in reactor safety studies.

A preliminary draft design was drawn up for a fast materials-irradiating reactor (PEC - Prova di Elementi di Combustibile) and work continued on parameter studies for large reactors with the aim of comparing the different versions studied so far. In addition, a start was made with detailed studies on steam generators. The CNEN proposal concerning the extension of the association up to the end of 1967 provides for continuation of this work, including the commencement of construction of the PEC reactor. This particular point calls for a modification to the second programme, which did not include such a project originally, and has held up the signing of the contract for the extension of the association.

4. *Euratom/Belgian Government Association*

The agreement of association linking the Commission with the Belgian Government was signed in December 1965.

The work programme is intimately bound up with that of the Euratom/GfK Association and is directed in particular to the adaptation of the 1000 MWe sodium and steam reactor designs drawn up at Karlsruhe (Na-1 and D-1) for a U-235 cycle, economic fuel cycle studies and safety studies on large fast reactors. The association is also assisting with a programme for the development of a plutonium fuel for the ENRICO FERMI reactor; more particularly it is carrying out the fabrication studies and will subsequently handle fabrication of the fuel pins for irradiation in this reactor. This programme has unfortunately been slowed up owing to the incident which occurred in the ENRICO FERMI reactor in October 1966. Finally, the association is examining the possibility of adapting for fast reactor fuels the dry reprocessing method developed at Mol for thermal reactors.

5. *Euratom/TNO-RCN Association*

The contract of association between the Commission and the TNO-RCN group was signed in November 1965.

The work programme is closely connected with that of the Euratom/GfK Association and is for the most part concentrated on the development of materials and components (pumps and heat exchangers) for sodium systems. All the study loops provided for under the contract (in the main critical shock loop and corrosion loops) went into operation in 1966 with the exception of a test loop for small pumps. The first experimental results were obtained at the end of the year. A preliminary design was drawn up for a large pump and a 70 MWth steam generator.

6. *Miscellaneous*

a) By mutual agreement, the Euratom Commission and Atomic Power Development Associates have suspended the contract concluded between the two parties in 1965 for the irradiation of fuel samples in the ENRICO FERMI reactor. The incident which occurred in the reactor in October 1966 necessitated a protracted outage. It is hoped that the reactor can be started up again at the end of 1967.

b) In November 1966, Euratom signed a contract with the UKAEA for the irradiation, in the Dounreay DFR reactor, of fuel samples prepared by the Euratom/GfK and Euratom/CEA Associations and by the Institute of Transuranium Elements. By means of this contract the number of Community users availing themselves of the DFR irradiation facilities has been increased in 1967. The first fuel samples are to be placed in the reactor in March 1967.

c) The Institute of Transuranium Elements continued its close collaboration with the programmes of the Euratom/CEA and Euratom/GfK Associations.

Fabrication of the plutonium elements for MUSURCA was completed in October 1966 (these elements were used for criticality of this assembly in November 1966). Furthermore, the Institute has continued with its work of adapting to plutonium several of the fuel fabrication results obtained by the Euratom/GfK Association.

d) The Ispra Joint Research Centre Establishment also continued its experimental work on sodium boiling, this being closely dovetailed with the activities of the Euratom/GfK Association.

DOCUMENT No. 7

PLASMA PHYSICS AND CONTROLLED FUSION

Controlled thermonuclear fusion will not be achieved in practice until a solution is found to the problem of producing a sufficiently hot, dense plasma and confining it, or at least heat-insulating it, from all material walls.

It is chiefly this second imperative that is still giving great trouble in spite of the variety of magnetic configurations that have been thought up and, in most cases, tested experimentally, with the aid of plasmas of widely varying composition, temperature, density and production methods. The reason is that a great many phenomena can disturb the confinement state, which is in any case essentially transient; owing to the complexity of the problem, theory can only help to a limited extent, while experiments almost always demand substantial funds, staff and time. On the one hand, therefore, theoretical work must make sufficient progress to be able to predict, or at any rate explain, the events likely to occur and their influence on the confinement, and on the other hand (and this is a trend already to be found in every laboratory), experiments must be devised to produce accurate even though limited information.

Thus certain paths which seemed at first sight to lead more directly towards controlled fusion are gradually being abandoned for others which, although less ambitious, are hoped to prove more useful.

For this reason programmes under the contracts of association cover a wide range of subjects which, unless we remember the nature of the problems, seem to have little or nothing to do with controlled fusion. Space will not allow here of more than a list, incomplete at that, of the work achieved by over 400 research scientists in the associated laboratories. More detailed information can be found in the annual reports drawn up by the five associations.

I. Theoretical studies

Analytical and numerical research continued at Garching on closed magnetic configurations and their equilibrium, with low or high plasma pressure; promising configurations were discovered at Fontenay-aux-Roses; at the same time the studies on stability were pursued, not only with regard to configurations of immediate interest but with more general aims as well and taking actual plasma properties into account. These studies are based on macroscopic or microscopic equations or (at Jutphaas) on thermodynamic considerations. Major activity is further developing, often in connection with stability problems, on the linear and non-linear study of waves in plasmas. At Fontenay-aux-Roses, for instance, waves and micro-instabilities in cylindrical geometry are being investigated and important advances, coupled with experimental work, have been made in the study of non-linear effects. At Garching work continues on the generation of harmonics of the cyclotron frequency of electrons, and at Jutphaas on wave propagation in a non-homogeneous plasma.

The use of electromagnetic waves for the production and heating of plasma, as also the characteristics and more especially the stability of the plasmas obtained, were the subject of numerous investigations, mainly at Saclay, as was the interaction of very high intensity (laser) light waves with matter, mainly at Frascati, Garching and Fontenay.

Other research, chiefly connected with diagnostics, were developed mainly at Fontenay, Garching and Jülich. At Frascati studies continued on the dynamics of gas or metal layers employed to compress a hot plasma and on the properties of high-density plasmas.

In May a number of the associations' theoretical scientists met in Varenna to compare notes.

II. Experimental pinch research

a) *Linear Azimuthal Pinch*

In essence, the discharge from a fast capacitor bank over a cylindrical coil creates a magnetic field which produces and compresses the plasma, confining it laterally but not axially.

At Garching the experiments ISAR-1 (2.6 MJ, 40 kV) and ISAR-3 (80 kJ, 40 kV) were used for further study of end-losses and the effect thereon of magnetic mirrors or cusps. The ISAR-2 device (500 kJ, 40 kV) was assembled. Ion and electron temperatures and confinement times in a relatively short coil were investigated on the fast compression device ISAR-4 (115 kJ, 2 × 40 kV, period 7 μsec). Heating by turbulence was studied in a device of 10 kJ, 2 × 40 kV and 2.6 μsec period.

At Frascati, after all possible information on shock-wave structure had been extracted from the CARIDDI machine, it was dismantled for modifications aimed at improving the performance and flexibility so that the subject can be researched further.

At Jülich the 600 kJ device is being modified to bring it up to 1.2 MJ with optional crowbar. The plasma lifetime has been lengthened by anti-parallel field trapping, the persistence of trapped fields over a half-period having been verified with different starting conditions. The bremsstrahlung has been studied with particular attention; this factor must be accurately known since it is one of the most widely used methods for evaluating electron temperatures. A new, very fast device (15 kJ, 40 kV) is under construction. The structure of shock waves was studied in relation to the starting conditions.

b) *Toroidal Pinch*

The mechanism of particle loss was examined at Garching, on the SPINNE experiment (50 kJ, 18 kV), with a hexapolar field superimposed to offset the weakening towards the outside of the main magnetic field. In particular, the magnitude of the losses along the hexapolar cusp lines differs according to the temperature and density conditions. The LIMPUS linear device, with an undulating magnetic field, was built to serve as a preliminary step from which to move on to the azimuthal structure in toroidal geometry.

At Fontenay-aux-Roses, following improvements to the STATOR device (toroidal geometry with central conductor), lifetimes of the order of 400 μsec with densities of 3.10^{14}/cc have been achieved; at the same time the propagation of certain externally-excited waves with a view to heating the plasma was further studied on the EPPE linear version.

At Jutphaas, the alternating-pinch experiments revealed the formation of secondary layers in the neighbourhood of the wall and thus had to be abandoned. The "helicoidal" pinch, in which two coils are excited in phase, continues to show promise, for on the two devices in service no gross instabilities have been observed yet, a fact for which a theoretical explanation still has to be found. An improved system is being developed.

III. Magnetic traps

a) *Fast Ion Injection*

At Fontenay-aux-Roses, on the MMII experiment (injection of molecular ions into a magnetic mirror) a new Penning source with an output of 0.5 amp of 40 KeV H_2^+ ions was installed. The study of the plasma formed was interrupted in order to improve the vacuum in the chamber by means of a large tank and very-high-delivery pumps.

At Jutphaas, the experiments on ion injection into a cusp configuration were pursued with more numerous and efficient diagnostic methods.

b) *Plasma Injection and Plasma Guns*

At Fontenay-aux-Roses the DECA-2 device was used for detailed studies of low-density conditions (10^{10}/cc). A view-time of 200 µsec was observed, which appears to be determined solely by charge exchange between the plasma and the co-existing neutral gas. Again at Fontenay, on the BET experiment, the plasma column formed by the collision of bursts from two guns was used for studying a method of heating by very fast magnetic compression. After suitable processes had been developed for measuring the plasma density and ion and electron temperatures, it was possible to observe the formation of shock waves and the very rapid conversion of a fraction of the magnetic energy into thermal energy.

At Jülich, for plasma acceleration by progressive waves, a pulsed 100 kV line was built. With a view to a switchover to an accelerator in steady-state operation, preliminary studies on ionization and initial acceleration were carried out. For this purpose a model was designed and a definitive experiment prepared.

At Jutphaas, the experiment on injection by radial gun was terminated after the penetration of plasma into the magnetic field had been demonstrated.

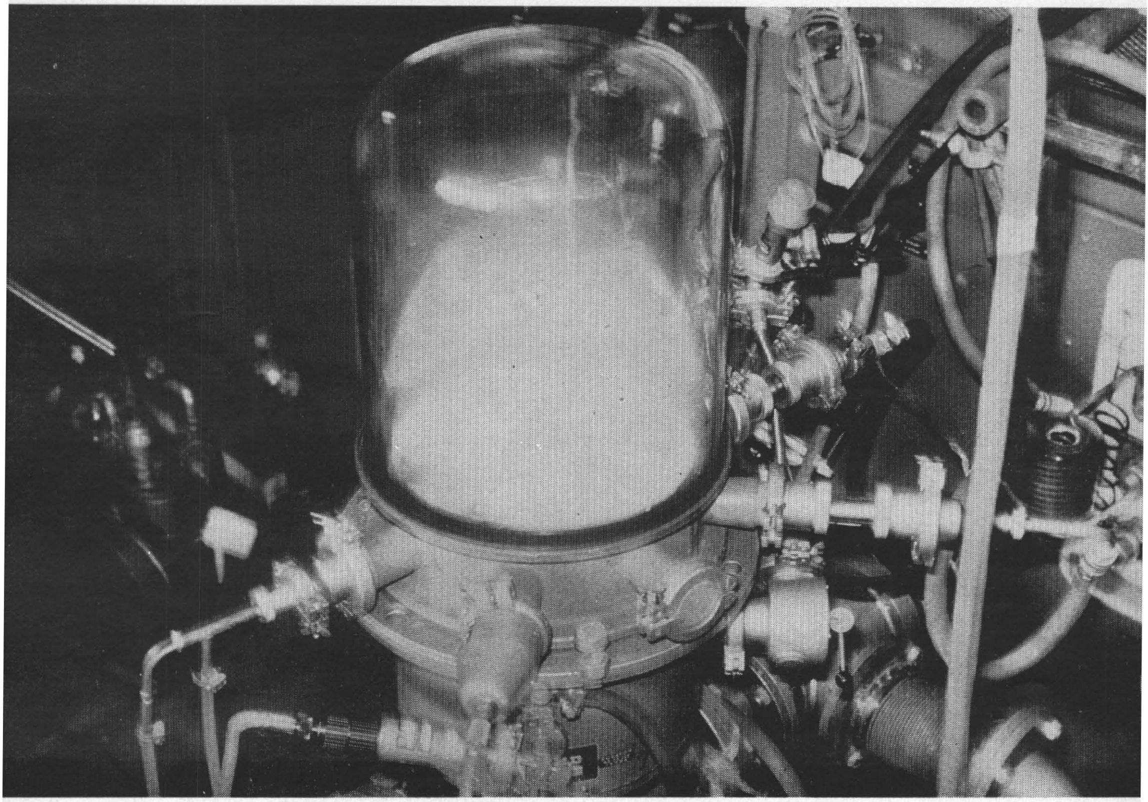
At Amsterdam, the Kruisvuur experiments (plasmas rotated by the effect of a radial electric field in a mirror configuration) were stopped, as the results set out in the programme had been achieved.

c) *Closed Configurations*

On the STELLARATOR (Wendelstein) devices at Garching the supports, which had caused major losses, were reduced for further experiments. An alkaline plasma in thermal equilibrium is produced inside through contact ionization on a hot metal target.

The measurements effected reveal a far lower loss rate than that observed elsewhere in apparently similar anomalous diffusion experiments. This rate may be accounted for by normal diffusion mechanisms, thus suggesting the presence of a stable equilibrium.

At Fontenay-aux-Roses research continues on the two HARMONICA devices.



ISPRA (Italy) — HIGH-TEMPERATURE CHEMISTRY. HF PLASMA METALLIZATION DEVICE

A new toroidal project (cold gas blanket) at Jutphaas should also be mentioned, though actually in this experiment the magnetic field serves mainly for heat insulation purposes, the confinement being effected at least partially by an external cold plasma.

IV. Build-up of very dense plasmas

At Garching, on the EIERUHR experiment and on arc discharges, stationary high-density plasmas almost in thermal equilibrium were built up with temperatures of several hundred thousand degrees. Furthermore, the pressure profile was shown to be influenced by the electric currents produced by the combined effects of the magnetic field and the transverse temperature gradient; these results are extremely interesting, especially in connection with the Jutphaas cold gas blanket project mentioned above.

At Frascati the encouraging results with the MIRAPI-1 (40 kJ, 35 kV) experiment, on radial compression of a thin cylindrical layer of plasma, led to the designing of a new device, MIRAPI-2 (120 kJ, 40 kV), now being built, in which the deuterium column and the tubular envelope will be created independently so that their mass range can be varied within wide limits.

As regards the MAFIN experiment (compression of a liner by means of chemical explosives), after the new rig had been completed magnetic fields of 5.5 MG were achieved in a conical device by flux compression.

The principal work on plasma compression is being conducted on a theta-pinch experiment with a magnetic field of the order of 1 MG produced by explosives, a special device providing for very fast run-up of the field in the compression coil.

At the same time, work continued on a method for axial injection of the plasma produced by two guns.

In the HOT-ICE experiment on plasma production by laser beam action on a solid substance, attention centred mainly on the suspension of the target (LiD_2 or D_2) and on the construction of a neodymium laser giving approximately 1 GW.

At Fontenay, new plasma-forming methods using a laser beam triggered by a giant pulse were studied. The beam, focussed on a point in a gas, produces a local breakdown, the mechanism of which raises interesting problems concerning the interaction of the radiation and the atoms. An electrical process for suspending a solid particle to be vaporized and ionized by a light beam was developed.

Similarly, at Garching a solid hydrogen bead is suspended in an alternating electric field, then vaporized and ionized by a powerful laser pulse.

V. Build-up, confinement and acceleration of a plasma by oscillating fields - Miscellaneous research

At Saclay, the deuteron energy on the PLEIADE-2 accelerating device was raised to 30 KeV, whilst on the CIRCE-1 experiment (accumulating plasma between two HF structures which, positioned at the mirrors of a magnetic bottle, act as an injector and plug), accumulated densities of 2.10^3 elect/cm^3 were achieved, with an ionization rate of over 80% and an HF energy transfer to the plasma of about 80%.

At Jutphaas work on RF confinement was concentrated on the effects of non-adiabatic reflections of electrons in the RF barriers; these reflections are of predominant importance and provide an explanation of the ionization degrees and temperatures observed.

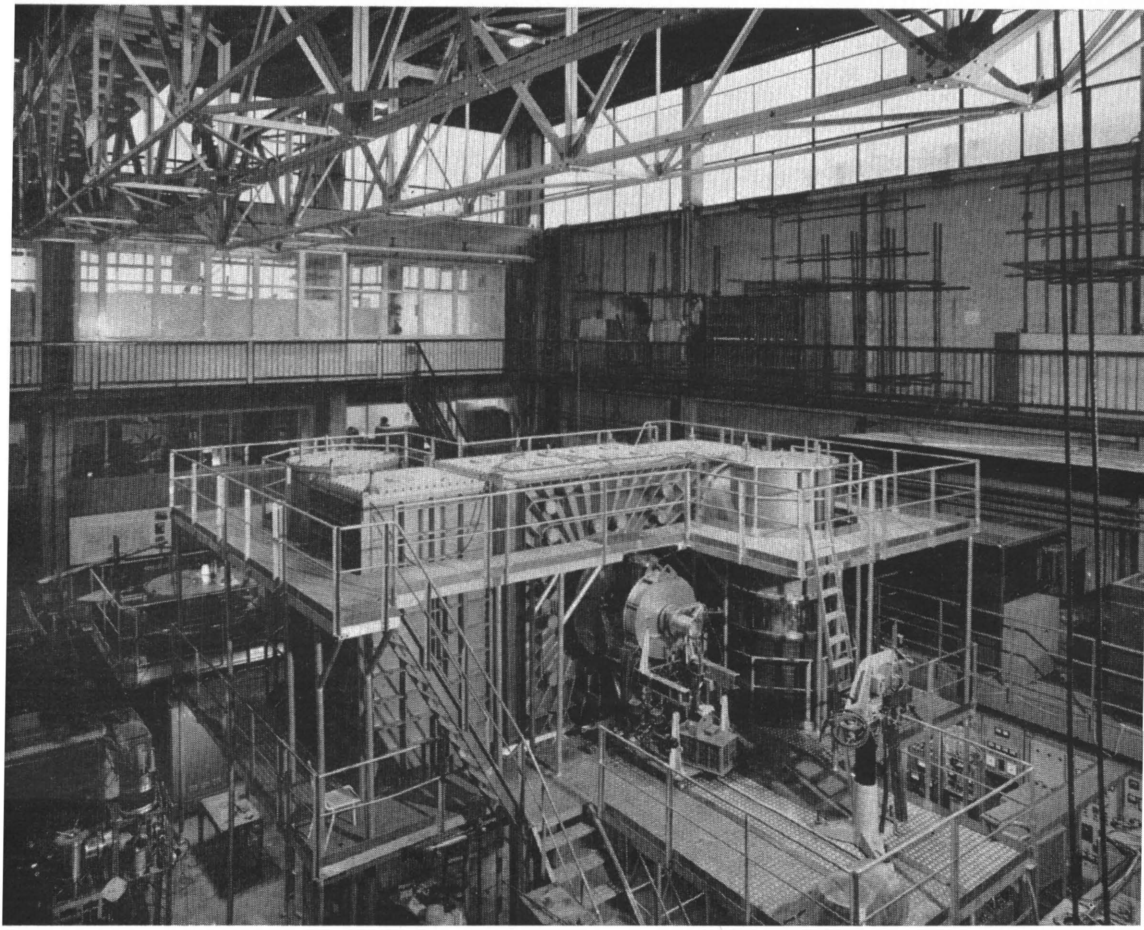
Turning to alkaline plasmas at Garching, the ALMA-2 and 3 (caesium) and BARBARA (barium) experiments are being used to study the behaviour of a plasma column in virtually perfect thermal equilibrium, together with the excitation, propagation and damping of electrostatic ion waves in a plasma in various stages of ionization. At Frascati, on the PETER experiment, a 10^{10}/cc plasma in thermodynamic equilibrium with the temperature of an incandescent cavity (about 2000°K), studies were performed on the abnormal resistivity and the interaction of microwaves with the plasma density fluctuations.

As to the particle-wave interactions particularly connected with the study of micro-instabilities and anomalous diffusion, scientists at Saclay, using a plasma column obtained by diffusion on DAPHNIS-1 and with an appropriate velocity distribution, observed radial losses of a magnitude somewhere between resistivity diffusion and anomalous Bohm diffusion. A DAPHNIS-2 device is being assembled so that this finding can be verified with higher magnetic fields and degrees of ionization.

With regard to "synthesis plasmas", the beam intensity has been improved (better focussing and extraction) and a more sophisticated diagnostics system (emitter probe) is in use.

At Fontenay-aux-Roses, in research on wave propagation, the non-linear interaction of two excited modes in a plasma column was studied and the production of a third mode, whose frequency is the sum of, or the difference between, the frequencies applied, was observed. The theoretical conditions governing the appearance of this third mode, assuming that the coupling is due to the plasma, were verified experimentally.

At Amsterdam, the electron beam/plasma interaction measurements were continued to confirm the spikes observed at the cyclotron frequencies and plasma frequencies of ions and electrons. Two states have to be distinguished, one in which there is no HF ionization and the plasma density falls off between each pulse, and the other where HF ionization begins to play a part. The boundary between the two states was studied.



FONTENAY-AUX-ROSES (France) — RESEARCH INTO PRESSURE. MAGNETIC MIRROR AND ION INJECTION DEVICE (MMII) DURING CONSTRUCTION AT THE END OF 1966

(See other side of page for caption)

Promising closed magnetic configurations, with a low or high plasma pressure, have been obtained at Fontenay-aux-Roses this year.

DOCUMENT No. 8 STUDIES RELATING TO REACTOR SERIES DEVELOPMENT

I. Treatment and storage of radioactive waste

With funds earmarked for this work cut by 40%, the research programme on radioactive waste treatment and storage was confined to a few items of outstanding interest to the Community. The subjects of the few research contracts concluded between the Commission and laboratories or other bodies were:

— the devising of new processes or methods for decontaminating high-activity effluents by fixation in the form of solids which can be easily transported and stored;

— the recovery of certain radioisotopes contained in solutions of fission products;

— the prototype-scale development of various methods of permanent storage with built-in safeguards;

— the economic assessment of the various treatment and storage methods.

Studies begun in 1965 in the above field progressed satisfactorily during the year under review and the main results are set out below.

1. *Treatment of medium and high-activity waste*

Methods currently being developed relate either to the adaptation of the lyophilization process or to the fixation of certain radionuclides on natural inorganic carriers (pozzolana) or synthetic carriers (zeolites).

The firm of Leybold built an experimental lyophilization unit with a capacity of 400 litres a day for systematic studies on the influence of various parameters (pressure, temperature, flow-rate) governing the evaporation of salt solutions at low temperature.

In the meantime, certain difficulties encountered in perfecting the concentrate freezing operation have been satisfactorily dealt with.

A start has recently been made on designing the lyophilization chamber. Technical and economic evaluation of the performance of this technique is not yet possible.

At the same time Ugine-Kuhlmann is investigating the fixative capacity of various types of silicate of the zeolite family in respect of the most highly radioactive fission products (strontium-90, caesium-137, cerium-144, zirconium-95). Results are very encouraging, with volumes being reduced by factors of the order of 250. Experiments in the processing of very-high-activity solutions are in progress.

Meanwhile, it has been demonstrated by the experimental coating of charged zeolites in bitumen that this method, which is already in industrial use, can be employed for coating the sludges obtained from chemical processing of low-activity waste. Tests are also in hand on a process of irreversible fixation of active elements by fusion of the charged zeolite.

Finally, the Commission drew up a contract with CNEN covering research into the use of detrital materials which are in cheap and plentiful supply for processing waste of varying degrees of radioactivity. Yellow Naples tuff possesses very interesting ion exchange properties and detailed studies of its structure and physicochemical properties have therefore been undertaken. Mineralogical analysis has shown this material to consist of various zeolites. Once its ion exchange properties have been fully determined, a comparative assessment will be made of methods for the decontamination of different types of waste based on fixation of the most "troublesome" radionuclides either on yellow Naples tuff or on synthetic zeolites.

2. *Recovery of fission products*

The work on the recovery of certain products carried on at the CEN over a number of years was continued. Proceeding from earlier results it was possible to devise a technique, on the active pilot laboratory scale, for separating caesium-137 and strontium-90, based on the development of new inorganic ion exchangers such as molybdate ferrocyanide and polyantimonic acid. More exhaustive work recently has confirmed the validity of the method, which has been successfully applied to concentrated solutions of fission products of different origins (Marcoule, Eurochemic). In addition, a method is under development for separating the radioactive element from its fixation carrier with regeneration of the ion exchanger.

A point to be noted is that the CEA is building facilities for the production and encapsulation of strontium-90 and caesium-137 sources at Marcoule and The Hague respectively, employing processes developed under design study contracts signed between the Community on the one hand and the CEN and CEA on the other. With these facilities it will be possible to produce intense radiation sources of the order of several million curies a year.

3. *Permanent storage of radioactive waste*

Studies directed towards the discovery of suitable sites for storage on the surface (in desert regions) or within stable geological formations (salt domes or derelict salt mines) were pursued by the CNEN and the Gesellschaft für Strahlenforschung respectively. As a result, detailed investigation has begun of a few sites which appear to be suitable for use as permanent stores along these lines.

Backing up these investigations, fundamental research on radionuclide migration in different kinds of formation is being conducted at the Centre d'Etude de l'Energie Nucléaire at Mol and the Bureau de Recherches géologiques et minières. This research is of value, too, for the development of "curative" measures in the event of accidental contamination of the soil by radioactive elements. Thus CEN has demonstrated the effectiveness of chemical barriers to restrict the migration of radioisotopes in soils of different composition; chemical compounds are injected round the edge of the contaminated area to fix such toxic elements as strontium, etc., or else reduce considerably the speed at which they migrate.

II. Chemical reprocessing of irradiated fuels

Work on the development of chemical reprocessing of irradiated fuels by fluorination was speeded up in the year under review. At the same time it was decided to angle research more specifically on the processing of mixed uranium/plutonium oxide fuels obtained from fast neutron reactors. This meant tackling problems of criticality and questions bound up with the very high burn-ups contemplated for these fuels (stripping, heat transfer, high concentration of plutonium and fission products).

The 1967 timetable for CEN has been so arranged as to yield sufficient technical and economic data in time for the decision to be taken regarding construction of a pilot industrial-scale facility for the reprocessing of irradiated fuel elements, which is to form part of the Na-1 fast neutron prototype reactor installation.

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Evaluation of the interhalogen compounds as fluorination reagents for uranium/plutonium oxides continued. Chlorine trifluoride and monofluoride were the subject of thoroughgoing research, both basic (chemical kinetic studies on a thermobalance) and technological (testing in a fluid-bed reactor).

In this way plutonium volatilization in the presence of chlorine trifluoride was shown to be virtually nil at a temperature of less than 300 °C. Nevertheless this important result will need to be confirmed on uranium oxide/plutonium oxide mixtures; the volatile plutonium hexafluoride formed in the chemical reactor may perhaps be very quickly converted into non-volatile tetrafluoride in the presence of the residual reducing gases (chlorine, etc.) formed *in situ.* The effect would then be the same as if the chlorine trifluoride volatilized the uranium selectively, with the considerable advantage of easily separating the latter from the plutonium.

It was also demonstrated that chlorine monofluoride reacts selectively on powdered U_3O_8 even at very high temperature (600 °C).

With intensive use being made of the laboratory equipped for handling fluorinated plutonium in large quantities (100 g), the hot laboratory pilot unit and a shielded thermobalance for trials on small highly-irradiated samples, it should be possible to accumulate sufficient data on which to choose, not later than the end of 1967, the best chemical lay-out for reprocessing fuel irradiated in fast neutron reactors.

Meanwhile, at the Ispra Joint Research Centre, development of an electro-refining process for irradiated fuel reprocessing went ahead. Direct conversion of the uranium metal dissolved in the liquid cathode into the corresponding carbide was handled by the SNAM company, which has perfected a carburization method based on gaseous hydrocarbons such as methane and its higher homologues. Special studies were devoted to obtaining a uranium carbide of precise composition: the monocarbide can be produced by continuous control of a hydrocarbon/hydrogen reagent mixture.

Likewise to be noted is the development of a new type of ceramic, namely, lanthanum/beryllium oxide (La_2BeO_4), which possesses remarkable chemical inertia in the presence of such reducing metals as uranium in the liquid state. This material seems very promising for the fabrication of crucibles for melting uranium.

A crucible fabrication method has also been developed using a matrix of zirconium oxide stabilized with lanthanum/beryllium oxide. This type of crucible possesses excellent stability at high temperature and very good thermal shock resistance, so that it may well be used for melting uranium/zirconium, uranium/niobium alloys, etc.

Lastly, it has been shown that lanthanum/beryllium oxide can be successfully employed for welding ceramics of different composition and even for bonding ceramics to metals. A patent has been taken out to cover this application and a licence in respect of it has been applied for by an industrial undertaking in the Community.

In conclusion, mention should be made of a method developed for pretreating MTR fuels, by which the uranium can be separated from the aluminium matrix in the form of UAl_3; this results in a considerable reduction in volume along with a very good decontamination factor.

During the past year, a pilot unit was installed in a hot cell at the Ispra Centre and the technique will be demonstrated shortly on irradiated fuel elements. This process, it will be recalled, has the advantage of greatly increasing the capacity of an aqueous processing plant by substantially reducing the volume of very-high-activity radioactive effluents.

DOCUMENT No. 9 IRRADIATED FUEL REPROCESSING

I. Eurex facility

Building of the Eurex facility proceeded in 1966 in accordance with the contract signed between the CNEN and the Bombrini Parodi Delfino company (BPD). The latter joined forces with the Nazionale Metanodotti company (SNAM) to erect and install the whole unit, the work being divided between them broadly as follows:

— BPD to supply the chemical equipment and special mechanical parts and to be responsible for the reprocessing building;

— SNAM to be in charge of the other civil engineering, ventilation and instrumentation work and general supervision of the site.

Construction went forward according to schedule; no delays had occurred by the end of 1966 and if the same pace is maintained in 1967 cold testing will start towards the end of the year.

Alongside the construction work, CNEN's research programme was directed towards the chemical and technological aspects of the Eurex process, determination of the characteristics of the equipment, the instrumentation, analytical methods and possible modifications leading to greater flexibility. Numerous laboratory reports were drawn up on this research.

Pursuant to the agreement signed between the Commission and the CNEN, the latter performed a series of experiments, under an individual research contract, to test the decontamination factors expected with the Eurex amino extraction process. A report on these experiments, in which irradiated MTR plates were used, is now in the course of preparation.

The CNEN provided Euratom with a large amount of documentary information, an initial list of which was communicated to the Member States, persons and enterprises in accordance with Article 13 of the Treaty.

The annual report for 1965 was published.

As building progresses, interesting prospects are opening up for personnel from Community organizations and undertakings to be seconded to the plant on a temporary basis to observe the construction work and especially the start-up trials.

II. Other activities

Euratom participated in the work carried out at the different bodies making up Eurochemic in an attempt to determine the general trend of its activities. In particular, an exchange of views was arranged on data relating to the fuel cycle for power reactors in the Community and their unloading programme in order to enable a reasonably accurate estimation to be made of the quantities of irradiated fuel available for reprocessing.

The specifications of the substances recovered are also under discussion with fuel element manufacturers and reactor operators.

Also, during the period covered by this report the Commission examined investment projects in connection with reprocessing, of which it was informed by virtue of Article 41 of the Treaty.

DOCUMENT No. 10

LABELLED MOLECULES AND RADIOISOTOPES

I. Labelled molecules

The fourfold objective of the programme as set out in the Ninth General Report was pursued along the lines indicated below. Work was slowed down considerably by budgetary restrictions.

1. *Labelled Molecules Bank*

A number of compounds which are not obtainable on the commercial market were delivered to users in Community countries and others, enabling research to be undertaken which would have been impossible otherwise. Lack of funds prevented restocking or increasing the number of substances held by the bank.

2. *Research Contracts*

Research with the aim of preparing new substances or perfecting new methods of synthesis were carried out under contracts with the following:

Belgium:	Nuclear Study Centre (CEN), Mol
France:	Faculty of Science, Strasbourg Faculty of Medicine, Strasbourg Faculty of Science, Paris Institut Gustave Roussy, Villejuif Collège de France, Paris
Germany:	Berlin University Munich Institute of Technology
Italy:	University of Pavia University of Milan

As a result, 25 new substances were prepared, all of indubitable value in biology, medicine or research into physicochemical mechanisms, and general methods were developed by which numerous varieties of labelled compounds of greater purity than existing ones can be produced at lower cost.

These studies formed the subject of a score of papers published in the specialist press or presented at scientific gatherings.

Three new contracts have just been signed with the Battelle Institute in Frankfurt, the Paris Faculty of Medicine and the Faculty of Science at Montpellier.

The aim is to prepare compounds which are essential for research into the mechanism of hormone activity and normal or pathological cell structure, and to devise means of exploiting the properties of liquid ammonia to prepare a vast new range of tritium-labelled compounds.

3. *Meetings of Experts and Relations with Bodies in Non-Member States*

A liaison committee was set up consisting of representatives of Euratom, the French Atomic Energy Commission and Geneva University, assisted by 16 pharmacology experts in the Community and other European countries. This Committee carried out a survey among pharmacologists to discover which labelled compounds are already in use and which ones ought to be manufactured. The results of the enquiry will be communicated to the producers of labelled molecules.

A joint IAEA/Euratom working group created to draw up specifications for labelled molecules used in medicine meets alternately in Vienna and Brussels. This working group is in contact with the WHO.

The enquiry into the availability, utilization and quality of the labelled molecules requested was continued in collaboration with the IAEA.

4. *Information, Publications and Conferences*

Two international conferences were held in 1966.

The first, which took place at Pisa in January, was on the use of labelled proteins in the study of conditions such as diabetes, in research into the mechanism of hormone activity and in the detection and treatment of tumours. The report of this conference was published in August 1966.

The second conference, held in Brussels in November 1966, was devoted similarly to that of November 1963 to methods of synthesizing and preserving labelled molecules.

The Pisa and Brussels conferences were attended by 500 persons from Community countries and twenty non-Member States, both the United States and Britain being well represented.

II. Research on radioisotopes

Owing to financial restrictions, a contract with Darmstadt Technische Hochschule, which had been pending for three years, could not be signed until 1966. It concerns a systematic study of generators of short-lived radioisotopes.

Activity was accordingly limited in the main to the administration of existing contracts.

1. *Production of new radioisotopes*

Four contracts are still current, besides the one with Darmstadt Technische Hochschule mentioned above. They relate to the production of high-activity Cl-36, generators of short-lived radioisotopes, new metallic tritium targets, and heat-proof tritiated plastic targets.

2. *New Radioisotope Applications*

Collaboration in this field with the BR-2 Operations Group and the Direct Conversion Group at Ispra continues satisfactorily. A delay due to changes in the geometry of the source prevented completion of the SNAP low-power facility on time.

An original application of Ce-144 - Pr-144 and Ru-106 - Rh-106 (intense neutron source) had to be limited to preliminary tests and a brief published note because of lack of funds.

DOCUMENT No. 11

INDUSTRIAL APPLICATIONS OF RADIOISOTOPES AND RADIATIONS (BUREAU EURISOTOP)

The growing use of radioisotope and radiation applications in Community industries is now reflected both in technological advances in control and production processes and in the development of new nuclear industries.

Sectors in which techniques using isotopes and radiations are an essential of modern industry include mining, chemicals, the iron and steel and metallurgical industries, civil and agricultural engineering, plastics and textiles.

In 1966 the Bureau Eurisotop continued its work of promoting, coordinating and furnishing information on industrial applications of radioisotopes, deploying its resources in support of specific nuclear techniques in particular branches of industry.

I. Development and promotion of activation analysis

The research programme on activation analysis carried out under contract in 1966 yielded concrete results of immediate value in industry.

Ghent University, in conjunction with the Sames company, developed an automatic activation analysis unit for oxygen assaying in steel. By decision of the International Committee for the Study and Rationalization of the Methods of Gas Determination in Iron and Steel, this unit was installed on the furnace bed of a Belgian steelworks, the ECSC High Authority and the Euratom Commission contributing to the cost.

A start has been made on research to develop similar analysis units for silicon assaying in steel and silicon and phosphorus assaying in iron. As part of the research to perfect measuring techniques, programmes are planned for the fabrication of germanium single crystals having more sophisticated characteristics and for the development of semi-conductor detectors, backed up by appropriate electronic equipment.

II. Nuclear techniques in the textile industry

Two years ago the Commission launched a campaign to promote the introduction of control and regulation techniques using isotopes and the elaboration of a development programme in the textiles field. This campaign is drawing to a close and its practical effects can now be discerned.

A hundred practical applications of radioisotopes and radiations have been devised and will be submitted to textile undertakings at two public conferences in 1967, at Evian and Baden-Baden.

Numerous contacts and information exchanges between nuclear experts and specialists from the textiles industry have helped to bring the two technologies closer together. The textile industry itself is displaying increasing interest in nuclear techniques and undertaking nuclear research.

Various bodies are basing their research programmes on the immediate results of Euratom's campaign and a target development programme, for which data had hitherto been lacking, is being drawn up.

III. Promotion of irradiation techniques

To bring irradiation techniques to the notice of industry, the Commission has mounted a Community-wide campaign to promote the industrial application of these methods.

The whole campaign rests on a practical, realistic basis. A mobile irradiation unit of 175,000 curies of caesium-137 will tour Community countries. It will be set up in the major industrial areas and will irradiate all kinds of materials and substances free of charge.

Working parties, study groups and action groups have been or are being formed to look into the wide variety of questions — whether technical, industrial, operational or administrative — involved in the industrial use of irradiation techniques and the supply of information to the quarters concerned.

Experts from industry and irradiation specialists have discussed possible industrial applications at a number of working meetings. Among those considered are the preparation of wood/plastics combinations, the blending of natural and artificial fibres, the disinfection and sterilization of textiles, the decontamination of fodder and other animal feeding-stuffs, and the disinfection and preservation of agricultural produce and foodstuffs.

The caesium-137 mobile irradiation unit has been shown to representatives of national organizations, leading industrial figures and public health experts.

IV. Development work

Certain development or study contracts were signed with undertakings, university laboratories, research institutes or experts in the Community, some directly linked with the Community campaigns described above, others aimed at adapting existing nuclear techniques to the specific requirements of certain specialist branches of industry. Thus the matters covered by these contracts include the radiochemical analysis of water supplies, activation analysis of steel, gamma-spectroscopy in civil engineering and the use of tracers in sedimentation studies. In addition, prototype devices constructed under these contracts contribute to the development of more sophisticated density measuring techniques in brewing, the observation of the hydraulic transport of solids, the determination of moisture content in soils and building materials and the construction of thermo-electric radioisotope generators.

V. Coordination

The promotion and extension of the industrial applications of radioisotopes and radiations call for ever closer coordination owing to the wide diversity and speedy development of nuclear techniques and the need to avoid encroaching on the territory of research workers, private firms and nuclear organizations.

Hence the Bureau redoubled its efforts in 1966 to establish permanent contacts with a large number of laboratories and research institutes, both public and private, as also with industrial or national associations and organizations such as ATEN, the atomic forums, Comisotop, etc.

VI. Documentation and information

The Bureau continued its processing of recent technical documents concerned with the industrial applications of radioisotopes and radiations for storage in its bibliographical card indexes and specialist library.

Furthermore, there is an industrial documentation section covering technical data relating to European undertakings and some 250 enterprises outside the Community which supply products, apparatus and services in connection with radioisotopes.

This fund of documentation, extremely rich in this particular technical field, is the reference basis essential to the Bureau's work of promotion and development and supplies the material for answering the many demands for information from undertakings and persons in the European Community who consult it.

Activity in the domain of dissemination of information takes concrete form in the issue, in collaboration with the CID, of publications such as the *Nouvelles du Bureau Eurisotop* and the *Cahiers d'Information.*

The Bureau Eurisotop has also shared in arranging seminars and technical exhibitions at national or Community level.

VII. Legal and economic aspects of the use of radioisotopes and radiations

The Bureau has published a volume of statistics on radioisotope production and utilization in the European Community. An analysis of the economics of the industrial applications of radioisotopes and radiations is under consideration. Studies are also in hand on present administrative procedures and the sociological aspects governing industrial applications of radioisotopes.

DOCUMENT No. 12 NUCLEAR MARINE PROPULSION

I. Participation in the "Otto Hahn" nuclear research ship project of the Gesellschaft für Kernenergieverwertung in Schiffbau und Schiffahrt mbH (GKSS), Hamburg

Performance of Contract

Fabrication of the nuclear parts in 1966 provided fresh data concerning the development of new manufacturing methods and partial modifications to the original design to simplify construction. The new data refer more particularly to the development of new methods of fabricating and assembling the secondary shield in the reactor compartment, the supporting structure of the safety containment in the hull, the welding and plating of the pressure vessel, the fabrication of the Inconel forced-circulation steam generator, the fabrication and heat treatment of the fuel rod cladding tubes and the design of compact auxiliary circuits with the help of a mock-up of the reactor.

The above problems meant delays of a few months in the construction of the prototype, such as are to be expected in such cases.

Work to date confirms that a compromise reconciling the demands of nuclear science, naval architecture and navigation produces a sound design. It has also been shown that the relevant data can only be acquired by actually building a prototype reactor in a ship.

Status of the Work

A progress report published by Euratom set out the position at the end of 1965. Since then the Kieler Howaldtswerke AG shipyard has almost completed the internal fitting-out of the vessel.

The Deutsche Babcock & Wilcox-Dampfkesselwerke AG which, along with Interatom (Internationale Atomreaktorbau GmbH), is responsible for the whole of the nuclear installation, has started mounting the internals in the reactor vessel at its Friedrichsfeld works.

The French firm of Pompes Guinard has delivered the primary pumps.

Installation of the ventilating system by the Krantz (German) and Van Swaay (Dutch) concerns has been completed.

The Italian company of Bombrini Parodi Delfino, which is supplying the auxiliary circuits, has finished installing the greater part of the pipework.

Fabrication of the fuel elements by Nukem (German) and Cerca (French) and of the electrical and electronic equipment by Hartmann & Braun is still in progress.

The collaboration of Community industries, and the classification of the ship by the German Lloyd and Bureau Veritas companies, presented concrete problems which could be avoided in future if administrative regulations on technical safety were brought into alignment in the Community, especially in regard to approval of materials, inspection and testing of materials and equipment, and standards of skill demanded in particular for welders.

II. Contract of association with the Reactor Centrum Nederland

The Reactor Centrum Nederland continued its theoretical and experimental work on developing a pressurized-water-reactor for use in marine propulsion.

Research was concentrated on parts of the programme which were essential to the reliability of the proposed reactor in operation. For instance, it was found, on the basis of successful experiments on the KRITO critical assembly, that the control rod design needs revising. A way of incorporating UB_4 as a burnable poison in the fuel pellets has been developed and will be adopted if research in 1967 demonstrates that under irradiation this substance retains its calculated effect on the excess reactivity of the core.

A study has been initiated, in collaboration with the Fiat company, to develop a computer code for calculating core burn-up from a burnable poison embodied in the fuel in particle form. To that end an RCN method of employing these paticles to calculate neutron absorption, which diminishes as a function of time, will be incorporated in the Fiat code for determining core life.

The NEPTUNUS experimental rig for studying pressurizer performance is now completed. Testing went ahead on this and the other big experimental rigs constructed in previous years and now in operation; final results of this experimental research will be known in 1967.

An order was placed by RCN for a prototype primary pump designed by the Stork company as sub-contractor; a series of tests will be carried out under the association contract with Euratom.

At the end of 1966 ten publications were issued on the work covered by this contract; they consist of two main reports providing a general outline of the project and a progress report on the research work, and eight specialist reports giving details of specific studies. Two of the latter describe the PUK and KRITO subcritical and critical assemblies; four others deal with core physics calculations relating to neutron flux distribution, the effect of a burnable poison, heat transfer and coolant flow, while the remaining two illustrate a digital method for calculating the heat exchanger and an analysis of fuel cycle costs.

III. Association contract with Fiat-Ansaldo

Publication in January 1966 of the intermediate project for a nuclear-propelled oil tanker marked an important stage in the performance of the contract. During the year the accent was on efforts to obtain more detailed data on certain major parameters or to plan certain variants to the solutions adopted for the intermediate project.

As regards the nuclear part, experimental research was mainly directed to measurement of the drop time of a control rod mock-up, development of a method for welding stainless steel or Inconel tubes, the steam generator tube plates and the redistribution of coolant flow in the core channels. Burn-out heat flux measurements continued on the SORIN 600 kW loop at Saluggia.

The theoretical and experimental results of this latter line of research were given in four papers published by Euratom. The applicability of various correlations between the burn-out heat flux and the thermohydraulic parameters was evaluated for uniform and non-uniform power distributions. Furthermore, theoretical and experimental studies of burnable poisons were made in collaboration with RCN. The main lines of enquiry concern calculation of the self-shielding factor and how it changes during irradiation of the fuel. Theoretical studies were devoted to the thermohydraulic stability of the steam generators when subjected to big variations in inclination, and the improvement of nuclear codes.

As to the marine part, research centred on the supporting structure for the safety containment and its mounting in the ship, along with problems relating to the automation of the propulsion unit. The solutions adopted for the intermediate project nuclear tanker were reported at the International Symposium on Automation in Shipping held at Genoa in June 1966.

An overall evaluation of the results will be possible at the end of the contract, which has been extended until the end of 1967.

IV. Collision tests (performed under contract of association with Fiat-Ansaldo)

The sixth collision test was carried out at Naples in April 1966, using the same test-rig as for the five previous tests in 1963-1965.

This time two new factors were introduced. For the first time the circumstances of a real collision between two tankers were reproduced as they actually occurred; since the tankers in question were smaller than the projects on which previous tests were patterned, the scale of the rammed and the ramming models was increased to 1/10 instead of 1/15 so as to make them correspond more or less to those used in earlier tests as regards dimensions and plating thickness. The second new factor was that the ramming ship struck the other at an angle of approximately 76 degrees, which necessitated fixing the rammed model on the test-rig at the appropriate angle. Modifications were therefore necessary and these were carried out with the consent of CNEN, who own the test-rig.

This test revealed a very close resemblance between the actual and the simulated collision as regards damage to the bows of the ramming ship, but the extent of the damage to the rammed model was less than in the actual collision.

A seventh test was arranged, with the rammed model rigidly fixed on land, in order to check whether fixing the rammed models to a bogey equipped with devices to simulate the effect of the water's resistance on a vessel displaced laterally as a result of a collision constitutes an acceptable method. This experiment was performed in July 1966 with similar models to those used in the fifth test. The circumstances of the collision were the same. The damage caused to both was practically identical, which suggests that the "semi-floating" method does not yield distorted results.

Later in the programme it is planned to simulate a collision in which the rammed vessel also has way on.

Information exchanges with the German Kernenergiegesellschaft study group continued throughout 1966 and will be kept up in 1967.

V. Shielding tests (contract of association with the Gesellschaft für Kernenergieverwertung in Schiffbau und Schiffahrt mbH - GKSS)

Theoretical and experimental studies were again carried out at the Geesthacht research centre. During the last quarter of 1966, the reactor was stopped so that work could begin on raising its output to 15 MW.

Measurement of the absorbent properties of laminated screens made of hydrogenated materials and iron or lead in varying proportions continued on the ESTAKOS facility with a view to determining the best ratios by volume.

Research is going ahead on ESTAGROP-1 into neutron and gamma ray propagation in right-angle elbow tubes 5-10 cm in diameter immersed in water or sunk in concrete. The ESTAGROP-2 unit could not be used owing to alterations being made to it.

The principal advances in radiation detectors were the development of a liquid-nitrogen-cooled Ge(Li) semi-conductor detector for gamma-spectrometry and further experiments on a semi-conductor sandwich detector for fast neutron spectrometry.

The chief items of theoretical research concerned the optimization of marine reactor shielding, the Monte Carlo method of calculating shielding penetrations and the development of the MUTRAP transport code for the study of plane laminar configurations.

Detailed reports on this work are published by Euratom annually.

VI. Mechanical tests on marine reactor parts (contract of association with the Gesellschaft für Kernenergieverwertung in Schiffbau und Schiffahrt mbH - GKSS)

Mechanical tests were carried out in 1966 on reactor parts for the "Otto Hahn".

On the vibrating bench at Geesthacht a dummy fuel element was subjected for 200 hours to vibration similar to that produced by a ship's engines. The trials showed the rugged design of the fuel elements to be fully satisfactory.

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Mounting of the vessel intended to contain the reactor control rods on the rolling-rig was delayed as acceptance tests at 91 atmospheres had shown that certain parts needed to be modified. Problems relating to the thermal insulation of the vessel have been solved and testing will begin early in 1967.

DOCUMENT No. 13 MATERIALS - TESTING REACTORS

I. The BR-2 test reactor

The BR-2 materials-testing reactor at Mol, in Belgium, has been operated since 1963 by Euratom and the Belgian Nuclear Study Centre (CEN) at its rated specific power. The third configuration of the reactor core, loaded with 26-28 fuel elements, was retained in 1966, this system giving the reactor an output of 57 MWth at a rated specific output of 400 W/cm^2. The maximum neutron flux reached in the reactor is $8.6 \cdot 10^{14}$ $n/cm^2/sec$.

The reactor operated at full-power for 220 days during 1966 (192 in 1965), 122 days being taken up by servicing, fuel loading and inserting the experimental charge. The reactor had to be shut down for 22 days owing to minor incidents and xenon poisoning of the core. The average burn-up of the fuel elements was raised to about 37% in order to achieve more economic operation of the reactor.

The services supplied by BR-2 and its connected laboratories in 1966 showed an increase of about 30% on the previous year, 90% of them being used for programmes run by the Community and the Member States (70% in 1965).

With the aim of standardizing irradiation devices and rationalizing their manufacture, two in-pile furnaces — known as CHOUCA and COBRA — developed by the CEA for the CEN Grenoble reactors were adapted for the BR-2 and were used for the irradiation of cladding materials.

A structural materials irradiation programme is under way for the fast reactor project being conducted by the GfK at Karlsruhe in association with Euratom. A high-temperature high-pressure gas-cooled loop was put into service for Siemens and was used for the irradiation of fuel elements and structural materials. Fuel elements were irradiated at 1000°C for the KfA's THTR project at Jülich. In addition, the very-high-temperature gas loop built for the DRAGON project was employed for in-pile studies of mass transport phenomena in graphite swept by helium containing given percentages of impurities. Numerous irradiations of fissile materials, in particular mixed plutonium and uranium oxides, were carried out, as well as the irradiation of structural materials used for basic research, either in irradiation devices such as the boiling-water capsule or in the hydraulic conveyor. As in previous years, work was continued on the production of radioisotopes such as cobalt-60, iridium-192, etc.

Of 131 new irradiation devices placed in the reactor in 1966, more than two-thirds were built under the supervision of the technology department. A device was designed for carrying out uniform neutron doses on all samples, as well as for cycling. A new hydraulic conveyor, known as HR-2, together with a thimble for irradiations of varying duration, was installed in the reactor.

In the BR-02 reactor, the zero-power version of the BR-2, numerous measurements were carried out to check the MFB-3 loop and Babcock calculation codes and for dosimetry on a model.

The very-high-activity hot cells were used for dismantling 180 irradiated devices, some of which were filled with NaK. The lead cells were occupied for 2673 hours for mechanical tests, metallographic examinations and physical and hardness measurements, as well as for heat treatment of irradiated samples. Among other things, about 700 samples of steel and fissile materials, e.g., UO_2-PuO_2, coated particles and graphite pellets containing uranium carbides, were handled by remote control.

The 1000 C cell used for americium treatment was converted into a polyvalent cell so that it could be used for fission gas release tests, sectioning fuel pins, carrying out dimensional measurements and dissolving fissile materials.

II. The HFR reactor at Petten

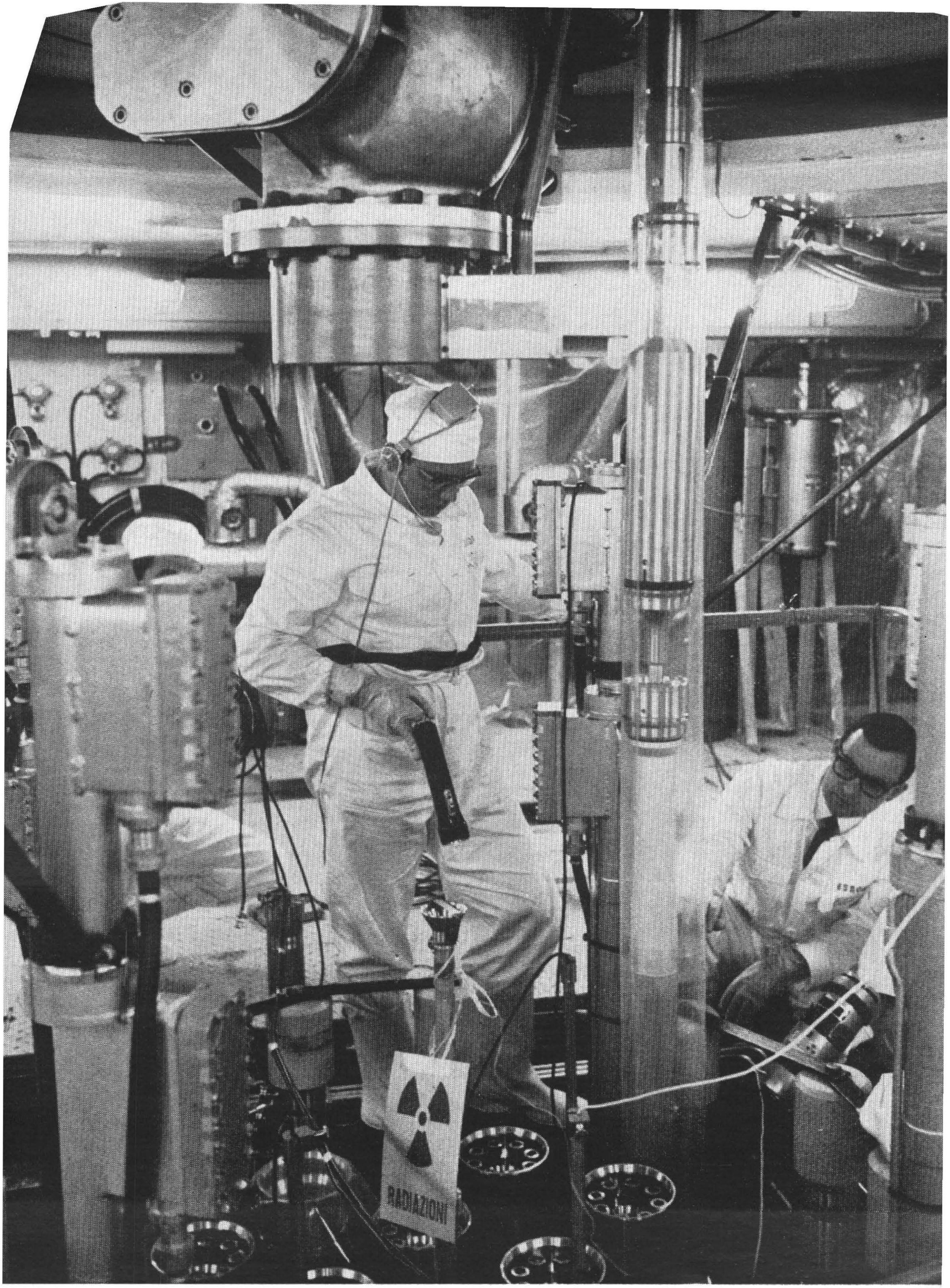
The HFR reactor continued to make a major contribution to the irradiation programmes of the Member States and the Euratom Commission.

Its power was stepped up from 20 to 30 MW, and it operated mainly for the Reactor Centrum Nederland and the CEA.

The occupation of the reactor's irradiation devices reached 70% during 1966, and through the increase in the reactor's power the irradiation facilities in the HFR will be improved even further in the future.

The hydraulic studies were continued both in the reactor and in the hydraulic test loop set up in the technology hall.

In addition, very effective collaboration was maintained with the RCN in order to study means of increasing the number of positions in the reactor, which led to an improvement in the fast and very fast fluxes at thermal rates.



ISPRA (Italy) — VIEW OF UPPER SPACE OF ESSOR REACTOR

(See other side of page for caption)

This space can only be entered when the reactor is shut down. It is used for observing loading operations. Two technicians inspect the insertion of a driver element, which slides into one of the reactor channels through an opening in the rotating section of the shielding base.

In the reactor hall, the post-irradiation operating working group put into service a dismantling cell which has helped to improve the handling of irradiated devices considerably. The bulk of this group's work is in connection with activities of interest to clients for irradiations in the HFR.

In the field of capsule fabrication and development, work was carried out, as in previous years, for outside clients and for internal users. Work on the development of new capsules and the improvement of existing types was also pursued. This bore mainly on:

— the attempt to improve the performance of the capsule at present available for irradiations on the swimming pool side;

— the development of a fully reloadable device for irradiating structural material at high temperature;

— the conceptual design of a device for evaluating clad particles for testing the performance of loose-coated particles at extreme temperatures.

As a result of the creation of a new laboratory for materials testing and for studies of mechanical properties, examinations could be carried out on the homogeneity of several graphite-containing industrial materials in an attempt to select representative samples for irradiation.

Finally, a number of more basic studies were successfully completed in 1966, ranging from studies on molten salts, physical chemistry and electrochemistry to research into surface emissivity.

DOCUMENT No. 14 PLUTONIUM AND TRANSPLUTONIUM ELEMENTS

I. Plutonium

The Commission's activity in this field has been twofold — direct, at the Transuranium Institute with fast reactors as the main target, and by contract, relating, this year especially, to plutonium recycling in light-water reactors (see Doc. 1).

Fast Reactor Work at the Transuranium Institute

Results achieved by the laboratories in operation included:

— The fabrication of composite fuel assemblies based on mixed UO_2-PuO_2 oxides, for irradiation in the ENRICO FERMI reactor.

— The fabrication of elements for the MASURCA critical experiment. A total of 2100 rods of uranium-plutonium-iron alloys utilizing 175 kg of plutonium were fabricated in nine months. These elements, which satisfied the stringent acceptance conditions imposed by a critical experiment, were delivered to Cadarache just as the rig for which they were intended was reaching completion.

— Basic research: the Transuranium Institute began contributing substantially to the study on the U-Pu-O system phase diagram (taking part in the International Atomic Agency's Panel on this subject). Vapour pressure measurements are being effected on the same compounds and interesting results have been obtained with the PuO_{2-x} oxides. Precise heat conductivity measurements in the 20-800°C range yielded values that can be interpreted coherently.

The alpha-gamma laboratory, which will undoubtedly soon constitute one of the Institute's main facilities, has come into operation. Pending the arrival of the fast reactor fuel elements currently being irradiated, elements from the light-water reactor at Kahl are being examined and analyzed; in particular, preparations are being made to measure plutonium and uranium concentrations along the rods by chemical analysis.

Work has begun on the irradiation programme. A device designed to attain high burn-ups rapidly is already in the BR-2 reactor; the fuel elements for ENRICO FERMI are being held in abeyance until the reactor has been overhauled. Fast reactor pins for irradiation at Dounreay are being prepared.

Current work and research includes the development of equipment for fabricating vipacked UO_2-PuO_2 elements and the start-up of a small-scale line for fabricating mixed (U, Pu)N nitrides. Good progress has also been made with the process for fabricating small PuO_2 pellets of controlled density by a sol-gel method.

Thermal Reactor Work at the Transuranium Institute

A cheap process for fabricating vibratable powders with homogeneous plutonium distribution is currently being developed. No major effort has been devoted to this research, however, for lack of a Euratom-partnered project.

II. Transplutonium elements

The processing of 3.4 g of americium-241 irradiated in BR-2 has already started in one of the chemistry cells in the alpha-gamma laboratory. In addition, 20 g of americium have been made ready for irradiation in the same reactor.

DOCUMENT No. 15

CENTRAL NUCLEAR MEASUREMENTS BUREAU

I. Neutron data measurements

In 1966 the CNMB programme for the measurement of microscopic neutron data was continued along the lines recommended by the European-American Nuclear Data Committee and the Community's panel of experts. This programme is aimed at satisfying major requests from nuclear physicists and reactor designers for new or more accurate data.

1. *Linear Accelerator*

During the months of January, February, March, July and August, the electron beam deflection device of the linear accelerator was adjusted and tested, while attempts were also made by the manufacturer to increase the beam power considerably, resulting in projects for improvements.

The accelerator was continuously operated during the periods April to June and September to December for neutron data experiments, running for a total of about 2200 hours without any serious breakdowns, the electron beam characteristics being kept within the limits guaranteed by the manufacturer.

High-resolution neutron data experiments were performed in the resonance region, in particular, measurements of the total cross-section of Pu-240, fission cross-sections of U-235 and capture cross-sections of Mo. In connection with this, new detector systems were developed and considerable improvements made to the electronic equipment. Total, fission and capture cross-section measurements are under preparation for U-233, U-235, Pu-240 and Pu-241 as well as measurements of important reference cross-sections.

In association with a group of physicists from CNEN (Casaccia) the first results of determinations of resonance spins were obtained. The method used is based on a change of the multiplicity of the gamma-cascade with spin.

In association with CEN (Mol) an attempt to carry out spin measurements of resonance levels in fissile nuclides was undertaken. The method is based on a precise measurement of the ratio of binary to ternary fission.

Data handling at CNMB and the teleprocessing to CETIS (Ispra) of data obtained from neutron measurements could be improved considerably by the provisional installation of an IBM 1401 computer.

The first results of data measurements on the linear accelerator were published or submitted for publication.

2. *Van de Graaff Accelerator*

Cross-sections for the following neutron-induced threshold reactions were measured using the activation technique:

— ^{60}Ni(n,p)^{60}Co and ^{63}Cu(n,α)^{60}Co in the neutron energy range 6-20 MeV;

— ^{103}Rh, ^{107}Ag, ^{113}In, ^{127}I, ^{133}Cs and ^{141}Pr (n,3n) reactions in the energy range 18-20 MeV.

The capture cross-section for the ^{59}Co(n,γ)^{60}Co reaction for the ground and isomeric state was determined at certain energies between 2 and 4 MeV.

Many angular distributions were measured for elastic and inelastic scattering on ^{7}Li between 1 and 2.3 MeV and on Si between 4 and 6 MeV neutron energy, as well as for elastic scattering on ^{6}Li between 1 and 2.3 MeV. Angular distributions of the emitted neutrons from ^{14}C(d,n)^{15}N and ^{15}N(d,n)^{16}O were also determined, both reactions being used as neutron sources between 8.5 and 11.5 MeV for threshold reaction measurements.

Several papers on neutron data obtained with the Van de Graaff accelerator were published, while others are in preparation, the data still being in the course of evaluation. The well-known compilation of cross-sections for neutron-induced threshold reactions was kept up-to-date and several new reactions included, resulting in an expansion taking up two volumes.

3. *Thermal Neutron Measurements*

Under a programme on reference data, high-precision measurements were performed in association with CEN (Mol) on the branching ratio of the ^{10}B(n,σ)^{7}Li reaction as well as on the Q-values of this reaction and of the ^{6}Li(n,α)^{3}H reaction. The results are ready for publication.

A completely automatic apparatus was built and tested for very precise intercomparison in a neutron beam of thin boron foils, which are used as reference samples in neutron measurements.

Preliminary experiments for a precise determination of the thermal fission cross-section of U-235 and Pu-239 relative to the $^{10}B(n,\alpha)$ cross-section were carried out.

II. Absolute measurements on radionuclides

As part of an international intercomparison of the use of threshold detectors, about 50 sets of Ni, Ti, Fe and Cu standard detectors were distributed to the Community's reactor centres and to the IAEA, Vienna, for limited distribution outside the Community. After irradiation they will be measured absolutely by CNMB and sent back to the participants together with sets of pure standard sources of Sc-46, Mn-54, Co-58 and Co-60.

Calibrated alpha, beta and gamma sources were prepared both for internal use and for outside laboratories.

In the course of this work, the counting equipment and counting methods were improved considerably.

The following data, pertaining to decay schemes of nuclei of interest to nuclear energy, were determined:

— fluorescence yield of Cr and Cl

— γ-branching of Kr-85

— conversion coefficients of Cs-137, Ce-137 and Hg-203

— branching ratios of Zn-65

— branching ratios of Cs-137

— Tl-204 half-life by microcalorimetry

— U-234 half-life

— branching ratio of Nb-95.

A dozen publications resulted from the studies on radionuclides, of which five were presented at the IAEA symposium on standardization of radionuclides (Vienna, October 1966).

III. Determination of isotope ratios of stable and fissile nuclides

The Bureau has completed a thorough study of the errors involved in precise isotopic composition measurements on boron, resulting in a final absolute definition of the CNMB boron isotope standard, which is now certified as (19.824 ± 0.020) atom % ^{10}B. In connection with this, the samples used in earlier measurements could now be defined absolutely, yielding a new value of (3836 ± 7) barn for the thermal neutron absorption cross-section of ^{10}B. The results are being published.

The chemical research preliminary to the establishment of an accurate lithium isotope standard is nearly finished. The heavy water standard intercomparison yielded a spread of about 0.02 mol % D_2O in the analysis results of the participating laboratories. A second intercomparison is under preparation. Research on the D/H ratio and on oxygen isotope analysis has been continued.

As a result the absolute measurement of the deuterium content in heavy water is now possible to within 0.003%.

Many solid and gaseous samples were analyzed by mass-spectrometry for outside laboratories.

IV. Sample preparation and assaying

CNMB continued its task to prepare and assay precision samples for nuclear measurements. A total of 7220 samples (spread over 164 different applications) were prepared and assayed, i.e., about three times the 1965 figure.

The preparation and analysis of U and Pu samples should be especially mentioned. The majority of the sample preparation facilities have been installed in glove boxes. Preparation techniques as well as methods for defining the samples precisely with respect to their isotopic and chemical composition and their physical properties were further improved.

Several of the ultra-high-vacuum balances (accurate to within about 1 μg) developed and built by CNMB were used for various purposes.

The efforts in sample preparation and assaying resulted in several publications.

V. Relations with national and international organizations

The coordination of measurement programmes at CNMB and in the Community was continued in cooperation with the Euratom Joint Nuclear Data and Reactor Physics Committee and the European-American Nuclear Data Committee. The Standing Subcommittee on Standards required for neutron measurements has stirred much interest in better standards for neutron data measurements. Further close contact was maintained with national and international standards laboratories. Plans for collaboration in neutron and gamma dosimetry were prepared.

An International Nuclear Data Committee meeting organized by the International Atomic Energy Agency was attended by a CNMB member.

Several papers were read at conferences organized by the IAEA, especially on the subject of standards for neutron data measurements (Paris, October 1966) and radionuclide counting (Vienna, October 1966).

DOCUMENT No. 16 REACTOR AND NEUTRON PHYSICS

1. *SORA study*

The SORA pulsed reactor study, which started early in 1962, was continued in the Reactor Physics Division with the assistance of some of the Ispra Establishment departments, in particular the Technology and Heat Exchange Departments and the General Studies and Radioactive Engineering Section. In March a condensed report entitled "The SORA Pulsed Fast Reactor" was prepared for submission to the Commission. The aim of this report, which contains a detailed description of the SORA reactor, is to keep the Commission abreast of the development of ideas in the field of intense neutron sources.

Two particularly important meetings were devoted to the examination of intense neutron sources for physics experiments. The first, held in July at the Dubna (USSR) Research Centre, was arranged by the International Atomic Energy Agency; the second, which took place at Los Alamos (USA) in September, was organized jointly by the ENEA and the USAEC under the sponsorship of the EACRP and the EANDC. The SORA reactor was a major focus of interest at both these meetings, whose joint findings as regards the SORA programme were as follows.

In many fields of neutron physics, and especially inelastic scattering, neutron fluxes of greater intensity are required. The only technically feasible ways of meeting this need in the immediate or near future are pulsed reactors and in the more distant future pulsed reactors and spallation machines. A 1 MW pulsed reactor compares favourably with a 70 MW steady-state reactor in major sectors of neutron physics. The construction of a 1 MW pulsed reactor opens up the way for a vast research programme in the fields in which such performances are already acknowledged as being superior to those of steady-state reactors and will at the same time act as a test bed for the development of new experimental techniques and more high-powered devices.

Work has continued on the SORA reactor critical experiment being carried out at Oak Ridge under a contract concluded between the USAEC and the Commission. The statistical studies provided for in the programme laid down in the "Memorandum of Understanding" signed in May 1965 were completed in the course of the summer. The USAEC intends to pursue and extend this programme, using Euratom's SORA mock-up. The Oak Ridge Centre has constructed a rotary pulsation device with which the pulse characteristics can be measured directly. At the time of writing, these experiments are scheduled for early 1967. Detailed comparisons of the experimental values with the calculations made at Ispra strengthened confidence in the SORA reactor concept while at the same time enabling the basic methods and data used in this project to be improved still further.

The first few series of cold source optimization experiments on a mock-up, to which reference was made in the Ninth General Report, were completed. The results served to corroborate the concepts underlying the cold and thermal neutron source design. Among the other investigations continued in 1966 were studies on the shut-down rod mechanism, mechanical studies on the reactor vessel and thermal studies on the reflector, which were conducted in cooperation with the Engineering Division.

2. *Neutron Optics*

Below is a summary of all the activity relating to installations and experiments using neutron beams.

With the aid of the cold neutron installation, the programme of research into the dynamics of the impurities and absorption phenomena was continued. Measurements were carried out on TaH(1-3% H), and experiments on the absorption of hydrogen, methylene and acetylene by carbon were performed.

The rotary crystal spectrometer was in service throughout the year for elastic measurements on the ferroelectric transition point of KH_2, PO_4 and KD_2PO_4. Measurements on the Debye-Waller factor on hydrogen in niobium and vanadium are now in progress.

As part of a broad-based experimental programme, the polarized neutron installation was used for measuring the circular polarization of neutron capture gamma rays in the case of Al, Cl, K, Cr-54, Cd and Pb.

The programme of tests with the double velocity selector was completed and all the major parts installed in the ISPRA-1 reactor. The experimental programme will be able to start up after acceptance of the installation by the Safety Committee.

As regards the cold source, the helium cooling device was fitted up and successfully tried out. The cooling power achieved was in accordance with the specifications. Installation of the cold source is proceeding.

The experiments with the Van de Graaff accelerator for optimizing the geometry and material composition of the various cold neutron sources for SORA were completed. A new method, using the single crystal technique, was developed for monoenergetic neutron decay experiments and measurements were carried out on H_2O and H_2O/D_2O mixtures. Further preparations were made for studies on the asymptotic neutron spectra of hot moderators and experiments are now under way.

As regards the development of experimental techniques for pulsed sources, such as the SORA reactor, various techniques for studying neutron diffraction by powders and samples of single crystals have been considered. Proposals for diffraction with and without polarized neutrons were drawn up. Various methods were developed for studying the inelastic scattering of neutrons by solids and liquids. A study is in progress on the production of polarized neutrons of energies ranging from thermal energy to several keV.

3. *Shielding*

In the field of radiation and shielding physics, work was continued on the theoretical and experimental studies. In particular, the Fourier transform technique applied to the Boltzmann equation provided analytical solutions which can be used as a basis for drawing up a programme for the calculation of neutron doses in laminated shields.

The BIGGI-3 and 4 photon transport programmes were completed and tested. Preparation of the handbook for the use of this system has now been finished. Work is being carried out on the extension of the same calculation process to neutrons.

The SABINE programme for the assessment of neutron and gamma doses with the aid of an improved displacement-diffusion theory was completed and tested.

The series of measurements carried out at the University of Padua on removal cross-sections have given the cross-sections for iron, lead, coal, aluminium and terphenyl in an energy range from 0.5 to 8 MeV. These experimental cross-sections are being used in the SABINE programme.

The stacking factors for gamma rays emitted by a monoenergetic point source (1.3 MeV) were measured for several thicknesses of concrete.

In the ISPRA-1 reactor, assembly of the EURACOS irradiation device has been concluded. The technical tests and neutron-free start-up were satisfactory.

4. *Theoretical and Experimental Reactor Physics Studies*

The studies on the dynamics of moderators in the liquid phase resulted in the setting up of a model (hindered translator model), which enabled a detailed analysis to be made of the correlation between the dynamics of the individual particle and the differential neutron scattering cross-section.

A start was next made on analyzing the connection between the standpoint based on the microscopic dynamic model and that based on the master equation for the autocorrelation function of velocities in liquids.

A preliminary analysis of the dynamics of the protons in the hydrogen bond was made in order to have a basis for interpreting pulsed neutron measurements in water and in light-water/heavy-water mixtures at the temperature of liquid nitrogen.

The theoretical research on the neutron transport equation was concentrated on the basic study of its structure, the aim being to incorporate it in a general theory covering all transport phenomena.

A systematic study of the problem of the decay of a neutron pulse in a finite crystalline medium was commenced. Pulsed experiments in beryllium were interpreted with the aid of a new method which uses zero and first-order time moments of the time-dependent flux in the Boltzmann equation.

As regards the numerical solution of the Boltzmann equation, work on the j_N (multiple collision method) and statistical (TIMOC programme) methods has been continued with careful comparison of the two techniques for a fairly large number of practical systems. In addition, these two methods have been extended to the calculation of problems relating to the time-dependent slowing-down of neutrons and transient processes for one- and multigroup systems. Several computer programmes were added to, namely, CYLAN (calculation of anisotropic collision probabilities), S_N-THERMOS (the same as THERMOS except that the transport kernel is calculated by a collision probability programme called TIJ) and SNID (a multigroup one-dimensional SN programme in FORTRAN-4 language).

The final adjustments were made to the PETARD code for calculating resonance absorption by the collision probability method in a multigroup and multiregion formalism. The method has been used for the study of the 6.7 eV resonance of uranium-238 in cylindrical rods.

Theoretical studies on Pu-240 resonances are in progress.

The phenomenological model (TERMIDOR code) was improved to take account of the spectrum effects due to the thermal resonance of Pu-239. The

TFS (Thermal Flux Synthesis) code, which calculates the neutron spectrum in a heterogeneous medium by means of an iterated variational method, was developed and tested in a series of typical reactor cell cases.

A method of calculating reactivity for Pu-H_2O lattices was developed jointly with SNAM, under contract No. 072-65-11 TEEI; the modification and amalgamation of the GAM-2 and THERMOS codes are nearing completion.

5. *Reactor Calculation*

In the field of reactor dynamics, the one-dimensional cylindrical version (R) of the COSTANZA code was finalized. This code is used for the space-time solution of neutron diffusion equations coupled with thermohydraulic channel calculations. The study was undertaken aimed at the introduction of thermohydraulic calculations with boiling coolant into the code. An (R)-geometry version of the COSTANZA code will enable azimuthal xenon instabilities to be studied. There is also an axial version for the study of temperature instabilities.

A comparative study of various methods (finite differences, harmonic development, etc.) was carried out.

By these calculation methods it is possible to determine the variation in time in the propagation of the heat which passes from the fuel to the coolant. A new nodal method for space-time dynamics was developed further in plane and cylindrical geometry.

As regards fuel cycles, investigations have been conducted into the extent of fission product chains, for which purpose the BO code was written.

Modifications were made to the GAFFEE continuous loading/unloading burn-up code in order to introduce self-shielding factors as a function of the composition.

A code was written for studying the analytical resolution of evolution equations with self-shielding factors variable in time.

An automatic system was developed for calculating self-shielding factors (WRETCH code).

The BACCHUS continuous loading/unloading burn-up code was completed. The thorium fuel cycles with U-235 make-up were studied for ORGEL (which see) and HTGR reactors. An evaluation of the feed and breed cycle and the use of plutonium make-up is being carried out.

DOCUMENT No. 17 THE CETIS COMPUTER CENTRE

I. Equipment

The new computer operation programmes (utilization statistics, accounting, etc.) are now in service. They will be used to set up, *inter alia,* an analytical accounting system based on budgetary heads.

As regards renewal of the digital computers, the IBM 360/65 and IBM 360/30 systems were installed during the last quarter of 1966. It is planned to operate them alongside the IBM 7090 until the end of July 1967.

Now that an IBM 1401 has been installed at the Geel establishment, teleprocessing is carried out by direct line using magnetic tapes.

A new facility has been offered to people interested in using the analog computers, in that they can now make full "open shop" use of the machines (including operation). As a result the CETIS analysts and analog technicians have been increasingly busy with advisory work.

A special effort was made to utilize the electronic computing, applied mathematics and programming potential wherever research or association contracts called for calculating work compatible with the CETIS facilities.

II. Activities

Work at CETIS has developed in two complementary directions — collaboration with the Commission's departments or contractual partners in scientific and administrative uses of automatic computation, and CETIS' own research and development work in mathematics, new computer uses, system programming and automatic documentation and translation.

Collaboration with the departments has been close, covering a wide variety of activities that included the complete dynamics calculations for a 250 MWe ORGEL power plant, mathematical and computing work for reactor safety studies, the solving of various thermonuclear fusion problems, analysis and programming of the new EAEC/EEC pay-slip process and the analysis of an integrated automatic system for operating the library at the Ispra establishment, which can serve as a pilot system for all the Institution's libraries.

CETIS' own activities included, as to mathematics, work on functional analysis, numerical analysis (including collaboration on the SHARE organization's Numerical Analysis Project), methodological statistics and probability, systems verification and optimization, and development of mathematical methods in physics.

Examples of work in the last-named sector comprise problems of fluid dynamics, more especially shock propagation and the interaction of different media, the study of certain stochastic models in relation to the response function of semiconductor detectors, determination of the eigenvalues and eigenmodes of differential linear equations concerning elasticity problems, and analysis of numerical methods for "unfolding" spectra by means of integral detectors.

With regard to new computer uses, hybrid computer techniques involving parallel logic circuits were developed, and as a result a hybrid extension to the analog computers, known as SIOUX-4, was built. A start was made on the study of the possibilities offered by real-time access to a central digital computer via distant interrogation consoles, and of the problems attaching thereto. With this in view a compiler programme was written, named LICE, for a pilot experiment with the IBM 360/65 machine.

In system programming, the new version of the SAHYB programme (for IBM 360) for simulating dynamic systems and problems in general that can be processed on analog and hybrid computers, was planned and drawn up. A fresh section of the APACHE system (MODIFY) was written and tested. Work began on the theoretical study of the future APACHE for use with the new generation of analog and hybrid computers. The structure of the CARONTE system, for the automatic execution of a predetermined nuclear code sequence, has not yet been adapted to the new IBM 360/65 computer, but part of it has already been tested on the IBM 7090.

Operation of the computer programme library necessitated a considerable effort to ensure a trouble-free change-over to the new installation. Most of the work consisted in preparing numerous utility programmes and nuclear codes, together with critical analysis and comparative studies of the scientific subroutines. Of the nuclear codes, 48 have been translated from FORTRAN-2 into FORTRAN-4 and are now being adapted for the IBM 360/65.

In addition, CETIS has kept up active collaboration with the ENEA nuclear programme library (OECD) installed on its premises.

In the automatic documentation field, intensified research on association factors led to the defining and testing of several new types of factor. An experimental system of automatic key-word assignment is being set up.

Collaboration with the CID continued. A lengthy study involving a statistical comparison of the key-word assignments performed by two different teams (CID, USAEC) using the same thesaurus and indexing rules yielded useful pointers for current indexing work and made a major contribution to an evaluation of the CID information retrieval system.

The work on automatic translation dealt mainly with the defining of the structure of the new Russian/English translating system so as to take into account the potential of the new installation and also an extension of the dictionary from 35,000 to 200,000 words. This means completely recasting the procedure (list processing techniques, use of discs, etc.). The analysis part has been finished, including the new SLC language concept.

Tables 1 and 2 show, respectively, the use in hours of the various computers and the percentage breakdown according to user category, for the period 1 January to 30 November 1966.

Table I

JANUARY - NOVEMBER 1966

	IBM 7090	IBM 1401/1	IBM 1401/2	IBM 360/30 [1]	PACE 231 R [2]
Power-on time (in hours)	5184.76	4753.42	3849.76	660.94	3850.16
Use time (in hours)	4832.86	3725.97	2618.03	476.28	3524.19

[1]) This computer was installed in September. The figures refer to the period September-November 1966.

[2]) The figures relate to the whole analog installation, consisting of three PACE 231 R consoles.

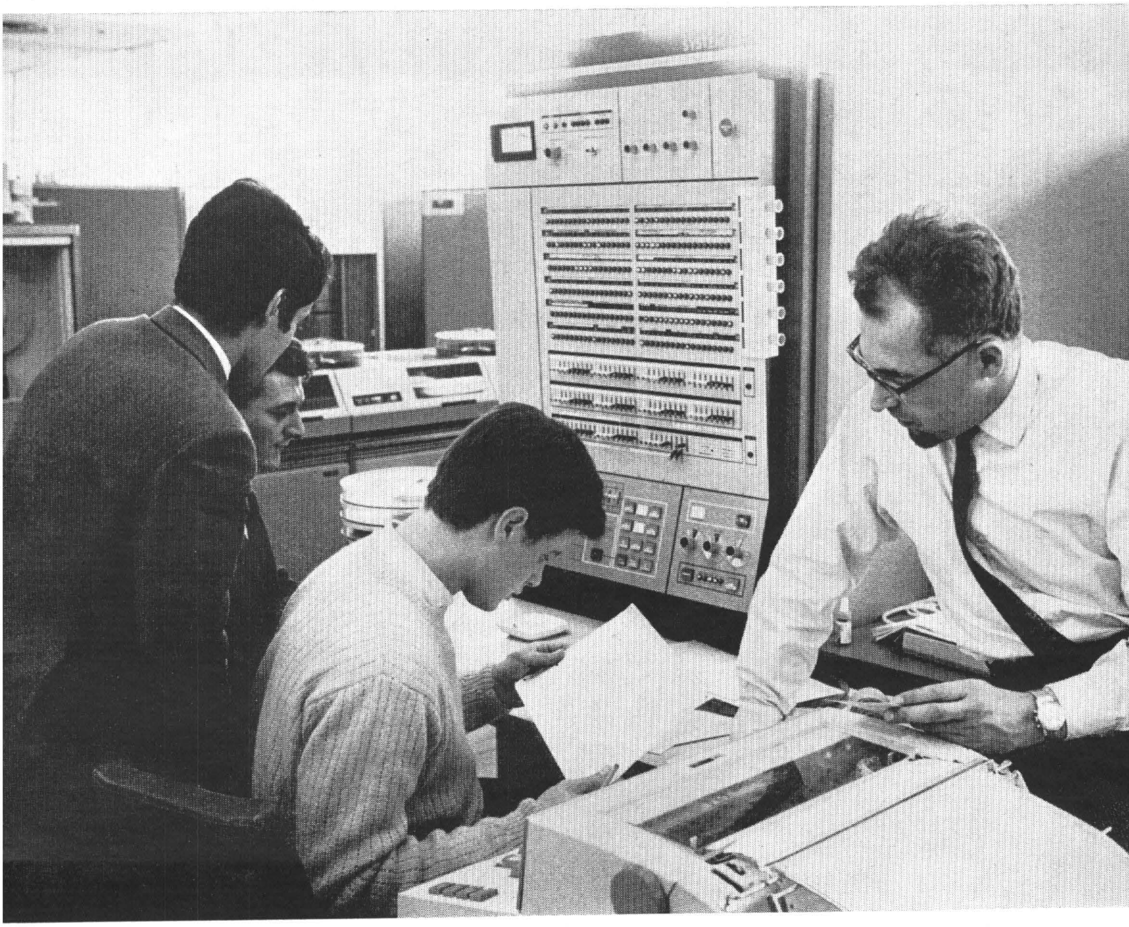
Table II
COMPUTER UTILIZATION ACCORDING TO USER CATEGORY (IN %)

A - "Closed Shop" Work [1]	IBM 7090	IBM 1401/1	IBM 1401/2	IBM 360/30	PACE 231 R
1) *Computer, operation and maintenance* (input-output, training, start-up, demonstrations, engineering changes, servicing, etc.)	12.03	89.83	25.93	27.58	17.36
2) *Operation of programme library and testing of programming systems*	7.49	0.56	3.48	21.83	—
3) *Computation services*					
a) for Euratom scientific and technical departments and Euratom contracts	8.28	0.60	5.05	2.34	55.52
b) for Ispra JRC administrative departments	1.91	0.38	29.66	29.35	—
c) for administrative departments of Euratom Head Office	1.40	0.30	2.92	1.08	—
d) for the European Communities' Statistics Office and the other Communities	3.36	0.79	3.15	1.62	—
4) *CETIS' own research* (system programming, numerical analysis, nuclear codes, hybrid computing, automatic documentation, special analog processes, etc.)	7.70	0.29	11.12	8.29	1.83
B - "Open Shop" Work [2]					
1) *Work for Euratom account*					
a) Reactor Physics Department	35.80	4.30	5.40	0.18	7.41
b) Engineering Department	1.23	0.39	1.09	0.21	6.10
c) Chemistry Department	0.87	0.01	0.04	0.08	—
d) Other scientific and technical departments of the Ispra JRC	1.52	0.23	0.46	0.09	—
e) ORGEL project [3]	4.96	0.10	0.49	0.35	—
f) Head Office and other establishments	3.88	0.85	3.90	0.39	—
2) *Work for outside account* (universities, nuclear research centres, scientific institutes, private firms, etc.)					
a) service-rendering contracts	1.31	0.04	0.37	0.04	10.87
b) research contracts, contracts of association or special agreements	6.46	1.19	0.43	0.05	0.91
c) ENEA programme library	1.80	0.14	6.51	6.52	—

[1] The term "closed shop" means computer work carried out by CETIS for the solution of problems referred to it by outside customers or arising from research covered by its own programme. This latter work is listed under Item 4.

[2] By "open shop" is meant computer work carried out by outside customers themselves, only the computer time and operation being provided by CETIS.

[3] The computer work carried out on behalf of the ORGEL Project by the JRC departments is included in the percentages relating to those departments.



ISPRA (Italy) — SCIENTIFIC DATA PROCESSING CENTRE (CETIS)

(See other side of page for caption)

The Ispra Centre is equipped with a number of electronic computers for processing the numerical and non-numerical problems arising in the departments of the Centre and elsewhere.

View of the control console of the IBM 360-65 computer.

DOCUMENT No. 18 BIOLOGY

Since the revision of the second five-year programme, the Commission's activities in this field have been confined to the bare essentials of the programme as laid down in previous years.

Intensive studies of the toxic effects of radioisotopes have continued to be carried out under contracts of association covering various complementary aspects of the problem. It was found that current ideas on the absorption, retention and elimination of a number of important elements such as plutonium and caesium need completely revising. For one thing, the physicochemical state of the element at the moment of absorption and the method of absorption play an important role in its future metabolism. Moreover it is now clear that the behaviour of the element within the organism varies considerably according to the content by weight of the contaminating element, so that no estimate can be made on the basis of experiments where different amounts of contaminant were involved.

Priority is still given, of course, in many laboratories in the Community to research on the treatment of irradiated subjects, bone-marrow grafting and related problems of immunology. Good progress is recorded in research into ways of reducing the secondary reaction which in most species — and certainly in man — follows transplantation of homologous bone marrow. The aim here is to devise a method of treating the graft which will reduce the secondary reaction without impairing its restorative properties, or to discover better ways of selecting donors so as to reduce incompatibilities to a minimum in the same way as for blood transfusions.

The effects of radiations on cancer growth and causation are likewise under investigation together with the relevant dosimetric data.

Work on radioactive contamination of the environment and of the food chain went ahead on several fronts. The Euratom/ITAL Association concentrated chiefly on the physicochemical parameters governing the behaviour of radionuclides in the soil, on soil/plant correlations and the mechanism of absorption and digestion of these substances by plants. The biology group at Ispra studied the movement of radionuclides in typical crops of the upper Po valley, namely, spray-irrigated crops and paddy rice. A major study was undertaken in the bay of Ispra, on Lake Maggiore, to study variations in the biomass and concentrations of stable elements and radionuclides in living organisms, water and sediment. Finally, the Euratom/CNEN Association continued its research on the marine environment at Fiascherino.

The "Eurosols" project was launched. This is a programme carried out jointly by the Euratom/CEA Association (contamination levels in the food chain), the Euratom/ITAL Association and the Ispra biology group. Its purpose is to study — in the laboratory (at ITAL, Wageningen), in growth troughs and in lysimeters (at Ispra) — the physicochemical characteristics of samples of seven main European soil types from the Netherlands, Germany, France and Italy and their interactions with radionuclides (strontium and caesium).

The Euratom/ITAL Association, backed up by sub-contracts in France, the Netherlands, Germany and Italy, pursued its research on induced mutagenesis in plants.

Concurrently with its work on background contamination, the Ispra biology group shared in research on the possible consequences to man of handling or ingesting substances used in reactor technology and of irradiations liable to occur accidentally at a nuclear centre. The metabolism of terphenyls, which are used as reactor coolants, was investigated and a highly sensitive apparatus devised for detecting the exposure of personnel to these substances in the form of vapour or dust. A standardized method of biological dosimetry was developed, based on homogenization of the thermocyte and lymphocyte cell nuclei, and proportional counters of various types have been made of tissue equivalent materials to simulate biological entities such as the canaliculi in bones, chromosomes, etc.

DOCUMENT No. 19 IMPLEMENTATION OF CONTRACTS UNDER POWER REACTOR PARTICIPATION PROGRAMME AND DECISIONS OF THE COMMISSION CONCERNING JOINT ENTERPRISES

I. ENEL power plant on Garigliano

1. *Operation*

Industrial operation of the plant proceeded without major interruptions after its reopening on 1 May 1966.

The good stability qualities of the reactor, even under very extreme operational conditions, and in particular its ability to operate at full power, with two circuits in natural circulation, were shown by tests carried out towards the end of May under a Euratom research contract.

The load factor for the whole year was 58.3%, and for the period 1 May to 31 December 86.8%.

The output and burn-up figures for 1966 were as follows:

— net electric power produced	755,483,500 kWh
— average burn-up up to 31 December 1966	7279 MWd/t

A summary of the work done in the first four months of the year is given below.

During an inspection a leak was found in one of the two drainage pipes between the bottom of the reactor vessel and the primary circuit demineralization plant, near the point where it enters the vessel. Calculation and metallurgical analysis revealed the existence of excessive local stresses on these two pipes, so they had to be cut, modified and rewelded. These rather tricky operations were rendered lengthy and difficult by the fact that the tubes were in inaccessible positions, in the middle of penetrations for the control rod mechanism. The necessary operations therefore had to be carried out with specially designed remote-control equipment and carefully planned in advance.

In order to repair the tubes, it was necessary to seal their openings inside the vessel. During this operation it was found that the liquid poison distributor (consisting of two semicircular perforated stainless steel tubes held by eight ties and welded to the inlet section) was broken. Fragments of the tubes and the ties were found at the bottom of the vessel. All the fragments were finally extracted after extremely complicated manipulations.

Visual and metallographic examinations of some of the pieces showed that the ties broke as a result of to-and-fro movements of the two branches of the ring; these movements were caused by pressure peaks transmitted by the piston pumps in the poison injection system. Once the ties were broken, water currents in the vessel bent the tubes, causing them and the inlet section to break. All of this must have happened during the test period and/or at the beginning of reactor operation. The ring was not replaced because this would have caused far too long a delay in re-start-up; moreover, its exclusion does not affect the safety of the plant. The inside of the vessel and the internals were inspected by means of a leaktight TV camera and a boroscope. It was found that the damage caused by the fragments was quite tolerable, with one exception. One of the 20 tubes installed for the guidance of the in-core instrumentation was found to be leaking with respect to the inside and the outside of the vessel. Since the leak towards the inside of the vessel is no problem, only the leak towards the outside was stopped by rolling.

The above operations were long and difficult; they took place over a period of about four months and necessitated *inter alia* the total unloading of the core.

During the operational period (May-December) no major difficulty was encountered. The pressure drop across the core mentioned in the Ninth General Report began to increase. However, the gradient observed up to the present suggests that the reactor can be kept in operation until the scheduled shut-down in May 1967. The last stainless steel channels will then be replaced by Zircaloy channels and will be loaded with 14 stand-by fuel elements in place of the same number of first-core elements.

Towards the end of the year, ENEL asked for the prorogation of the participation contract and invited tenders for the delivery of replacement fuel elements for the Garigliano plant. It is probable that these orders will be placed with Community firms.

2. *Performance of Contract*

a) *Secondments*

During 1966 the following personnel were assigned to the Garigliano power plant:

	Total	Man/months
Euratom employees	3	8.4
Personnel of Community organizations or firms	10	6.5
Student trainees	1	3.1
Total	14	18.0

The breakdown by country of the engineers seconded by organizations and firms, and of students was as follows:

Country	Engineers	Students
Belgium	2	—
France	3	—
Germany	5	—
Netherlands	—	1

b) *Acquisition of information*

A total of 18 reports were drawn up during the year by engineers seconded by Euratom and Community organizations and firms, and by one student trainee.

II. ENEL power plant at Latina

1. *Operation*

Industrial operation of the power plant continued normally for the greater part of 1966. The plant, which was not shut down for the scheduled annual maintenance, had only one major outage (one month) for reasons mentioned below. The average load factor for the whole year was 79%, exceeding 95% for the first four months and 85% for the last four.

The following are data on operation during the year:

— net electric power generated 1,373,646,700 kWh

— average burn-up at 15 December 1966 1583 MW/t

Inspection of equipment and circuits during normal maintenance showed that the plant was in extremely good general condition. Some of the troubles described in the Ninth General Report recurred, but to a much lesser degree. The protective plating on the backs of some of the low-pressure blades in the main turbines had to be repaired, and some leaks stopped in the sea-water circuits and in the water-vapour circuits of the steam generators. During 1966, for the first time since the commissioning of the power plant, the outage of the nuclear equipment sometimes reached values comparable with those for conventional and paranuclear equipment. This was due, for example, to the repetition of damage to clamps and cables in the loading/unloading machine, some rod drops, can bursts, and, worst of all, a temperature transient on the fuel, which will be discussed below. On 3 July 1966, resumed start-up following a rod drop on the previous day had to be interrupted during the temperature run-up phase because the temperature of a number of cans was exceeding permissible values as a result of an imprudent manoeuvre by the operator.

The elements of 17 channels had to be replaced during the year following indications by the burst-slug detection system — 12 of them following the above-mentioned temperature transient.

ENEL has requested the prorogation of the Latina power plant participation contract. It is probable that a certain amount of fuel elements can be ordered within the Community during the coming years.

2. *Performance of Contract*

a) *Secondments*

The following table gives the figures for secondment of personnel to the power plant during 1966:

	Total	Man/months
Euratom employees	2	23
Personnel of Community organizations or firms	3	2.2
Student trainees	2	5
Total	7	30.2

The breakdown by country of the personnel of organizations and firms, and of student trainess is as follows:

Country	Engineers	Students
France	3	1
Netherlands	—	1

b) *Acquisition of information*

A total of 24 reports were drawn up during the year by engineers seconded by Euratom and Community organizations or firms, and by student trainees.

III. SENA power plant at Chooz

1. *Status of the Work*

Plant construction is finished and start-up tests are in progress.

The following are major dates in the completion of the project:

— early 1962: commencement of the civil engineering work (some trial galleries and tunnels had been drilled in 1961);

— April 1963: decision to increase the rated power of the plant to its present value, i.e., 266 MWe net;

— 31 August - 5 September 1966: loading of the reactor core;

— 18 October 1966: first criticality.

A brief account of the main events in the test programme is given below:

The hot test, i.e., the overall test at rated pressure and temperature of the primary circuit, auxiliary systems and steam generators, with non-nuclear heating, took place between April and July 1966; the preliminary operations had been carried out in March. This test was interrupted by some incidents. The two main charge pumps, which are part of the chemical and volumetric control system, were used to produce rapid increases in the primary system pressure during the hot test. These pumps had to be taken out of service on several occasions for repairs and modifications (on the site and in the factory), particularly to the packings and the pistons.

Another trouble which caused an interruption of the tests was the jamming of the nuts on the stems of the primary valves. Other hold-ups of the hot test were due to the accidental passing of current through two sets of resistances on the pressurizer and to leakages in the flanges of the pneumatically actuated valves. All told, these troubles held the programme up by about two months.

The hot test was followed by the leaktight test on the metal lining of the reactor cavern; it lasted about a month. This test was preceded by preparatory work and preliminary and partial tests which took a considerable time. After some final adjustments the test was successfully completed. The leak-rates recorded in the last test were considerably below the value permitted by the competent authorities.

The loading of the core took 140 hours non-stop, including the welding of the primary sources. The operation was effected without major difficulties and at remarkable speed. Before closing the vessel the stems of the control rods were modified.

Once criticality had been reached (18 October) and some final adjustments made to the nuclear instrumentation and the control rod drive mechanisms, the zero-power physics tests were begun. The programme had to be interrupted towards the end of October because of damage to a primary pump, due to the fatigue fracture of some retaining screws in the internals. After dismantling of the three other primary pumps, it was found that this fault had occurred on three pumps out of four. Repair and reassembly of these pumps was completed in December.

Meanwhile flooding had occurred in the pumping station, which caused some damage owing to the fact that by a combination of circumstances the alarm signals were observed too late. The above two incidents were due to components which were commonplace and of minor material value, but which caused a delay of about two months in the test programme. This programme was resumed in December, and was interrupted at the beginning of 1967 by a fire in the neutron shielding.

As regards the nuclear fuel, during the first loading, eight elements fabricated by Community enterprises were inserted in the core; the same number of US-made stand-by elements were put in their place. The fuel elements for the second core have already been ordered from Community firms, as provided for in the contract of participation.

BARN REACTOR (BIOLOGICAL AGRICULTURAL REACTOR NETHERLANDS)
ITAL INSTITUTE, WAGENINGEN

(See other side of page for caption)

This reactor, which is used for irradiating biological matter, has an output of 100 kW and a maximum neutron flux of 10^{12} n/cm²/sec.

2. *Performance of Contract*

a) *Secondments*

The following personnel were assigned to the plant during 1966:

	Total	Man/months
Euratom employees	4	28.2
Personnel of Community organizations and firms	6	10.3
Student trainees	6	14
Total	16	52.5

The breakdown by country of origin of the Community employees and of student trainees is as follows:

Country	Engineers	Students
Belgium	—	2
Germany	5	2
Italy	1	2

b) *Acquisition of information*

A total of 39 reports and articles were drawn up during the year. This figure includes reports by engineers seconded by Euratom and organizations and firms in the Community countries, and also papers presented by these engineers and SENA representatives at the information meeting held on 10 and 11 May 1966, and reports by student trainees.

IV. KRB power plant at Gundremmingen

1. *Status of Work*

The big event in 1966 was the start-up of the power plant. Assembly of the circuits was practically finished by the end of April. The partial tests on the circuits were carried out stage by stage, as soon as the state of completion made them possible.

The dates of some important steps in the progress of the project are summarized below:

— November 1962: beginning of construction

— 10-23 August 1966: loading of the core

— 14 August 1966: first criticality

— 23 December 1966: full power attained for the first time

The gross electric power produced in 1966 was 94 million kWh in 1100 hours' operation.

As regards the construction of the power plant, it may be noted that the few delays in the programme, due mainly to the construction of the leaktight containment and delivery of the reactor vessel, have largely been made good.

The tests were performed without major difficulties. It is interesting to note that most of the modifications and developments carried out were to the conventional equipment. Some valves were not sufficiently leaktight, either in the stem or in the seat. The casings of the condenser coolant pumps were too brittle, and cracked after a few hundred hours' operation (one of them broke). The resin beds of the condensate circuit were rapidly saturated, apparently mainly because of impurities and corrosion products such as are always present during the initial operation of a circuit; the regeneration frequency required is at the moment still high. Regulation of the level, both on the vessel and on the evaporators and reheaters, required some adjustment.

The turbine regulation also had to be adjusted.

During a transient test there was a flux peak 28% above the rated value. The test consisted in effecting instantaneous load-shedding in the network while the plant was operating at rated power. The auxiliaries were to continue to be supplied by the group itself, whose speed was to remain almost constant; however, momentary overspeed of about 3% in the turbine was transmitted to the auxiliaries, and in particular to the recycling pumps. The flow of subcooled water was increased, resulting in the above flux peak, which in turn tripped a scram shut-down. As a result of the scram, the supply to the auxiliaries was seriously disturbed. This problem was solved by arranging for one of the three circulation pumps to be shut down at the same time as the load-shedding. The above difficulties did not cause serious delays, and in each case were rapidly overcome.

The temperature and power run-up took place in accordance with the predetermined programme, which included four stages. Numerous measurements were made during each of these stages. The carefully prepared operating tests were successfully completed. Transient tests showed that the proposed safety devices were adequate and were operating satisfactorily.

The plant is due to be handed over to the KRB during the first half of 1967.

2. *Performance of Contract*

a) *Secondments*

The following personnel were assigned to the plant during 1966:

	Total	Man/months
Euratom employees	4	24.5
Personnel of Community organizations or firms	20	43.7
Srudent trainees	3	5.5
Total	27	73.7

The breakdown by country of origin of the personnel of organizations or firms in Community countries and of student trainees is as follows:

Country	Engineers	Students
France	9	—
Germany	7	—
Italy	4	—
Netherlands	—	3

b) *Acquisition of information*

A total of 22 reports were drawn up during the year by engineers seconded by Euratom and organizations and firms in the Community countries, and also by student trainees.

V. GKN power plant at Dodewaard

1. *Status of the Work*

The construction of most of the buildings such as those for the turbine, the filters, the workshops and the office and canteen blocks was completed in 1966. The reactor building was sufficiently completed to permit installation of the pressure suppression system and the reactor vessel; it is still necessary to complete the biological shield and to assemble the metal roofing. The installation of the above equipment, preparations for which have already begun, will be followed by the construction of the 100 m power plant stack.

The assembly work as a whole is going ahead according to plan despite the delays in the delivery to the site of the vessel and the pressure suppression system components. Among the units assembled during the year were the condensers, the steel foundations of the turbo-alternator set, the tanks for the radioactive waste processing system, the components for the ventilation system, and the travelling cranes.

All the orders for key equipment have been placed. In particular, during 1966 the fuel elements, the control rods and their drive mechanisms and the neutron flux measuring systems were ordered from Community suppliers.

From the organizational angle, it is interesting to note that the GKN created a special quality control team, which works quite independently of the team responsible for the project. The first reactor loading is scheduled for January 1968.

2. *Performance of Contract*

a) *Secondments*

The following table summarizes the statistics for secondment of personnel:

	Total	Man/months
Euratom employees	2	24
Personnel of Community organizations or firms	1	6
Student trainees	1	2
Total	4	32

Breakdown by country of origin:

Country	Engineers	Students
Belgium	1	—
Germany	1	—

b) *Acquisition of information*

A total of 16 reports were drawn up during the year by engineers from Euratom and from organizations or firms, in Community countries, together with one student trainee.

VI. Lingen power plant

1. *Status of Work*

At the end of 1966 the civil engineering work was well advanced. The reactor building is practically finished, as is the main work on the building housing the superheater, the turbogenerator and the auxiliaries, the radioactive effluent building, the stack, the pump house and the coolant water inlet channel.

The discharge building is almost complete and the discharge channel is under construction. The leaktight containment was completed somewhat behind schedule, because of welding difficulties. The pressure test on the containment was carried out successfully in February 1966. The delays in the assembly programme were largely made good.

After successful completion of the shop hydrostatic test, the reactor vessel was transported to the site and installed during December. Work then began on the assembly of the vessel pipework and on preparation for assembly of the internals.

The shop fabrication of the steam generators is practically completed and acceptance tests and delivery to the site are planned for January 1967.

On-site assembly of the superheater is about half-finished.

The shop fabrication of the turbogenerator set is proceeding according to plan; assembly of the condenser is scheduled to begin in January and of the turbogenerator set in April 1967.

The assembly of the radioactive effluent system is almost complete; preoperational trials are to begin in February 1967.

The experimental work on the demineralization station is completed and its experimental entry into service is scheduled for January 1967.

The assembly of electrical equipment and cabling is in progress.

Work has already begun on the fabrication of the fuel elements and control rods, which were ordered from a German firm. The plant should be commissioned in 1968.

2. *Implementation of Euratom Decision*

Secondments and acquisition of information

In July 1966 one Euratom engineer was seconded to AEG. Commentaries were made on three reports.

VII. Condensed statement of statistical data

The two tables below summarize the statistical data given in the above paragraphs on the secondment of personnel and the acquisition of information in 1966.

Contractors	Euratom employees		Personnel of Community organizations of firms		Student trainees		Second-ments & training		Reports & papers
	man	months	man	months	man	months	man	months	
ENEL (Garigliano)	3[1])	8.4	10	6.5	1	3.1	14	18	18
ENEL (Latina)	2	23	3	2.2	2	5	7	30.2	24
SENA (Chooz)	4[2])	28.2	6	10.3	6	14	16	52.5	39[3])
KRB (Gundremmingen)	4[2])	24.5	20	43.7	3	5.5	27	73.7	22
GKN (Dodewaard)	2	24	1	6	1	2	4	32	16
KWL (Lingen)	1	5.5	—	—	—	—	1	5.5	3
Grand total	16	119.6	40	68.7	13	29.6	69	211.9	122

1) One employee was seconded for seven months, the others for short periods.
2) Two employees were seconded for the whole year.
3) This number includes papers presented at the special information meeting on SENA.

Secondment of personnel in 1966 : breakdown by country of origin						
	Belgium	France	Germany	Italy	Netherlands	Total
Engineers from Community organizations or firms	2	15	18	5	—	40
Student trainees	3	1	2	2	5	13

VIII. Information supplied by the contractors

In return for its backing and in implementation of the decisions concerning Joint Enterprises, the Commission receives, *inter alia,* information from its contractors which enables it to build up an overall body of intelligence and data on power plant design, construction, testing, commissioning and operation.

This documentation includes:

— contract documents, in particular copies of the contracts concluded between the contractor and his main suppliers;

— blueprints, specifications, schemes, data, main technical characteristics and construction and test schedules;

— safety reports;

— reports, some of them periodical, on all aspects of the construction of a nuclear power plant, such as the status of the work, design modifications introduced during construction, main difficulties and incidents, and steps taken to overcome them;

— information of a financial, technical and economic nature.

IX. Dissemination of information

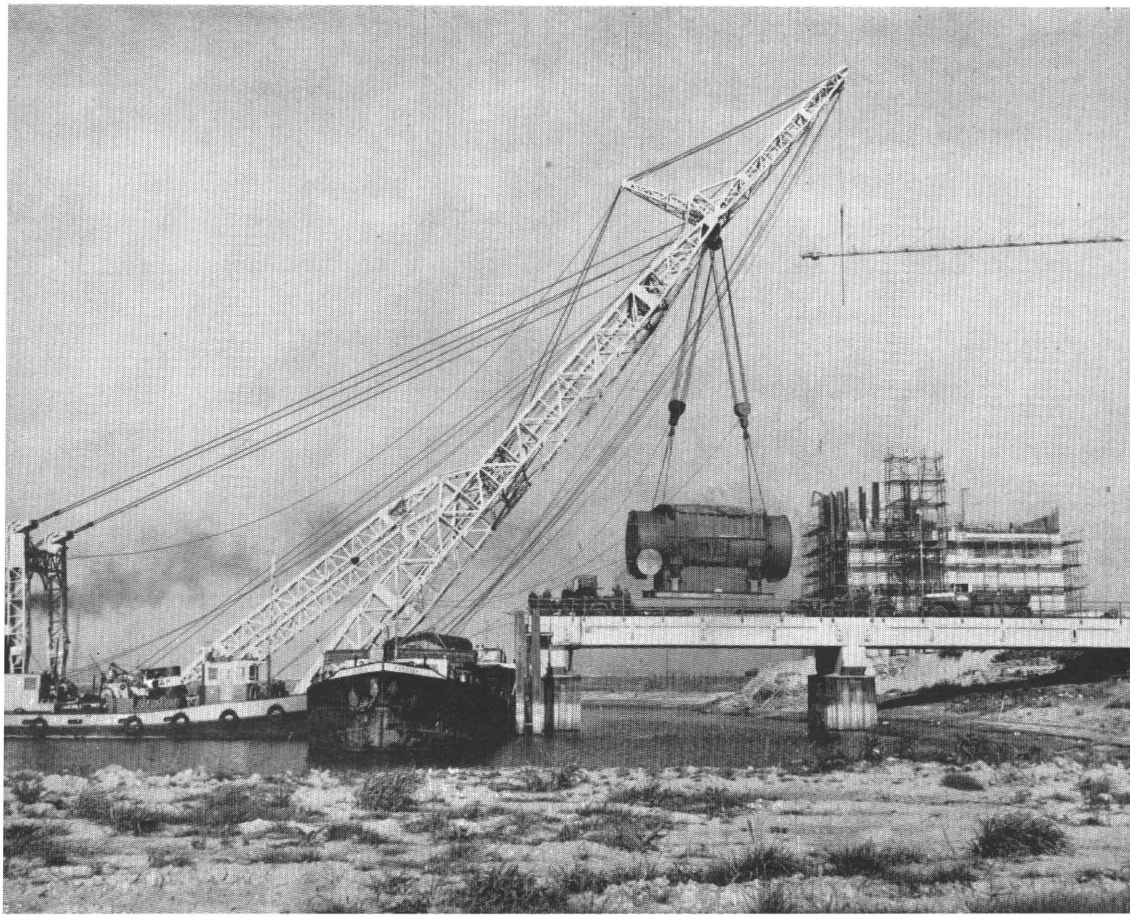
The information supplied to Euratom under contracts of participation and under the decisions concerning Joint Enterprises is placed at the disposal of organizations, enterprises and authorized persons and is disseminated in two ways:

Breakdown, by power plants and types of document, of the information received up to and during 1966 :

Information received	ENEL (Garigliano)			ENEL (Latina)			SENA (Chooz)			KRB (Gundremmingen)			GKN (Dodewaard)			KWL (Lingen)			Total
	up to 1966	1966	tot.	up to 1966	1966	tot.	up to 1966	1966	tot.	up to 1966	1966	tot.	up to 1966	1966	tot.	up to 1966	1966	tot.	
Initial reports	9	—	9	8	—	8	30	2	32	2	—	2	2	3	5	—	1	1	57
Annual reports	4	1	5	4	1	5	5	1	6	2	1	3	2	2	4	—	2	2	25
Quarterly and four-monthly reports	55[1])	8[1])	63	33[1])	3[1])	36[1])	18[1])	8[1])	26	11	3	14	6	3	9	—	3	3	151
Special reports	6	6	12	3	—	3	13	3	16	—	—	—	1	1	2	—	2	2	35
Safety reports and related reports	14	2	16	8	—	8	2	1	3	12	5	17	4	—	4	—	—	—	48
Blueprints, specifications, etc.	308	34	342	100	—	100	137	113	250	317	290	607	176	131	307	—	—	—	1606
Total	396	51	447	156	4	160	205	128	333	344	299	643	191	140	331[2])	—	8	8	1922

[1]) Technical and financial reports.

[2]) Account has been taken here of the fact that some documents have been superseded by their subsequent revised editions.



DODEWAARD (Netherlands) — CONSTRUCTION OF NUCLEAR POWER PLANT

(See other side of page for caption)

The Dodewaard nuclear power plant will be fitted with a boiling-water reactor developing 51.5 MWe. On the opposite page a view is shown of the condensers being unloaded by means of a floating crane.

1. *Dissemination of Documents:*

The following documents are distributed via six national correspondents:

— reports by engineers seconded by the Commission;

— periodical lists relating to the reports by engineers seconded by Community enterprises or firms and to documents supplied by the contractors.

The recipients of these lists can consult the documents which interest them or request microfilm copies from Euratom's head office.

2. *Information Meetings*

The seventh information meeting, devoted to the SENA project alone, was held in Brussels on 10 and 11 May 1966.

Some statistical details on information meetings organized by the Commission in the course of implementing participation contracts is given below:

Year	Subject/Place of meeting	Community organizations and firms represented	Participants
1962	Information meeting on the implementation of participation contracts (Brussels)	60	110
1962	Special meeting on the fabrication of fuel elements within the Community (Brussels)	35	65
1963	Information meeting on the implementation of contracts of participation (Brussels)	104	169
1964	Information meeting on the implementation of contracts of participation (Brussels)	109	250
1965	Information meeting on the implementation of contracts of participation (Brussels)	135	275
1965	Special information meeting on the KRB project (Munich and Gundremmingen)	88	153
1966	Special information meeting on the SENA project (Brussels and Chooz)	108	260

The figures shown in the table indicate the remarkable increase in the attendance of Community organizations and enterprises at information meetings organized in connection with the execution of contracts of participation.

DOCUMENT No. 20 EXCHANGE OF EXPERIENCE WITH NUCLEAR POWER PLANT COMPONENTS

Experience in the construction and operation of the various items of equipment for power reactors has shown that considerable difficulties may still be encountered with the conventional and paranuclear parts. It was therefore decided early in 1966 to set up a number of working parties to deal with these problems. To start with, the field was limited to:

— leaktight containments

— ventilation and gaseous waste processing systems

— steam turbines

— heat exchangers

— blowers

— pumps and valves

The working parties were made up of representatives of the electricity suppliers with experience in reactor operation and construction, together with Euratom personnel.

A complete record of the difficulties and damage which had occurred during construction or operation of the various parts of the equipment was submitted to the relevant working parties and discussed by them.

Documentation was assembled consisting of 32 individual reports and a general survey for each of the six fields of enquiry. The results of the first ten months' work were presented at a symposium held in Amsterdam in November 1966. Attendance at the symposium was restricted to representatives of Community utility companies. Some fifty delegates were present.

These arrangements for exchanging experiences having met with approval, it was decided to set up further working parties to deal with:

— reactor vessels and internals

— control rods and their drive systems

— instrumentation and control

— fuel element rupture detection systems

— effluent processing

— corrosion and mass transport by the working medium and coolant

— handling, storage and shipping of fuel elements

It was considered desirable to hold a symposium once a year and to make the systematic exchange of experience along these lines a permanent feature.

DOCUMENT No. 21 INVESTMENT PROJECTS NOTIFIED TO THE COMMISSION — APPLICATION OF ARTICLES 41-43 OF THE EURATOM TREATY

Nuclear investment projects relating to new facilities or to conversions of facilities which come within the industrial sectors enumerated in Annex II to the Treaty must be notified to the Commission in accordance with the terms of Article 41 of the Euratom Treaty. This obligation concerns investment projects, the costs of which are not less than the "floor" values laid down by Regulation No. 4 of the Council (dated 15 September 1958 — "Journal Officiel" of 6 October 1958) in respect of the various industrial sectors listed in Annex II to the Treaty (mines, concentration plants, fuel element preparation and fabrication, irradiated element reprocessing, moderator production, etc.), as well as all reactors, irrespective of cost, but only as to their fundamental characteristics in the case of those with a value of less than one million u.a.

After discussing the various aspects of the projects notified with, and in the presence of, representatives of the parties concerned, the Commission informs the licensee enterprise and the Member State concerned of its viewpoint. This procedure does not apply to reactor projects with a capital cost of less than one million u.a.

Since the introduction of the implementing regulations in 1959, a total of 77 projects have been notified under Article 41 of the Treaty, relating to 64 facilities representing overall investments of the order of 1904 million u.a. They have created nearly 7000 new jobs for operating personnel, as is shown in detail by the table on the next page.

The statistics in this and the following tables were compiled from all the data given in the project details notified, which were estimated on the basis of similar projects or else obtained from other sources where not provided by the licensee enterprises. In practically every case, the amount of the investment after implementation of the project has proved to be above the estimate, so the figures shown here constitute minimum levels. The data relating to new jobs are for the staff employed to operate the installations, but do not include the labour force required for their design and construction.

Although only approximate, the data in the foregoing table call for the following observations:

1. The heaviest investments are accounted for by reactors — nearly 1700 million out of a total of more than 1900 million u.a. In the case of reactors

Industrial Sectors (Annex II to the Treaty)	Belgium	Germany	France	Italy	Netherlands	Community
1. Uranium and thorium ore extraction :						
Number of plants	—	1	—	—	—	1
Amounts in millions of u.a.	—	10	—	—	—	10
Operating personnel	—	600	—	—	—	600
Capacity in t/yr U	—	400	—	—	—	400
4. Preparation of fuel elements in any form :						
Number of plants	—	1	—	—	—	1
Amounts in millions of u.a.	—	1.8	—	—	—	1.8
Operating personnel	—	10	—	—	—	10
Capacity in t/yr U	—	10	—	—	—	10
5. Fuel element fabrication :						
Number of plants	2	3	1	—	—	6
Amounts in millions of u.a.	6.5	24.6	3	—	—	34.1
Operating personnel	225	770	100	—	—	1095
Capacity in t/yr	0.5 Pu 105 U		45 U	—	—	
8. Fuel processing :						
Number of plants	1	2	1	2	—	6
Amounts in millions of u.a.	24	103.6	15	15.3	—	157.9
Operating personnel	500	800	200	110	—	1610
Capacity	350 kg/d U	1050 t/yr U	35 t/yr U	45 kg/d U-Th	—	
9. Reactor moderator production :						
Number of plants	—	1	—	—	—	1
Amounts in millions of u.a.	—	8	—	—	—	8
Operating personnel	—	35	—	—	—	35
Capacity in t/yr D_2O	—	25	—	—	—	25
11. Nuclear reactors :						
a) Experimental, test, research :						
Number of plants	1	8	11	7	3	30
Amounts in millions of u.a.	0.5	104.3	71.9	21.8	1.1	199.6
Operating personnel	5	325	340	130	40	840
b) Power :						
Number of plants	2	6	8	2	1	19
Amounts in millions of u.a.	300	690.8	344.3	136.5	30.6	1492.2
Operating personnel	300	1225	775	335	65	2700
Capacity in net MWe	1200	2225	950	350	55	4780
All industrial sectors :						
Number of plants	6	22	21	11	4	64
Amounts in millions of u.a.	331	933.1	434.2	173.6	31.77	1903.6
Operating personnel	1030	3765	1415	575	105	6890

and nuclear electricity generators, they total nearly 1500 million u.a. for a net electric power of 4780 MWe, or 313-314 u.a./kWe.

The high unit cost per kWe is due to the fact that the installations as designed include several prototypes and units which are being constructed for the first time in Europe and mark the start of the development of a particular reactor family.

It is reactors, also, which create the largest number of new jobs — 2700 in the case of power reactors and 840 in that of experimental test, research and training reactors, making a total of 3540. On this basis, therefore, every MWe installed in a power reactor represents 0.56 of a job.

2. Next in order of importance come the following plants:

The facilities engaged in the reprocessing of irradiated fuel — nearly 160 million u.a. in investments and 1610 new jobs.

The fuel element fabrication facilities, which aggregate 34 million u.a. of investments for the period from 1959 to 1966 and have created 1095 new jobs.

The ore extraction and fuel preparation and moderator production facilities, for which the capital outlay is only of the order of 20 million u.a. and which will have created some 645 new jobs.

3. As regards the geographical distribution of installations, the following table gives the approximate amounts of the planned investments and operating personnel:

Countries in which plants are located	No. of plants concerned	Amount in millions of u.a.	Operating personnel
Belgium	6	331.0	1030
France	22	933.1	3765
Germany	21	434.2	1415
Italy	11	173.6	575
Netherlands	4	31.7	105

The nuclear electricity capacities relating to projects already notified are 2225 MWe for France, 1200 for Belgium, 950 for Germany, 350 for Italy and 55 for the Netherlands.

4. The year-to-year trend of investment projects notified to the Commission is as shown in the table below:

Year	No. of projects notified	Amount of investments in millions of u.a.	No. of jobs created by operation
1959	7	94.5	920
1960	5	82.4	370
1961	8	203.8	500
1962	11	258.1	1020
1963	8	233.8	920
1964	11	156.6	1500
1965	4	120.2	260
1966	13	754.2	1400
Total	67	1903.6	6890

It will be noted that the 13 investment projects notified in 1966 are estimated to cost 754.2 million u.a., as compared with 1149.4 million for all 54 projects notified in the preceding seven years (1959 to 1965) and account for almost 40% of the total cost of the projects notified to the Commission over the eight-year period.

5. The investment projects notified in 1966 relate to the following facilities:

— three training and research reactors, the outlay for each of which is below one million u.a.;

— seven power reactors;

— one irradiated fuel reprocessing plant;

— two fuel element fabrication plants.

The projects notified in 1966 represent a total investment of 750-800 million u.a. and will entail a payroll of about 1400.

The seven power reactor projects notified in 1966 represent a total capacity of 2571 MWe net (against 2209 MWe for the previous seven years) or in one year 55% of the total planned capacities for all the eight years in question. The capital cost of nuclear power plants of this type is 733 million u.a.

In 1966, the Commission formulated and communicated to the licensee enterprises and the Member States concerned opinions in respect of three reactor projects, the data relating to which had been submitted in 1965 (totalling ± 320 MWe net for a capital cost of approximately 120 million u.a.) and six of the ten projects notified in 1966 which called for application of such a procedure. Four files were under study at the end of 1966.

DOCUMENT No. 22 ACTIVITIES IN THE FIELD OF INDUSTRIAL RESEARCH

The industrial documentation at the Commission's disposal covers some 3000 enterprises in the Community and various other countries.

The first concrete result obtained here took the form of the European Nuclear Buyers' Guide, issued in 1966, which gives information on some 300 products or by-products of nuclear and paranuclear industries and the 1200 concerns supplying them in the Community.

The card indexes on which the Guide was based are constantly being expanded by the addition of documentation on the numerous new undertakings which are beginning to take an interest in the fabrication or supply of nuclear or paranuclear materials.

During 1966, more than 500 requests for information reached the Commission from its own departments or Community enterprises, referring to every aspect of reactor construction, parts and components and other nuclear installations from the commercial, financial, technical and manufacturing angles.

The replies, it should be noted, were limited to information of a non-confidential nature. Classified data, such as those contained in statements of investments, which are governed by Article 41 of the Treaty, were not, of course, divulged.

In addition, the survey of more than 200 American concerns and their European interests, which had been started in 1965, was continued into 1966.

Several thousand items of information on new projects for which the go-ahead had been given, as well as work in progress and deliveries already made, were abstracted for adding to the relevant files to provide material for a new edition of the List of Nuclear Installations in the Community and to keep records of installations in non-Member States up to date.

DOCUMENT No. 23 TECHNICAL AND ECONOMIC STUDIES

In 1966 the Commission published the results of some technical and economic studies which it had sponsored. The first of these dealt with the development of a method for the calculation of the cost of a nuclear kWh. It was carried out under contract by a group consisting of the following organizations:

— the CEA

— the Société Indatom

— Siemens-Schuckert-Werke AG

— the Società Ricerche Impianti Nucleari (SORIN)

The Commission had also asked for the cooperation of consultants such as Electricité de France, the Comitato Nazionale per la Ricerca Nucleare and the Rheinisch-Westfälisches Elektrizitätswerk AG. This work resulted in the publication in 1966 of the "Euratom Economic Handbook". Other studies were concerned with an examination of methods of reducing the installation costs of a nuclear power plant of the light-water type. They were carried out by the French CEA and the Comitato Nazionale per la Ricerca Nucleare respectively, and also by the Technische Hochschule Aachen.

In order to enable a comparison to be made of the experience acquired hitherto and the present outlook with regard to the training and selection of operating staff for nuclear power plants in Community countries, the Commission has also sponsored a detailed study of this question by the Société européenne d'Equipement et de Conseil (EUREQUIP) in which the major utilities in the Community have lent their cooperation.

In addition, some studies on the effect of taxation on the cost and retail prices of a kWh of nuclear origin are still in progress with the Société Metra International. A report will be published in 1967.

Lastly, the Commission has concluded further study contracts, particularly with a view to placing nuclear power in the general energy context, the economic parameters of which require further clarification.

For similar reasons, a contract has been signed with the Deutsche Institut für Wissenschaftliche Forschung eV (Institut für Konjunkturforschung) in Berlin for a study of the possibilities of introducing nuclear energy into the general scheme of electrical energy production in West Germany between now and 1980, bearing in mind the economic effects, both general and local, and the social repercussions of such a step. It may be hoped that the experience gained by this study on one of the Community Member States may lead to a general study of this problem within the Community.

In order to define scientifically the role of nuclear energy in safeguarding energy supplies, the Commission has asked the Institute of Energy Economics of the University of Cologne to carry out a study on the subject.

It has also placed a contract with the BEN (Bureau d'Etudes nucléaires), Sobemap (Société belge des Mathématiques appliquées) and Electrobel companies for the execution of a study programme on the effects of the construction of pumping stations on the economic situation of nuclear power plants, with the aim of improving the use factor and profitability of the latter.

The Commission has also entrusted the CEA and an industrial grouping (Alsthom, Indatom, GAA, etc.) with a study on ways of reducing the capital cost of graphite-gas reactors.

The value of other applications of nuclear energy, particularly the desalination of sea water, having been demonstrated during the past year, it has now become expedient to examine their implications within the Community. The Commission has therefore decided, firstly, to make a preliminary study on possible water shortages between now and 1975 in some critical areas within the Community and, secondly, to examine the cheaper forms of nuclear desalination. Lastly, it will look into the prospects of combining the production of fresh water with that of electrical energy. Two contracts have therefore been signed, the first with Montecatini and Sowit and the second with Belgonucléaire, the Société de Traction and the Atlaswerke. The former will study requirements in the southern part of the Community and will examine the economic value of using nuclear energy produced in heavy-water and/or organic-liquid reactors. The latter will study the requirements of the northern part of the Community (North Sea coastal areas of Belgium, the Netherlands and West Germany) and the economic aspects of the possible use of nuclear energy from light-water reactors. The results of these two studies should be available towards the middle of 1967.

DOCUMENT No. 24 THE PRESENT LEGAL SITUATION AS REGARDS NUCLEAR THIRD-PARTY LIABILITY IN THE EUROPEAN COMMUNITY

The Paris Convention on third-party liability in the field of nuclear energy, dated 29 July 1960, and the Supplementary Convention dated 31 January 1963, as amplified to include the Additional Protocols, dated 28 January 1964, were signed by all the Member States of the Community. The Paris Convention has further been signed by Austria, Denmark, Greece, Norway, Portugal, Sweden, Switzerland, Turkey and the United Kingdom. The Brussels Supplementary Convention was signed by all these countries with the exception of Greece, Portugal and Turkey. The Paris Convention will come into force when five Member States have deposited their instruments of ratification, the Brussels Supplementary Convention when six Member States have done so. France and Belgium ratified the Paris Convention on 9 March 1966 and 3 August 1966 respectively and the United Kingdom on 23 February 1966. Prior to this, the Convention had been ratified by Spain and Turkey, the latter prior to the signing of the Additional Protocol, which still requires its ratification. In these circumstances, therefore, the Paris Convention is not yet deemed to have come into operation.

The Brussels Supplementary Convention was ratified by France on 30 March 1966 and by the United Kingdom on 24 March 1966. As it had previously been ratified by Spain, three instruments of ratification have been deposited to date. In Belgium, Parliament has completed the ratification procedure and the relevant instrument is to be deposited next year.

The Convention on the liability of operators of nuclear ships (Brussels Nuclear Ship Convention), dated 25 May 1962, has not yet come into force, only Belgium among the Community countries having appended its signature.

The Vienna Convention on civil liability for nuclear damage, dated 21 May 1963, incorporating the Optional Protocol concerning the compulsory settlement of disputes (Vienna Convention), has not yet been signed by any Community country.

The legal situation with regard to nuclear third-party liability in the Community Member States is marked by the existence of temporary laws which implement the main provisions of the Conventions but in some cases show certain divergencies; this frequently leads to complicated administrative procedures where international transport is involved and may give rise to serious difficulties where damage extends beyond the frontiers of the States concerned.

In *Belgium,* the law of 18 July 1966 (*Moniteur belge* of 23 August 1966, page 8491 *et seq*) repealed the law of 27 July 1962 applicable to the National Research Centre at Mol. By the terms of the law of 18 July 1966, the Paris Convention becomes part of the national law in Belgium, in anticipation of its passing into international law. This provisional law incorporates the main implementing procedures provided for by the Paris Convention. The law or implementation proper of the two Conventions is now before the legislative bodies.

In *West Germany,* the applicable provisions are those of the 1959 law on atomic energy, which will nevertheless have to be amended when the Conventions are ratified. The Federal Government plans to submit, not later than 1969, the bill for ratification and the bill for adaptation of the "Atom Law" to the Conventions.

In *France,* the provisional law promulgated in 1965 is to be superseded when the Conventions come into force. The law for implementing the Conventions will be submitted to Parliament in 1967.

In *Italy,* the 1962 law on nuclear energy embodies regulations which accord with most of the provisions of the Conventions on liability and insurance. The Italian Government is at present engaged on preparations for submitting to Parliament the ratification law and the modifications which this entails in Italian law on nuclear energy.

In *Luxembourg,* too, the Government has started on the preliminary work for ratification of the Conventions.

In the *Netherlands,* a provisional law was passed in 1965. The Dutch Government is now preparing the way for ratification of the Conventions and amendment of the laws now in force.

DOCUMENT No. 25 NUCLEAR RISK INSURANCE

I. Insurance of JRC installations

As regards the insurance of its own nuclear installations, the Commission, in keeping with the policy which it has followed hitherto, has considered it unnecessary to cover these risks, in particular the Ispra Centre reactors, against material damage of a nuclear nature.

In the field of third-party liability, on the other hand, it has had to contend, in the case of Ispra, with the Italian legal provisions, which make it compulsory for the operator of a nuclear installation to provide financial security of five million u.a. by insurance or any other means. Up to the present, it has covered its Ispra liability by insurance.

A similar course has been adopted in the case of the CNMB.

As far as Karlsruhe is concerned, various reasons have constrained the Commission to cover its liability by its own resources.

The policy to be followed in covering Euratom's nuclear third-party liability in respect of its own installations is still under discussion between the Commission and the Member States.

II. General problems of nuclear insurance

The structure of the insurance market showed no substantial changes compared with the previous year.

A large proportion of nuclear risks are covered by "insurance pools" formed by insurance companies. Such a pool operates in every Community country with the exception of Luxembourg. It groups all insurance companies desirous of participating in the coverage of nuclear hazards. The companies concerned agree to underwrite for a period of one year every insurance contract concluded by the pool up to a predetermined amount. Reinsurance of nuclear risks can only be effected through the pools.

In this particular field, the British pool has the largest reinsurance capacity and is therefore the leading reassurer of nuclear risks in the Community.

Leaving aside the risks inherent in isotopes, which can be insured against with individual companies, nuclear risks are only covered by pools. In Germany, however, the insurance companies in the pool also have the right to insure, independently of the pool, nuclear third-party liability risks relating to nuclear facilities other than reactors. Although the vast majority of insurance companies in the Community still stand by their view that nuclear risks cannot be insured otherwise than by pools on a joint basis, there has nevertheless been a relaxation of their attitude. The Community pools have stated their willingness, as a general rule, to insure risks situated in other countries. This means that the regional cartel is now a thing of the past.

While facilitating the conclusion of insurance contracts, the pools system nevertheless has the effect of restricting competition.

It is a noteworthy fact that the premiums asked by nuclear insurers have for several years been following a steady downward trend.

Pending the time when the present exceptional situation on the nuclear insurance market will be remedied by an increase in the number of nuclear installations insured, the Commission has been endeavouring to persuade insurers and insured not to wait for that time but to set to work now on finding a solution, by mutual agreement, to the practical problems involved in nuclear insurance. In line with this policy, the Commission prepared and published in 1966 the Euratom skeleton third-party liability policy in respect of installations in close cooperation with Community nuclear insurers, UNICE (Union of Industries of the European Community) and the Committee for the European Community of UNIPEDE (International Union of Electric Power Producers and Distributors). This skeleton policy contains the most important elements of an insurance contract designed to cover the nuclear third-party liability of the operator of a fixed nuclear installation as laid down in the Convention on Third-Party Liability in the Field of Nuclear Energy (Paris Convention) and the Supplementary Convention (Brussels Convention).

The skeleton policy has the following salient features. It does not cover damage due to radioactive fuel, substances or waste in the course of carriage outside the nuclear installation in question. Such damage is covered by a special additional policy. Also excluded is damage caused by nuclear substances taken in charge by third parties with the object of using them for industrial, commercial, agricultural, medical or scientific purposes.

In view of the fact that the Paris Convention is covered by the legal channelling principle, coverage of the nuclear third-party liability of a person other than the operator is in practically every case superfluous.

Third-party liability cover is valid for damage suffered in any part of the world, on the basis of the law applicable in the country concerned, save where the right to compensation has been recognized by a court of a State non-signatory to the Paris Convention and where:

— the judgement in question has been obtained by fraudulent means;

— the person against whom judgement has been given has not had the opportunity to present his case in equitable conditions;

— the judgement is contrary to the public policy of the State whose law governs the relations between the parties of an insurance contract or is incompatible with the fundamental rules of justice.

The skeleton policy provides for three different amounts of financial security, namely:

— to meet the liability of the operator implicated in damage caused by a nuclear incident;

— to meet the expenses incurred by the operator in limiting or minimizing damage;

— to meet interest and costs relating to actions for compensations.

Damage caused by irradiation or contamination due to the deliberate release of ionizing radiations from the nuclear installation are not included in the cover afforded by the skeleton policy, except where an act of God has contributed to cause such damage. The fact is that the insurers are unwilling to cover damage resulting solely from normal operation and therefore not constituting an act of God.

Since nuclear third-party liability insurance is compulsory, and has been established primarily for the benefit of victims of nuclear damage, it has been laid down that the only consequence of non-fulfilment by the insured of the obligations stipulated in the insurance contract (e.g., non-payment of the insurance premium) will be to entitle the insurer to recourse against the insured or to cancel the contract, which, however, he can only do after giving not less than two months' notice of such cancellation to the insured and to the competent public authorities.

The skeleton policy described above will also form the basis of the work now being carried out with the aim of formulating a skeleton policy to cover nuclear third-party liability in respect of the carriage of nuclear substances.

DOCUMENT No. 26 MANAGEMENT OF INDUSTRIAL PROPERTY

The portfolio of Community patents continued to grow steadily. The Commission has not changed its patents policy, which is still based on the four successive statements to the Council concerning the contract-research patent system (1961), the system of "basic patents" held by contractors (1963), the Commission's attitude to the granting of licences in respect of its patents to non-Member States and to persons or enterprises outside the Community (1963), and the system of patents arising from contracts of association (1964).

1. *Communication of Patent Applications (Article 16)*

By 31 December 1966 the Commission had received details of 13,907 patent applications, 1337 of which were notified in 1966. The number of inventions covered by patent applications communicated to the Commission in the form of either accounts of contents or simple notifications totalled 10,116.

2. *Patents filed by the Community and Holders of its Contracts*

By 31 December 1966 the Commission's Patents Office had examined 1075 proposals for inventions stemming from the research programme. These inventions, between the entry into force of the Treaty and the end of 1966, had been the subject of 904 first patent applications filed in one country on behalf of either the Community or the holders of Commission contracts, including 190 first applications filed in 1966.

The total number of patents and patent applications at that date stood at 3933. The breakdown of first applications by holder is as follows:

Community	353
Contractors and associates	408
DRAGON	127
Miscellaneous	16
	904

The breakdown by programme is as follows:

	1966	Total (1958-1966)
Ispra + ORGEL	39	261
Fast reactors	58	152
Fusion	26	98
DRAGON	17	128
THTR	13	61
Others	37	204
	190	904

A list of the patent applications filed between 1 January and 31 December 1966 is given in Document No. 34.

The periodical *Euratom Information* publishes the administrative details concerning the patents granted and their principal claims.

3. *Exploiting the Portfolio Patents*

In 1966 five licence contracts were concluded. These licences were granted in respect of patents concerning a digital frequency multiplier, a process and device for coating surfaces, a thin-layer chromatography plate developing rig and an electrical connecting device with automatic series mounting. In most cases, the contracts likewise cover technical assistance in the development of equipment or processes. Still being negotiated are a licence and technical assistance contract relating to SAP manufacture, for which agreement in principle has already been obtained, a contract concerning laboratory equipment (interchangeable column body for a rig for fractional distillation of substances, especially solids, with high boiling points), and a contract for developing composite units of a universal human-body scanning device, a collimator for high-energy radiation and a device for drawing up scintillograms.

4. *Standardization of Industrial Property Rights Within the Community*

The Commission continued its participation in the work on the preliminary draft European Patents Convention.

DOCUMENT No. 27 SAFEGUARDS AND CONTROLS

I Field of application of regulations Nos. 7 and 8

The table below shows the extension of the field of application of the Commission's Regulations Nos. 7 and 8 to installations in the Community.

	Number of installations				
	1.1.63	1.1.64	1.1.65	1.1.66	1.1.67
Regulation No. 7	97	117	135	165	185
Regulation No. 8	134	155	168	192	216

Regulation No. 7 lays down the basic technical characteristics to be communicated to the Commission by all nuclear installations.

Regulation No. 8 prescribes the data relating to stocks and movements of source materials or special fissile materials to be supplied to the Commission regularly by the enterprises concerned.

II. Notification of technical characteristics of installations (Regulation No. 7)

Installations whose basic technical characteristics had been communicated to the Commission by 1 January 1967 are set out in the following table according to industry:

	Belgium	France	Germany	Italy	Netherlands	Community
Concentrate fabrication	1 [1]	4	1	2 [2]	—	8
Fuel fabrication	1	8	1	—	—	10
Fuel element fabrication	3 [3]	5	6 [2]	2	—	16
Reactors	8 [5]	34 [7]	34 [4]	23 [4]	9	108
Irradiated fuel reprocessing	1	1	—	1	—	3
Laboratories	5	8	13	12 [6]	—	38
Materials depot	—	1	—	1	—	2
	19	61	55	41	9	185

1) Outside the Community (Democratic Republic of the Congo).
2) One installation halted.
3) Including two installations halted.
4) Including one shut-down reactor.
5) Including one reactor outside the Community.
6) Including two laboratories no longer reprocessing nuclear material.
7) Including three shut-down reactors.

III. Materials, stocks and movements (Regulation No. 8)

The figures below show the position regarding the implementation of Regulation No. 8 at 1 January 1967.

a) The enterprises, establishments and installations to which Regulation No. 8 applies are distributed as follows:

	Belgium	France	Germany	Italy	Netherlands	Community
Enterprises	7	17	38	15	10	87
Establishments	8	48	40	21	10	127
Installations :	16	85	61	37	17	216
Mines	—	22	2	2	—	26
Concentrate fabrication	—	4	1	—	—	5
Fuel fabrication	1	5	1	—	—	7
Fuel element fabrication	1	8	5	2	1	17
Reactors	7	32	34	21	8	102
Irradiated fuel processing	1	1	—	1	—	3
Laboratories	6	11	18	10	8	55
Depots	—	2	—	1	—	3

b) Stocks held and stock movements within the Community:

— Ores: 10 enterprises send the Commission quarterly statements of output and stocks at 26 mines;

— Source materials and special fissile materials: 81 enterprises send the Commission the balance-sheets and inventories of 190 installations.

c) Export and import transactions with non-Member States:

— 32 enterprises sent the Commission 486 import or export declarations relating to the transfer of the following, to or from non-Member States:

	Imports	*Exports*
— Natural uranium	81	27
— Depleted uranium	18	13
— Thorium	36	78
— Special fissile materials	152	81
	287	199

A total of 106 of these imports and 43 of the exports related to materials delivered to the Community under agreements for cooperation.

d) The following tables show the growth of activity in the principal sectors of the fuel cycle, together with the increase in the volume of materials covered by commitments assumed by the Community in agreements with non-Member States.

STOCKS OF IMPORTED SPECIAL FISSILE MATERIALS

	Bilateral agreements concluded by									
	Community	Member States	Community	Member States	Community	Member States	Community	Member States	Community	Member States
	31.12.1962		31.12.1963		31.12.1964		31.12.1965		31.12.1966	
Enriched uranium (U-235 kg)										
Research centres	2	98	4	151	2	545	8	232	32	235
Fuel production	1	138	130	473	212	588	1,165	797	1,663	652
Reactors	106	680	1,145	836	2,661	1,074	3,476	1,230	5,939	1,495
Depots	—	—	—	—	—	—	142	298	32	317
	109	916	1,279	1,460	2,875	2,207	4,791	2,557	7,666	2,699
Total for Community	1,025		2,739		5,082		7,348		10,365	

***

	Bilateral agreements concluded by									
	Community	Member States	Community	Member States	Community	Member States	Community	Member States	Community	Member States
	31.12.1962		31.12.1963		31.12.1964		31.12.1965		31.12.1966	
Plutonium (kg)										
Research centres	1.0	1.0	8.0	4.0	51.0	4.4	121.9	7.7	191.2	8.0
Industrial installations	—	—	—	—	—	—	116.1	5.5	66.0	1.5
Reactors	0.2	0.1	0.4	0.2	2.0	0.2	80.8	1.4	228.6	1.4
Depots	—	—	—	—	—	—	17.1	—	8.9	—
	1.2	1.1	8.4	4.2	53.0	4.6	335.9	14.6	494.7	10.9
Total for Community	2.3		12.6		57.6		350.5		505.6	

STOCKS OF NATURAL URANIUM (TONNES) IN REACTORS IN THE COMMUNITY, AT:

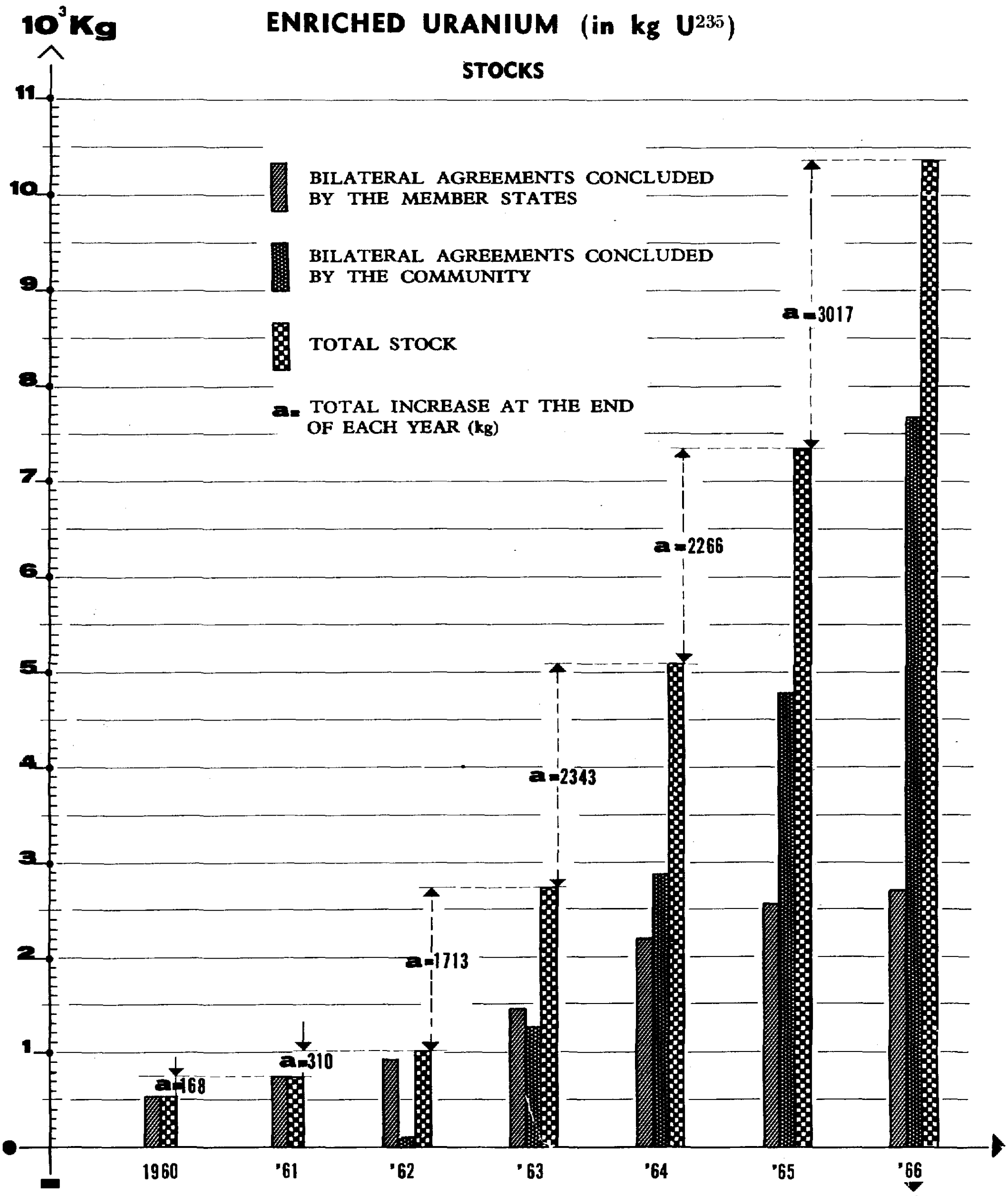
	31.12.1962	31.12.1963	31.12.1964	31.12.1965
Reactors	669	844	1230	1781

e) The following graphs illustrate the trend in stocks and imports of enriched uranium and plutonium within the Community in recent years.

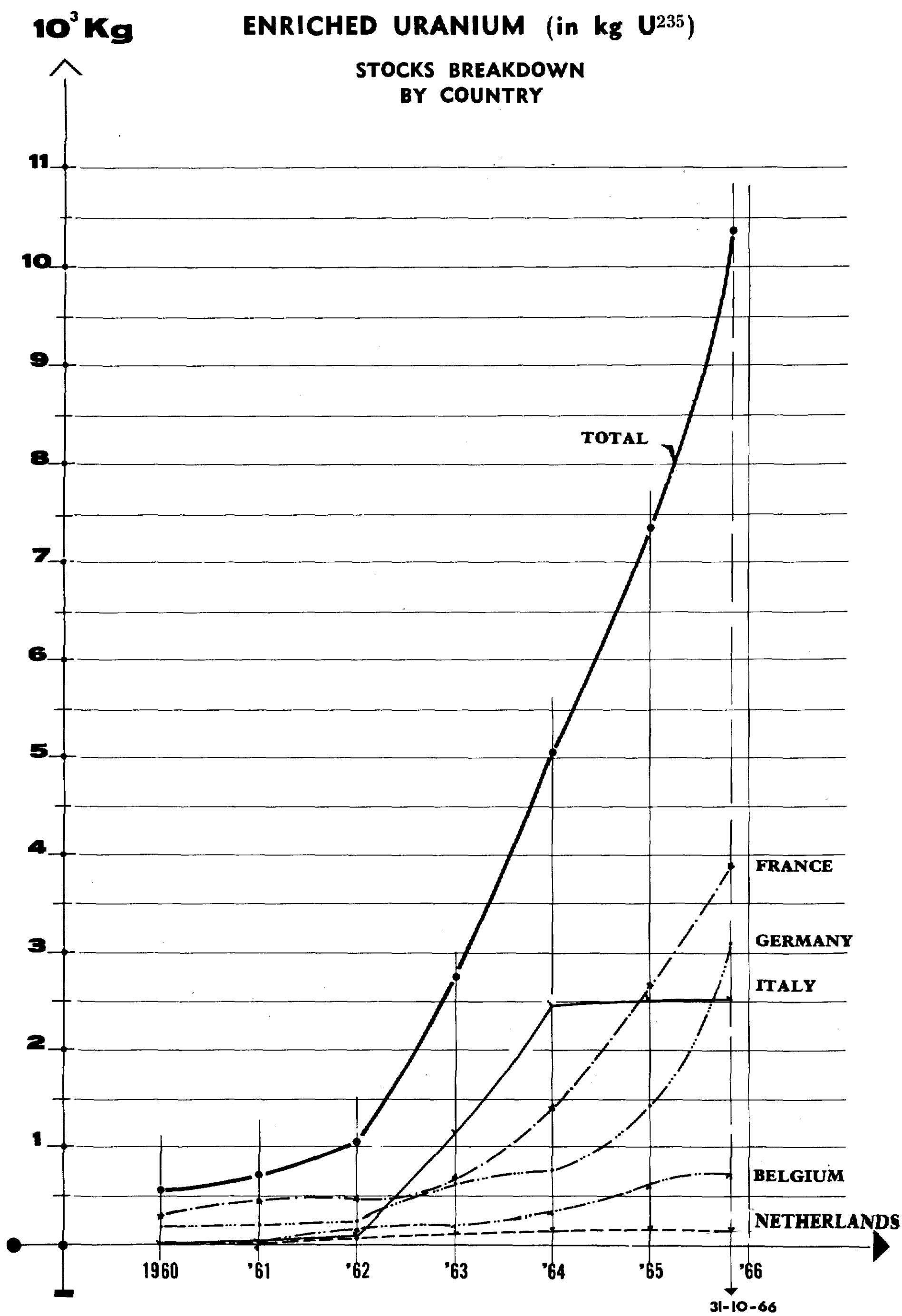
IV. Inspections

During 1966, a total of 110 inspections were carried out. The overall number of inspections effected up to the end of 1966 amounted to:

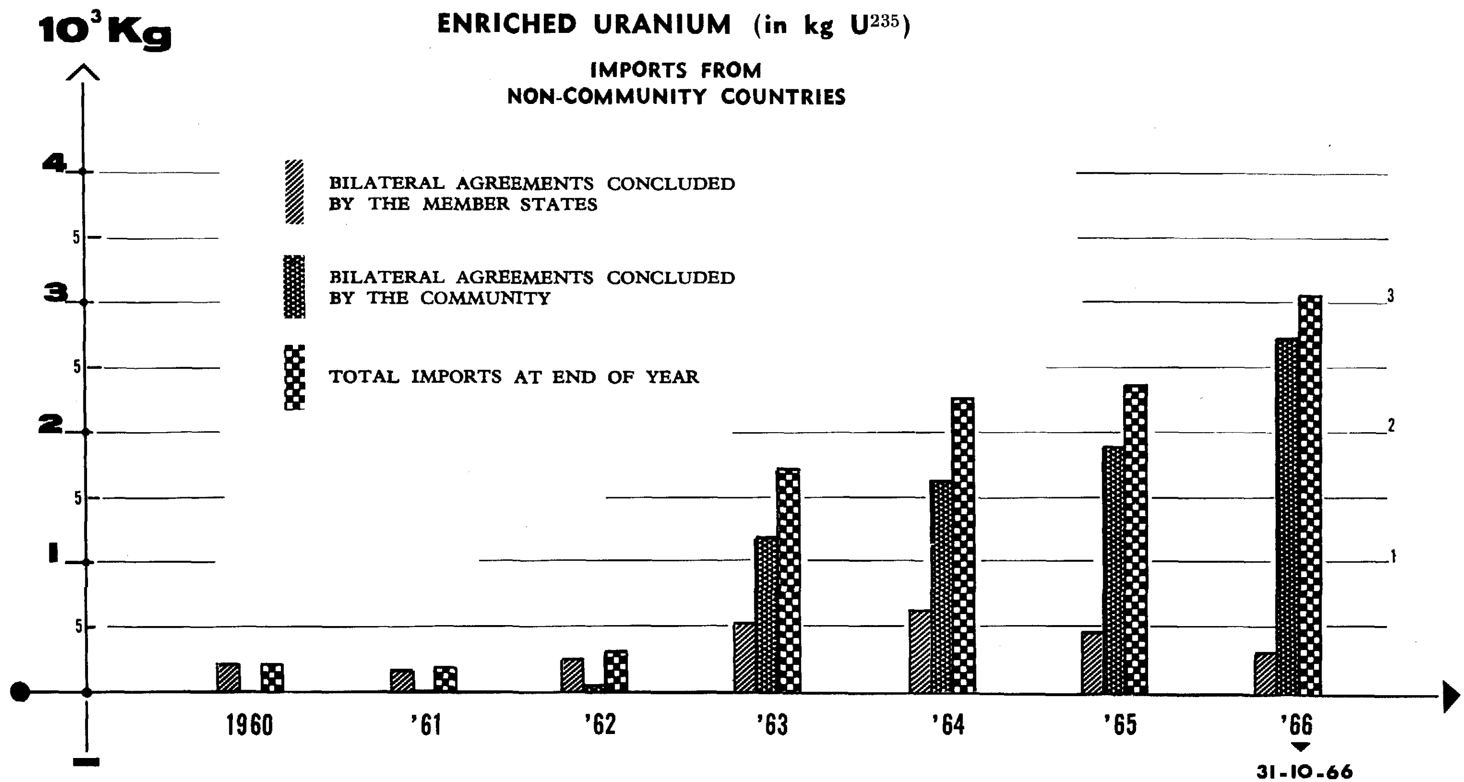
	No. of inspections
Concentration plants	4
Fuel preparation plants	21
Fuel element fabrication plants	41
Power reactors	36
Research reactors	134
Research laboratories	51
Irradiated fuel reprocessing plants	7
	294



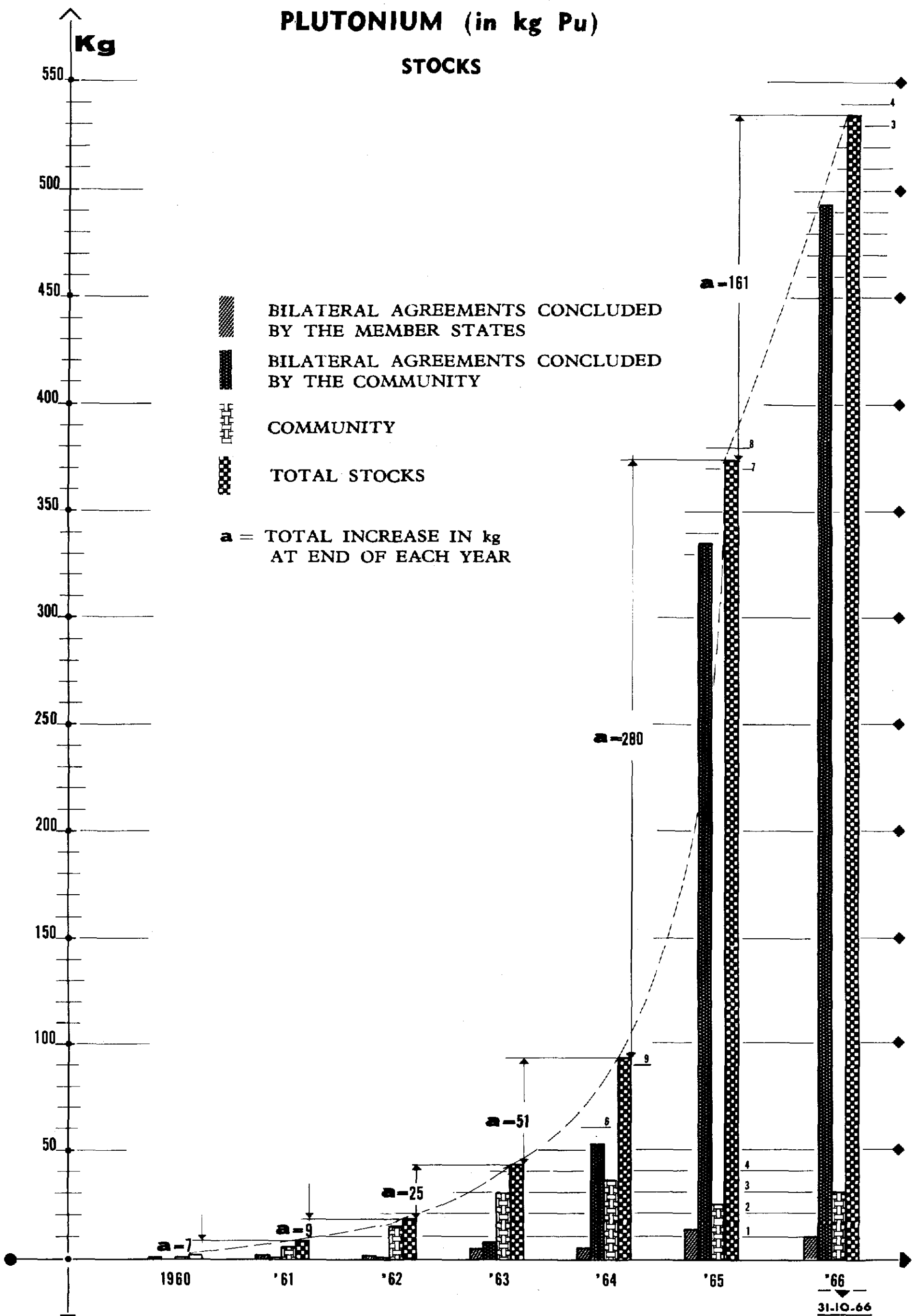
N.B. — THE BILATERAL AGREEMENT CONCLUDED BETWEEN FRANCE AND UNITED STATES HAD NOT YET EXPIRED BY THIS DATE (19-11-66)



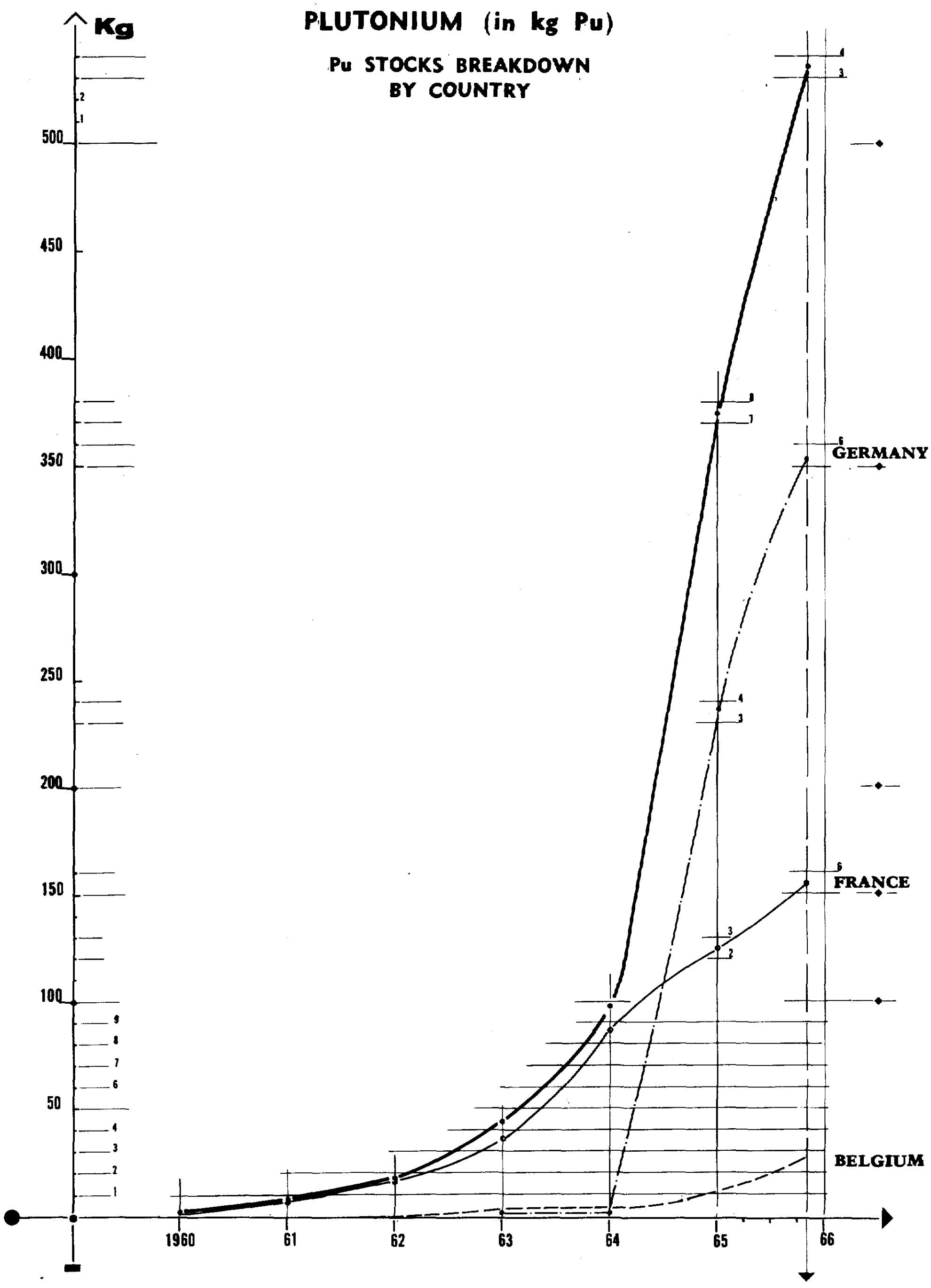
10^3 Kg
ENRICHED URANIUM (in kg U^{235})
STOCKS BREAKDOWN
BY COUNTRY
11
10
9
8
7
6
5
4
3
2
1
TOTAL
FRANCE
GERMANY
ITALY
BELGIUM
NETHERLANDS
1960
'61
'62
'63
'64
'65
'66
31-10-66



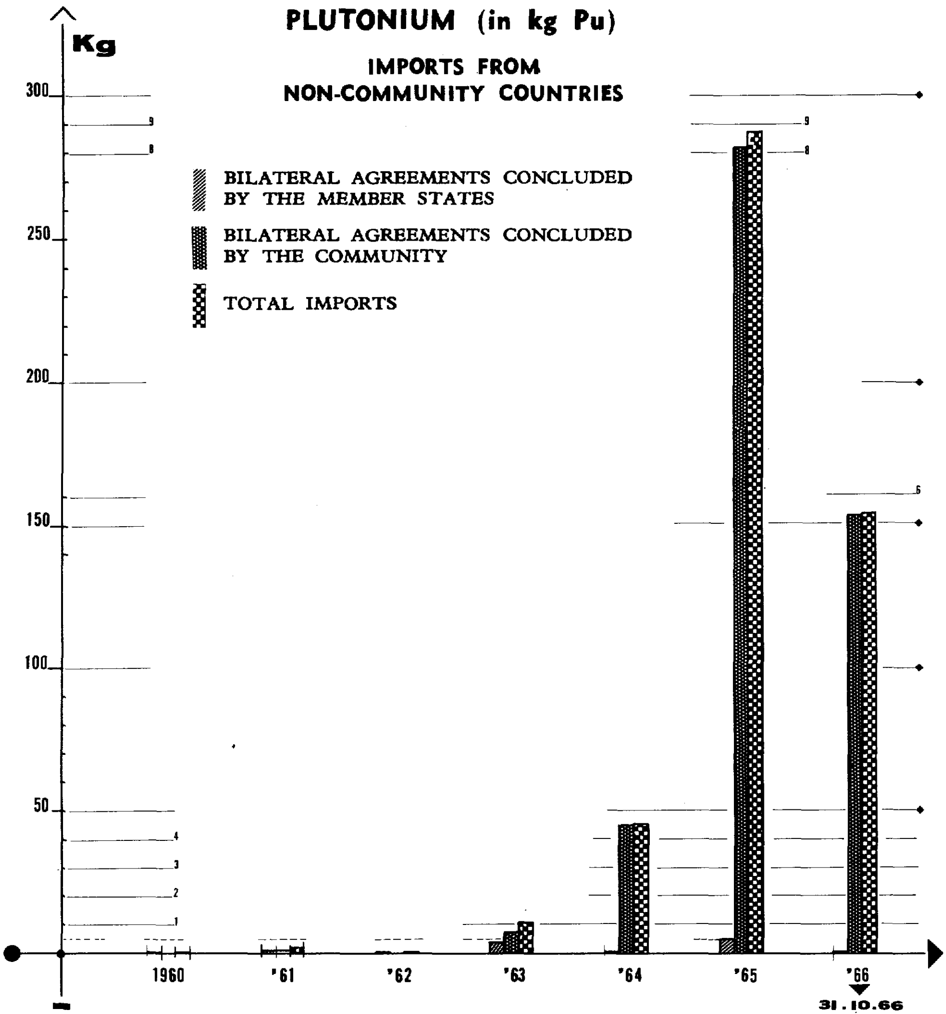
10³ Kg
ENRICHED URANIUM (in kg U235)
IMPORTS FROM
NON-COMMUNITY COUNTRIES
BILATERAL AGREEMENTS CONCLUDED
BY THE MEMBER STATES
BILATERAL AGREEMENTS CONCLUDED
BY THE COMMUNITY
TOTAL IMPORTS AT END OF YEAR
4
5
3
5
2
5
1
5
1960
'61
'62
'63
'64
'65
'66
31-10-66



N.B. — THE BILATERAL AGREEMENT CONCLUDED BETWEEN FRANCE AND THE UNITED STATES HAD NOT YET EXPIRED BY THIS DATE (19-11-66)



N.B. — THE ITALIAN AND DUTCH STOCKS DO NOT EXCEED 1 kg



PLUTONIUM (in kg Pu)
IMPORTS FROM NON-COMMUNITY COUNTRIES
Kg
300
250
200
150
100
50
BILATERAL AGREEMENTS CONCLUDED BY THE MEMBER STATES
BILATERAL AGREEMENTS CONCLUDED BY THE COMMUNITY
TOTAL IMPORTS
1960
'61
'62
'63
'64
'65
'66
31.10.66

DOCUMENT No. 28 — ACTIVITIES OF THE SUPPLY AGENCY

The Supply Agency's activities in the commercial field developed considerably in 1966 as regards both the leasing and the sale of enriched uranium and plutonium.

The framework contract for the leasing of enriched uranium, concluded with the USAEC in 1963, enabled substantial quantities of enriched uranium to be made available to Community users to meet nuclear research requirements.

This uranium was for the following test reactors:

— PEGASE at Cadarache (17 kg uranium with a U-235 enrichment of 93%)

— HFR at Petten (31.7 kg uranium with a U-235 enrichment of 90%)

— BR-2 at Mol (52 kg uranium with a U-235 enrichment of 90%).

These supplies represent a total value of $1,100,000.

Under the framework contract for the short-term leasing of enriched uranium, signed with the USAEC at the end of 1964, for the exclusive purpose of supplying the fast reactor programme, 321 kg of uranium with enrichments ranging from 30 to 93% were imported into the Community in 1966, to the value of $3,750,000.

Other orders placed in 1966 will not be delivered until the beginning of 1967; these relate in particular to 2346 kg of uranium with U-235 enrichments of 20-35%, representing a value of $8,100,000.

To these leases must be added purchases of enriched uranium effected under sales contracts concluded with the USAEC:

— 68 kg uranium with a U-235 enrichment of 93% for the OSIRIS reactor at Saclay;

— 75 kg uranium with a U-235 enrichment of 20% for the CNEN, for the fabrication of uranium samples to be irradiated under the Italian fast reactor programme;

— 13 kg uranium with a U-235 enrichment of 90% for the ESSOR reactor at Ispra.

Mention should also be made of some thirty purchase contracts covering smaller quantities of enriched uranium and plutonium. In all, the contracts with the USAEC for the purchase of plutonium and enriched uranium to meet research requirements totalled $1,400,000 in 1966.

As to plutonium, the Agency contracted with the USAEC to purchase 2 kg for the Transuranium Institute at Karlsruhe.

The Agency obtained the USAEC's permission to lease 6 kg of plutonium to Belgonucléaire. This supply could be made on a lease basis rather than as a sale because the fuel elements fabricated with this plutonium will be used for irradiations experiments in the ENRICO FERMI reactor in the United States. The plutonium is valued at $258,000.

Similarly, 6 kg of plutonium were leased to the UKAEA for Belgonucléaire's recycling programme under the Euratom/Belgonucléaire/CEN Association.

In addition, during 1966 about 150 kg of plutonium were delivered under the fast reactor programme in line with the terms of the contract signed with the USAEC in June 1965.

In November 1966, following the expiry of the France/US Agreement for Cooperation, the special fissile materials supplied to French users under this agreement were switched over to the Euratom/US Agreement for Cooperation. This transfer concerns:

— 5764 kg of plutonium, and

— 1355 kg of U-235 in uranium with various enrichments.

Important contracts have been drawn up *to cover the nuclear fuel requirements for power reactors.* A barter agreement, negotiations for which opened in 1965, for supplying the Lingen reactor operated by the KWL (Kernkraftwerk Lingen GmbH) was signed in 1966. It covers 970 kg of U-235 in uranium with enrichments ranging between 1.68 and 2.34% and amounts to approximately $7,900,000.

The Lingen reactor was the only one, apart from the KRB (Kernkraftwerk RWE - Bayernwerk GmbH), to enjoy this advantageous form of contract, for at the beginning of 1966 the USAEC decided to abandon barter agreements under its general policy.

For supplies to the GKN (NV Gemeenschappelijke Kernenergiecentrale Nederland) and KWO (Kernkraftwerk Obrigheim GmbH) power reactors, the Agency concluded two sales contracts with the USAEC:

— the first for 290 kg of U-235 in 2.5%-enriched uranium with a value of $2,300,000;

— the second for 1160 kg of U-235 in uranium with an average enrichment of 2.8%, valued at $9,600,000.

The total sum of power reactor supply contracts concluded by the Agency in 1966, which virtually cover only the first core charge for the above-mentioned reactors, amounts to $19,800,000.

It should be pointed out that during the negotiations for all these contracts the Agency succeeded in obtaining for users in the European Community more favourable clauses than in the past as regards analysis procedures and the taking back by the USAEC of materials that do not comply with the specifications requested.

DOCUMENT No. 29 — HEALTH AND SAFETY LEGISLATION ENACTED AND DRAFT TEXTS SUBMITTED TO THE COMMISSION UNDER ARTICLE 33 OF THE EURATOM TREATY DURING 1966

Belgium

Belgium communicated to the Commission, under Article 33 of the Treaty, a draft royal decree relating to the general military regulation of protection against ionizing radiations.

The following texts, upon which the Commission had already given an opinion, came into force in 1966:

— the royal decree of 17 May 1966 amending the royal decree of 28 February 1963 relating to the general regulation of the protection of the population and workers against the hazard of ionizing radiations;

— a circular relating to irradiation tables;

— a circular relating to interpretation of the definition of the controlled area.

France

In France the following texts, upon which the Commission had already given an opinion, came into force in 1966:

— the decree of 20 June 1966 relating to the general principles of protection against ionizing radiations;

— the decree of 1st July 1966 amending the regulation on the transportation of dangerous materials.

Italy

Italy communicated the following to the Commission under Article 33 of the Treaty:

— a draft decree concerning the transportation of radioactive substances, adopted in implementation of Article 5 of the nuclear law;

— a draft decree laying down the procedures relating to the declaration of holdings and the keeping of accounts of radioactive materials;

— a draft decree relating to the nuclear installations that are subject to the terms of Article 5 of DPR No. 185 dated 13 February 1964;

— a draft decree concerning the definition of types of radiation-producing devices the use of which may entail ionizing radiation hazards.

The following texts came into force in 1966:

— the first two decrees mentioned above;

— a decree concerning the classification of commercial undertakings;

— a decree concerning the procedure for the delivery of a favourable opinion on commercial undertakings of category B;

— a decree amending and amplifying the law of 31 December 1962 on the peaceful uses of nuclear energy.

The last three decrees had been communicated to the Commission in draft form in 1965.

DOCUMENT No. 30 BACKGROUND RADIOACTIVITY

Every Community country has laboratories monitoring the radioactive contamination of the air, precipitation, water and foodstuffs. The findings are sent to the Commission, which analyzes and publishes them in the form of quarterly and annual reports.

The air, precipitation and water measurements relate mainly to overall beta activity, but in foodstuffs it is chiefly the concentration of strontium-90 and caesium-137 that is determined.

Of the vectors that carry fission products from nuclear tests to man, milk is generally the most important in the Community countries. The figures for the radioactive contamination of milk are published in the quarterly reports together with those for air and precipitations. The figures for radioactive contamination of other foodstuffs are issued in the annual reports, which give an estimate of the average annual strontium-90 uptake in man.

Owing to the relatively long time required to send in the strontium-90 findings, it is not possible to include information on the 1966 radioactive contamination of other foodstuffs in the present report.

I. Radioactive contamination of the air and fall-out in 1966

The attached graphs show, on the one hand, the daily values for radioactive contamination of the air observed at the Brussels, Ispra (Euratom JRC) and Bari stations during 1966; they also show the monthly average values observed at these stations since 1959.

The values obtained for averall beta radioactivity in the air remained at the very low level already recorded at the end of 1965 (less than 0.1 pC/m^3) excepting the monthly values for June and July, which were slightly affected by the French and Chinese nuclear tests. As regards the Community, the average monthly value did not exceed 0.3 pC/m^3 for June 1966.

As to radioactive fall-out, it is estimated that in 1966 the overall beta activity fell by a factor of 2.2 with respect to the previous year (63 mC/km^2 for 1965 and 26.2 mC/km^2 for the first nine months of 1966).

II. Radioactive contamination of milk in 1965

Generally speaking, the surveillance programmes on milk contamination in the Community countries were maintained and in some cases the number of samplings was increased. An endeavour to standardize the actual measuring systems was observable in certain countries.

The average monthly strontium-90 and caesium-137 concentrations in the Community countries and, for comparison purposes, in the United States and Canada, are shown in the attached graphs.

The downward trend in milk contamination which started in early 1964 continued in 1965. The annual strontium-90 average for 1964 was 27.1 pC/g Ca; in 1965 it was 20.9 and was thus reduced by a factor of about 1.3. The monthly strontium-90 averages remained fairly level around 25 pC/g Ca during the first six months, whereas in the last five months the value obtained was always lower than 20 pC/g Ca.

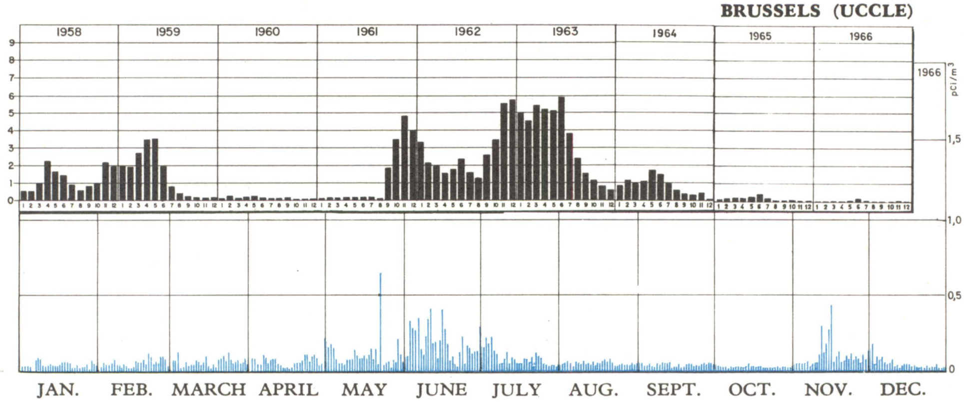
As to caesium-137 the monthly average, which was 156 pC/litre in 1964, decreased by a factor of about 1.6 in 1965, to 95 pC/litre. The highest monthly average values were recorded in the first quarter of the year (140 pC/litre). During the next two quarters a gradual fall can be observed, down to a value of 65 pC/litre for the last three months, i.e., a drop of a factor of 2.15. As in the previous year, this effect was more pronounced with caesium-137 than with strontium-90.

The strontium-90 concentration values obtained at the end of 1965 amount to no more than 45% of the maximum values recorded in the summer of 1965. The caesium-137 concentrations found at the end of 1965 are at most a quarter of the maximum 1963 summer values.

It will be observed that the average values found in Canada, the United States and the United Kingdom followed a similar curve.

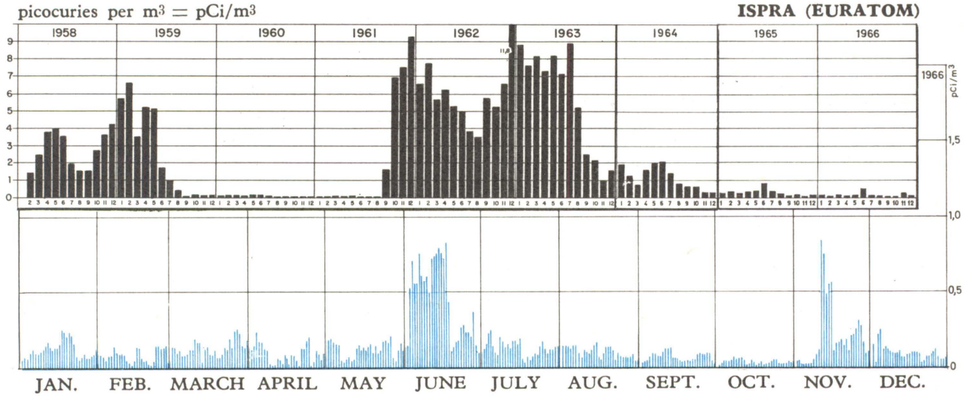
ARTIFICIAL BETA ACTIVITY IN AIR

BRUSSELS (UCCLE)



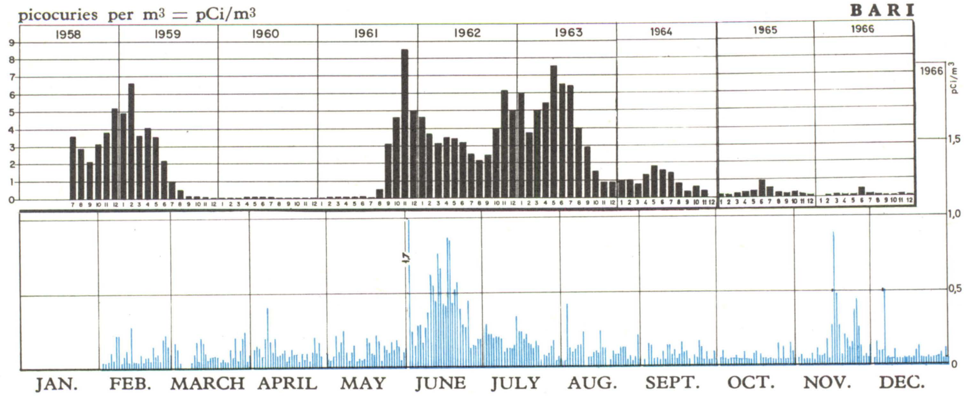
picocuries per m3 = pCi/m3

ISPRA (EURATOM)



picocuries per m3 = pCi/m3

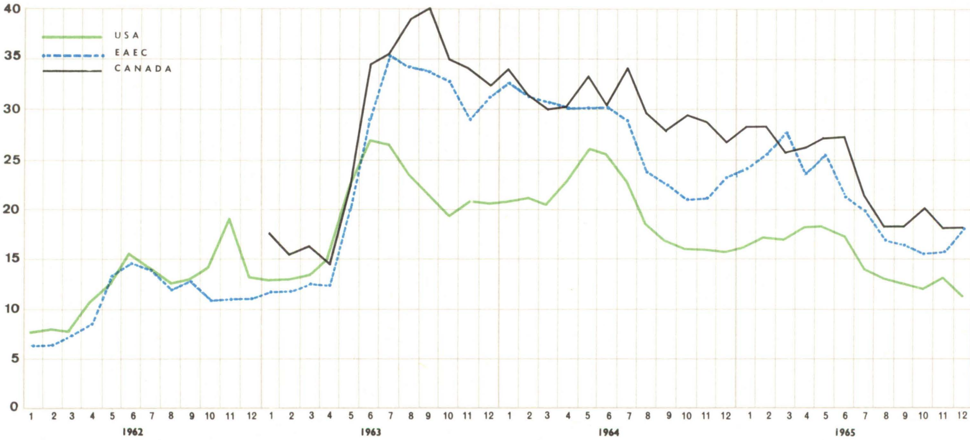
BARI



Example of artificial atmospheric beta radioactivity measurement in 1966 and from 1958 tot 1966 at Brussels, Ispra and Bari.

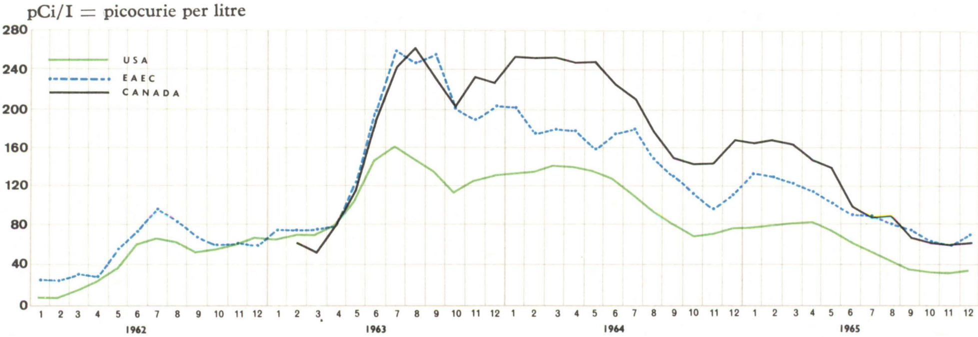
^{90}Sr IN MILK

pCi/gCa = picocurie per gramme of calcium



^{137}Cs IN MILK

pCi/l = picocurie per litre



Radioactive contamination in milk by ^{90}Sr and ^{137}Cs from 1962 to 1965 in the Community countries and the USA and Canada.

DOCUMENT No. 31 NUCLEAR PLANT SAFETY

I. Safety assessment studies relating to certain nuclear installations

The studies being carried out in fulfilment of the basic contracts concluded with companies operating nuclear power plants under the Euratom/US Agreement for Cooperation were continued, as were the assessments under contracts concluded at the request of governments or stemming from agreements between the authorities of certain Member States and the Commission.

As in the past, close collaboration with the competent national authorities and bodies was maintained in these studies, with which experts from the other Member States and, where appropriate, from outside the Community, were associated on the broadest possible basis.

Apart from the investigations and verifying calculations, this work occasioned numerous fruitful discussions with the operators and principal suppliers of the nuclear installations concerned.

1. *ENEL-SENN Power Plant, Garigliano*

The studies effected in consultation with the competent departments of the CNEN and with the cooperation of German experts and USAEC technical advisers were in the past year devoted mainly to the difficulties encountered during the initial period of operating the plant. An assessment report was drawn up and sent to the Euratom/US Joint Reactor Board, the CNEN and the ENEL.

2. *Franco-Belgian SENA Power Plant, Chooz*

The technical studies conducted jointly with the competent departments of the CEA and with the cooperation of experts from the Italian CNEN, the Institut für Mess- und Regelungstechnik of the University of Munich, and the Belgian CEN culminated in the preparation of two assessment reports before the commissioning of the power plant. The first report was the outcome of the Commission's obligation to pass an opinion on the proposal to upgrade the rated power from 210 to 266 MWe. The second covered all safety aspects of the plant with a view to its start-up, which took place in the second half of 1966.

Both these reports were sent to the Euratom/US Joint Reactor Board, the competent French and Belgian authorities and the SENA company.

3. *KRB Power Plant, Gundremmingen*

The studies, for which the help of the experts of the Institut für Mess- und Regelungstechnik and the Italian CNEN was called in, ended with the preparation of an assessment report prior to start-up of the plant (September 1966), which was sent to the various competent authorities and bodies in West Germany, the KRB company and the Euratom/US Joint Reactor Board.

4. *GKN Power Plant, Dodewaard*

The practical procedures for cooperation with the competent Dutch authorities were established at the start of 1966, and the past year has been spent in initial discussions with the operators and constructors of the power plant, regarding specific safety aspects.

The studies are being effected with the collaboration of outside experts from the Italian CNEN, the French CEA, the Institut für Mess- und Regelungstechnik, Munich, the Cologne Institut für Reaktorsicherheit, the Rhineland TÜV (Technical Inspection Authority), the Bavarian TÜV and the Belgian CEN.

5. *Nuclear Vessel "Otto Hahn" and Joint Enterprise KWL*

The practical procedures for cooperation between the competent German technical departments in safety matters and Euratom, assisted by experts from the other Member States and, where appropriate, other countries, have now been established.

6. *Marine Propulsion - NS "Savannah"*

The studies conducted jointly with the shipping classification offices of Germanischer Lloyd (Germany) and the Bureau Veritas (France) on the safety aspects of the initial operation of the NS "Savannah" gave rise to the publication of the fifth report prepared by this joint working group. The report has been widely circulated inside and outside the Community in all circles concerned with nuclear marine propulsion.

7. *Eurochemic*

The Belgian government again asked the Commission for an opinion on the operational safety of the Eurochemic reprocessing plant; this time the request concerned the whole plant, i.e., the sections for reprocessing both low-enrichment and high-enrichment irradiated fuels. Following this request, the Commission set up virtually the same committee of experts as had previously drawn up a safety assessment of the adaptation of the Eurochemic installations to the reprocessing of highly-enriched fuels. The work under this committee has reached an advanced stage.

The Commission's departments continued to participate as before in the work of the Eurochemic/Belgian Public Health liaison committee.

II. Harmonization through systematic pooling of knowledge, ideas and experience in the field of nuclear plant safety techniques

The specialist working groups through which it is hoped, by systematic pooling of ideas and experience, to achieve greater technical harmonization should be divided up as follows, according to the broad opinion of the national experts consulted:

Group 1: to define the range and scope of safety analyses; to draw up, as far as possible, a standard form for safety reports; to review analysis methods; to study the design requirements for plants that are to be sited in densely populated areas; to develop design criteria;

Group 2: to define operational limitations and requirements; to study methods of measuring typical plant variables; to define the range, scope and procedures of an inspection programme;

Group 3: to conduct a comparative study of present siting criteria and practice, and if necessary prepare a guide on this subject; examine the possibility of embodying engineered safeguards requirements and the findings of accident analyses in siting conditions and emergency plans;

Group 4: in respect of plants for fuel manufacture, fuel reprocessing and radioactive waste storage and with regard to transportation matters, to examine in turn most of the subjects listed under Groups 1-3.

III. Exchange of views on priorities in the domain of experimental programmes and tests connected with safety techniques

After the meeting of September 1966 the Commission's departments began preparing a project for listing and classifying the experimental nuclear safety programmes and related theoretical studies, current or scheduled for the future, in the various Community countries and elsewhere.

A list of this kind will serve as a practical handbook of information on nuclear safety matters and be a useful guide to the working group of technical experts. This group should draw up a list, in order of priority, of the tests and experimental work needed to supplement the theoretical data used in safety assessments of individual nuclear plants.

IV. Technical evaluation of nuclear hazard

Following up the conference of nuclear insurance firms, nuclear power plant operators and UNIPEDE, constructors and UNICE, and bodies concerned with safeguards and controls, held on 2-3 June 1966, a restricted working group on "Technical Evaluation of the Nuclear Hazard" reached the conclusion that it would be advisable:

— to arrange information courses at power plants under construction so that insurers can obtain even closer acquaintance with nuclear techniques and the various aspects of safe operation of these installations in particular;

— to set up a system for listing and classifying incidents, accidents and equipment failure, which would in time yield statistical data on power plants;

— to promote technical conferences on the analytical inventory methods hitherto used or contemplated by certain organizations and groups with regard to the reliability of mechanical and electronic equipment.

The two latter items should ultimately permit of introducing realistic probability values into studies on aspects of nuclear plant safety.

V. Relations with specialist bodies in non-Member States

Exchanges of views and information with the technical bodies that specialize in nuclear plant safety in non-Member States developed considerably in 1966, through conferences and multilateral contacts linking experts of the Member States and through active participation by the Commission's departments in projects within the ambit of the IAEA or the ENEA.

— The Brussels "Steel" conference (January 1966) on brittle fracture and safety problems was followed by more restricted group discussions on special subjects, arranged by the Commission's departments, after which agreement was reached on the lines along which an experimental programme on crack behaviour in flat and complex-geometry steel test pieces should be divided amongst various competent institutions and organizations (the UKAEA Safeguards Division, the CEA and the Staatliche Materialprüfungsanstalt, Stuttgart Technische Hochschule).

  Contacts were established with USAEC officials to explore a possible tie-in with similar programmes envisaged in the United States.

— Under the Committee on Reactor Safety Techniques (ENEA-CREST), active progress was made during the first and second committee meetings (November 1966) and at the experts' meetings, in particular the meeting on heat transfer during rapid transients, held at Cadarache in April 1966, and the meeting on interaction between impact phenomena and reactor structures, held at Ispra JRC in June 1966.

  At the second CREST meeting a restricted working group, composed of representatives of the CNEN, the Institut für Mess- und Regelungstechnik, the USAEC and Euratom, was set up. Its task is to list, in respect of water-cooled power reactors, the unknowns and uncertain factors that still exist in safety analyses, in the light of the findings so far available from the experimental safety programmes.

— The Commission's departments took an active part in the work of two special committees set up by the IAEA, the one on "Possibilities of Periodical Inspection of Steel Reactor Pressure Vessels" (Pilsen, October 1966) and the other a committee to prepare a "Code of Practices for the Safe Operation of Power Reactors" (Vienna, December 1966).

DOCUMENT No. 32 ALLOCATION OF FUNDS UNDER THE SECOND FIVE-YEAR PROGRAMME IN ACCORDANCE WITH THE COUNCIL OF MINISTERS' DECISION OF 13 MAY 1965

Beneficiary or object	Appropriations from the first programme	Appropriations under the second programme	Approximate allocation: Personnel and operating expenditure	Plant, equipment, etc.	Investment in real estate	Contracts	Reserve	Personnel employed on 1-1-63	Personnel employed on 31-12-67
	in millions of EMA u.a.								
I JRC-Ispra	6.6	80	64.8	10.9	—	4.3	—	1270	1700
II -Karlsruhe	3	25.5	8.9	7.4	3	6.2	—	60	300
III -CNMB	0.322	12	8.1	3.1	0.6	0.2	—	120	180
IV -Petten	8.5	17	8.5	8	—	0.5	—	50	300
V ORGEL programme	—	64	—	47	8.5	8.5	8.5	—	—
VI Fast reactors	—	82.5	2.9	—	—	79.6	—	25	90
VII Advanced gas reactors	6	24.5	1.5	—	—	23	—	42	60
VIII BR-2 reactor	—	14	2.1	—	—	11.9	—	60	70
IX Proven-type reactors	—	22.75	1.6	—	—	21.15	—	21	43
X Fuel reproccessing	—	5.75		—	—		—		
XI Radioactive waste processing	—	3		—	—		—		
XII New reactor types	—	7	1.4	—	—	23.35	—	20	40
XIII Marine propulsion	—	6		—	—		—		
XIV Radioisotopes	—	3		—	—		—		
XV Fusion and plasma physics	—	34	4.3	—	—	29.7	—	85	130
XVI Health and safety-Biological studies	—	16	3.5	—	—	12.5	—	60	110
XVII Training and instruction	—	2	0.3	—	—	1.7	—	7	7
XVIII Dissemination of information and general documentation	—	8.5	4	3	—	1.5	—	90	120
XIX Reserve	—	3.078	—	—	—	—	3.078	—	—
Total	24.422	430.578	111.9	79.4	12.1	224.1	3.078	1910	3150(1)

1) Maximum number of personnel laid down in Article 3 of the Council's decision adopting the second programme.

DOCUMENT No. 33 CONTRACTS AWARDED BY THE COMMISSION IN 1966 UNDER ITS RESEARCH PROGRAMME [1]

RESEARCH AND SUPPLEMENTARY CONTRACTS [2]

Subject	Number	Total sum payable by the Commission during overall period of contract (in u.a.) [3]
Contracts relating to Joint Research Centre establishments :		
(a) ISPRA		
Scientific Data Processing (CETIS)	2	68,000
Direct conversion	5	107,000
Other research	3	41,000
(b) PETTEN	1	5,000
ORGEL Project	7	186,000
Proven-type reactors	29	5,845,000
Technical and economic studies	7	105,000
Power reactors	2	100,000
Irradiated fuel reprocessing	2	15,000
Processing of radioactive wastes and residues	1	86,000
Radioisotopes		
— research	5	129,000
— industrial applications	15	173,000
Biology and health and safety	7	247,000
	86	8,007,000

Contracts: 10,500,000 u.a.

[1]) For period 1 March to 31 December 1966.

[2]) This list takes account only of those supplementary contracts which raise the financial ceiling of he previous contracts.

[3]) Amounts quoted in round figures.

CONTRACTS OF ASSOCIATION AND SUPPLEMENTARY CONTRACTS

Subject	Number	Total sum payable by the Commission during overall period of contract (in u.a.) [1]
Fast reactors	2	4,100,000
Proven-type reactors	1	800,000
New reactor types	1	940,000
Marine propulsion	2	140,000
Biology and health and safety	5	1,149,999
	11	7,129,999

[1]) Amounts quoted in round figures.

LIST OF CONTRACTS AND SUPPLEMENTARY CONTRACTS AWARDED IN 1966

I. *Contracts relating to JRC establishments*

a. ISPRA

— Scientific Data Processing (CETIS)

No. of contract	Contractor	Subject of research
039-66-03 CETI	Praxis, Milan	Continuation of CARN project. Translation of nuclear code by IBM 360 computer Adaptation of APACHE code for this type of computer
040-66-05 CETI	Ars, Milan	Improvement of methods for space-resolution of kinetic equations

— Direct Conversion

No. of contract	Contractor	Subject of research
099-64-05 CODI Suppl. Contract 3	Saes-Getters, Milan	Research on the absorption properties of materials employed in thermionic converters intended for in-pile use and the development of a getter for use in converters

No. of contract	Contractor	Subject of research
014-65-04 CODD	Brown-Boveri, Mannheim	Design and construction of thermionic converters : technological problems and materials research - design and construction of thermionic reactors; neutron physics, criticality, calculations and technological problems - research and design for heating with isotopes
017-65-05 CODF	CSF, Paris	Thermionic converter engineering studies
020-65-08 CODD Suppl. Contract 1	Prof. W. Kluge	Research on low extraction potential anodes (extension of Contract 013 CODD)
022-66-04 CODD	Feldmühle AG, Düsseldorf	Development of alumina-niobium bonds

— Other Research

No. of contract	Contractor	Subject of research
133-64-09 ISPI	University of Padua	Measurements of macroscopic cross-sections
186-66-01 ISPI	CISE, Milan	Improvement of discrimination among nuclear events by analysis of the electronic signals emitted by particles
260-66-06 ISPI	Politecnico di Milano, Milan	Determination of neutron parameters from a single fuel element

b. PETTEN

No. of contract	Contractor	Subject of research
040-65-05 PETF	CEA, Paris	Alterations to HFR reactor core configuration so as to optimize the number of experimental positions and neutron flux densities, and optimization of the physical and thermal characteristics of the HFR reactor core in order to increase the power

II. *ORGEL Project*

No. of contract	Contractor	Subject of research
174-66-01 ORGF	Cerca, Paris	Research and development of a process for diffusion welding of SAP plugs to an ORGEL SAP cladding tube
245-65-04 ORGF Suppl. Contract 2	Ugine, Paris	Protection against hydrogenation of large-diameter Zircaloy-2 tubes in contact with terphenyl
265-66-04 ORGD	University of Bonn	Analysis of terphenyl decomposition products by mass-spectrometry
267-66-07 ORGD	University of Heidelberg	Study of the configuration/stability relation in polyphenyl-related molecules
269-66-10 ORGF	Sexta Industrie, Bagneux, France	Development of high-temperature strain-gauges
282-66-07 ORGF	Institut National des Sciences Appliquées, Villeurbanne, France	Study of lubricating properties of terphenyl
203-65-03 ORGC Suppl. Contract 1	Bayer, Leverkusen Progil, Paris	Research programme, to (a) standardize methods of analyzing polyphenyls and certain of their mineral or organic impurities (b) develop special analysis methods in order to improve the interpretation of research on polyphenyls

III. *Fast reactors*

No. of contract	Contractor	Subject of research
006-61-10 RAAF Suppl. Contract 5	CEA, Paris	Allocation, for performance of Contract 006 RAAF, of 45 kg of plutonium in oxide form, to be supplied by the UKAEA
009-63-01 RAAD Suppl. Contract 3	Gesellschaft für Kernforschung, Karlsruhe	Theoretical and experimental research on fast reactors

IV. *Proven-type reactors*

No. of contract	Contractor	Subject of research
017-63-11 TEGD Suppl. Contract 2	Babcock-Wilcox, Oberhausen	Study of CO_2 corrosion of graphite under relatively high specific power conditions
022-64-01 TEGN Suppl. Contract 2	Bredero, Utrecht	Study of the influence of high temperatures, up to 400 °C, on the mechanical, physicochemical and thermal properties of concretes and their components
024-64-04 TEAI Suppl. Contract 3	CNEN, Rome	Research on heat transfer in organic liquids; irradiation tests in CIRO loop; development of a bottom-actuated "r"-type rack and pinion control-rod drive mechanism; chemical analysis of terphenyl organic liquids and their purification
047-66-09 TEGF	CEA, Paris	Definition and developemnt of two heat-resistant concretes
062-65-08 TEGD Suppl. Contract 1	KfA, Jülich	Study of gas-cooled tubular fuel elements with internal and external finning
070-65-07 TEEC Suppl. Contract 1	AEG, Berlin SNECMA, Paris	Development of a boiling-water reactor with Vortex fuel
071-66-06 TEEI RD	ENEL, Rome	Research, on the Trino Vercellese nuclear plant, concerning the development of pressurized-water reactor technology
072-65-11 TEEI	SNAM, Milan	Development of computer codes for uranium-plutonium fuel cycles in light-water reactors
073-66-11 TEEI	Ars, Milan	Critical study of burn-out
074-65-10 TEEI RD	Sorin, Saluggia	Influence of nitrogen in iron and steels subjected to neutron irradiation
075-65-06 TEGB	Brussels University	Modification and adaptation of the mathematical model constructed under earlier contract No. 093-65-4 TEGB, to take into account new theories on the operation of a European Nuclear Fuel Element Guarantee Fund

No. of contract	Contractor	Subject of research
076-65-09 TEGB	Brussels University	Modification and adaptation of the mathematical model constructed under earlier contracts, to take into account new theories on the operation of a European Nuclear Fuel Element Guarantee Fund
077-66-01 TEEI	Sorin, Saluggia	Study of neutron propagation in bent pipes surrounded by water
078-66-02 TEEI	Fiat, Turin	Development of a prototype Zircaloy fuel element assembly for pressurized-water nuclear power plants
080-66-05 TEEF	Alsthom, Paris	Computer code simulating the dynamic behaviour of a boiling-water reactor core
082-66-01 TEED	AEG, Berlin	Antireactivity of absorbent substances
084-66-03 TEED	Interatom, Cologne	Development of a non-destructive method for exact determination of the burn-up in irradiated fuel elements
085-66-01 TEED RD	AEG, Berlin	Study of thermohydrodynamic instabilities in boiling-water reactors
086-65-12 TEGI Suppl. Contract 1	SNAM, Milan	Experiments concerning the determination of the infinite multiplication factor of natural-uranium/graphite lattices by the PCTR method (extension of Contract No. 038 TEGI)
087-66-01 TEEB RD	Serai, Brussels	Specification of a recommendable surface state to limit steel corrosion in pressurized water and in high-temperature-steam
089-66-02 TEEI	Fiat, Turin Ars, Milan	Development of nuclear codes for the IBM 360 computer
090-66-10 TEEI	Sorin, Saluggia	Post-irradiation examination of steel samples
092-66-06 TEEI	ENEL, Rome	Study of plutonium recycling in light-water power reactors
093-65-04 TEGB	Brussels University	Construction of a mathematical model for prospective simulation of the functioning of a European Nuclear Fuel Element Guarantee Fund
094-66-05 TEOI	Kuenzie, Ponte Chiasso	Research on a process for purifying organic liquids so as to destroy their capacity for fouling fuel element cladding

No. of contract	Contractor	Subject of research
095-66-05 TEOI	SNAM, Milan	Study of the high-temperature mechanical properties of zirconium alloys
096-66-05 TEOI	SNAM, Milan	Study of the mechanical properties of zirconium alloys in the hot state
097-66-07 TEOI	CISE, Milan	Development of swaged joints between Zircaloy-2 tube and steel tube
098-66-06 TEEI	Fiat, Turin	Research on ENRICO FERMI pressurized-water power plant
100-66-09 TEGF	GAAA, Plessis-Robinson	Method of calculating the three-dimensional distribution of power densities and temperatures

V. *Technical and economic studies*

No. of contract	Contractor	Subject of research
027-66-04 ECIB	BEN, Brussels Sobemap, Brussels Electrobel, Brussels	Study of the repercussions of pumping-station construction on the economic situation of nuclear power plants
029-66-04 ECIC	Belgonucléaire, Brussels Soc. de Traction et d'Electricité, Brussels Atlas-Werke, Bremen	Study on the production of fresh water from seawater in installations using nuclear energy as heat source as opposed to conventional heat sources
030-66-05 ECII	Montecatini, Milan Sowit, Milan	Desalination of seawater
031-66-02 ECIF	Alsthom, Paris CEA, Paris GAAA, Plessis-Robinson SARL, Paris	Study of foreseeable ways of reducing the investment cost of graphite-gas-reactors
032-66-01 ECII	CNEN, Rome Montecatini, Milan	Study of critical temperature of irradiated fuel elements
034-66-10 ECID	Deutsches Institut für Wirtschaftsforschung, Berlin	Regional, social and energy factors governing the use of nuclear power in West Germany
035-66-07 ECID	Prof. Wessels	Effect of nuclear power on the supply situation and on cheap power

VI. *Power reactors*

No. of contract	Contractor	Subject of research
008-65-10 REPC	Munich University CNEN, Rome	Safety aspects of the KRB nuclear power plant, Gundremmingen
009-65-10 REPC	CNEN, Rome Munich University CEN, Brussels	Safety aspects of the Chooz nuclear power plant (SENA)

VII. *Irradiated fuel reprocessing*

No. of contract	Contractor	Subject of research
008-66-06 RCID	Braunschweig University	Protactinium chemistry
008-65-06 RCIS Suppl. Contract 2	Battelle Institute, Geneva	Development of a ceramic crucible materiel for uranium melting

VIII. *Processing of radioactive wastes and residues*

No. of contract	Contractor	Subject of research
003-65-03 WASF	Ets. Kuhlmann, Paris	Research on the processing of radioactive effluents by means of zeolite silicates and on the problems raised by the use of detergents

IX. *New reactor types*

No. of contract	Contractor	Subject of research
002-64-04 NTAN formerly No. 002-63-04 SUAN Suppl. Contract 1	KEMA, Arnhem	Research concerning homogeneous aqueous suspension (SUSPOP) reactors

X. *Marine propulsion*

No. of contract	Contractor	Subject of research
002-61-01 PNID Suppl. Contract 2	GKSS, Hamburg	Work programme to advance the development of nuclear techniques in marine propulsion
007-61-06 PNIN Suppl. Contract 2	Reactor Centrum Nederland, The Hague	Preparation of construction plans and sufficiently detailed data to permit an assessment of the feasibility of building a prototype PWR marine reactor (theoretical and experimental work)

XI. *Radioisotopes*

a) Research

No. of contract	Contractor	Subject of research
078-64-06 RISN	TNO, The Hague	Tritium labelling by isotope exchange
089-66-10 RISD	Prof. Lieser, Darmstadt	Short-lived radioelement generators
091-67-01 RISF	Montpellier University	Study of labelled water-soluble lipid complexes
092-67-01 RISF	Centre de Biochimie Humaine, Paris	Preparation of tritium-labelled steroids
093-67-01 RISD	Battelle Institute, Frankfurt	Study of tritiation in liquid ammonia

b) Industry

No. of contract	Contractor	Subject of research
027-66-04 IRAF	Conservatome, Courbevoie	Study of the technical and economic conditions for use of a mobile irradiation source for promotion purposes among Community industries
031-66-10 IRAB	Comasci, Brussels	Technical and economic studies concerning the use of irradiation in the timber industry. Aid to secretariat of the study group on the use of radiation techniques in the timber industry, to be set up by the Commission

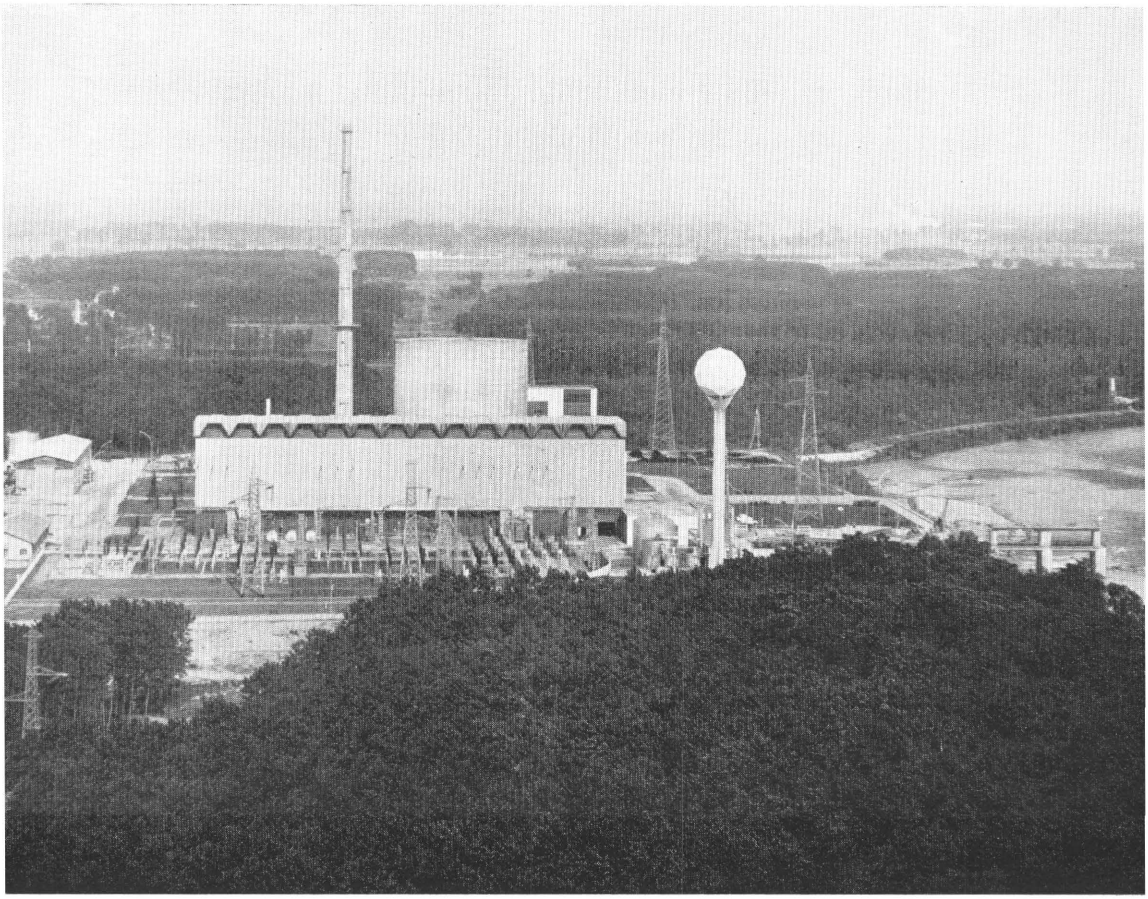
No. of contract	Contractor	Subject of research
033-66-10 IRAF	AGS, Paris	Research and development of gammagraphy for the non-destructive inspection of concrete civil engineering structures
039-66-07 IRAB	CEN, Brussels	Study of the non-technical conditions for the use of sealed sources in industry (thickness, level and density gauges only)
046-64-09 IRAI Suppl. Contract 1	Sorin, Saluggia	Application of radioisotopes in the textile industry
050-64-09 IRAI Suppl. Contract 1	Sorin, Saluggia	Application of radioisotopes in the textile industry
084-66-07 IRAD	Dr. Lothar Wiesner, Hanover	Application of radioisotopes in the textile industry
096-66-04 IRAD	Dr. Assemeyer	Development and construction of an instrument for measuring the density of beer
099-66-09 IRAF	Hispano-Suiza, Bois-Colombe, France	Design and construction of a thermoelectric conversion generator of about 200 MW output using bismuth telluride thermocouples and strontium-90 titanate heating elements
100-66-04 IRAD	Frieseke Höpfner, Erlangen	Preparation of a radiometric method and development and construction of a prototype rig for in-brewery measurement of the density of wort and beer
101-66-04 IRAI	Sorin, Saluggia	Performance of industrial controls, particularly in textile factories, by means of radioactive tracers
102-66-10 IRAB	Ghent University	Development of an automatic system for activation analysis of silicon in steels and of silicon and phosphorus in cast iron
103-66-05 IRAI	Mr. Ennio Denti	Programme on industrial uses for irradiation techniques, preparatory to a Community promotion campaign
105-66-04 IRAD	Prof. W. Stander, Karlsruhe	Development of radiometric instruments and methods for measuring and checking the hydraulic transportation of bulk materials by pipeline
106-66-07 IRAD	Land Schleswig-Holstein, Kiel	Construction and trial of a sea-bed sampling rig

XII. *Biology*

No. of contract	Contractor	Subject of research
007-61-10 BIAB Letter Suppl. Contract 1	Brussels University	Research on molecular biology (DNA, RNA and protein relationships) and radiobiology
024-63-02 BIAI Suppl. Contract 1	CNEN, Rome	Absorption, accumulation and loss of radioelements in marine organisms, and biological equilibrium in the ocean
059-65-07 BIOB	CEN, Brussels	Study of biological indicators and first lesions appearing after irradiation
060-66-01 BIAI sequel to No. 021 BIO	CNEN, Rome	Immunogenetics research
061-66-03 BIOI	Turin University	Metabolism of nucleic acids in cells of leukaemia patients
062-66-01 BIAN sequel to No. 029 BIA	TNO, The Hague	Bone-marrow transplantation in monkeys Breeding of pathogenic-germ-free rodents
063-66-05 BIOF	Claude Bernard, Paris	Radiation action on blood platelets

XIII. *Health and safety*

No. of contract	Contractor	Subject of research
003-61-10 PSAF Suppl. Contract 3	CEA, Paris	Study of radioactive contamination of the environment and food chain
025-65-11 PSTI	Turin University	Systematic study of nuclear reactors for biological dosimetry and protection purposes
029-66-09 PSTD	Freistaat Bayern, Munich	Development of new, original skin-decontamination processes against contamination caused by the handling of radioactive substances
030-66-11 PSTF	Kuhlmann, Paris	Decontamination of water containing radioactive ruthenium isotopes
024-65-11 PSTD	KfA, Jülich	Thermoluminescent dosimetry, pulsed radiation field dosimetry and the development of a non-photographic personal dosimeter



TRINO VERCELLESE (Italy) — THE "ENRICO FERMI" NUCLEAR POWER PLANT

(See other side of page for caption)

A vast study programme on the "Enrico Fermi" pressurized-water power plant is now in progress with ENEL. In addition to its direct interest with regard to the pressurized-water power plants now under construction, this programme is aimed at yielding the technical and safety data necessary for raising the power of the Trino Vercellese reactor.

DOCUMENT No. 34 ACTIVITIES OF THE CENTRE FOR INFORMATION AND DOCUMENTATION (CID)

The Centre for Information and Documentation (CID) continued developing its activities in 1966 in the two fields of scientific and technical documentation and dissemination of the scientific and technical knowledge acquired during the course of the Community's research programme.

As regards documentation, the outstanding feature of 1966 was that Euratom's computerized nuclear documentation system came into service, the use of it being limited, during the initial trial stage, to research workers of the Joint Research Centre's establishments and a selected few of the major nuclear centres of the Community. Within the first half of 1967 the system will become available to all users.

In 1966 as in previous years, the CID organized meetings of the Consultative Committee on Information and Documentation (CCID), composed of experts from the six Member States, and four meetings of the working group made up of heads of documentation services of the national nuclear research centres. These meetings were the occasion for thorough discussion of the development of the CID's work, with which the Member States are thus systematically associated.

The CID also continued to take part in the work of the International Federation for Documentation (IFD), particularly on documentation computerizing problems, and of the European Translation Centre, etc. In addition, since 1966 the CID has been participating in the work of the *ad hoc* group, set up by the OECD, on scientific and technical documentation and information policy.

I. Scientific and technical documentation

1. *Semi-Automatic Documentation*

Since 1961 the Commission has been anxiously considering the growing difficulty of making rational use of the mass of information on nuclear science and technology, assessed, at the end of 1966, at some 500,000 "information units" (articles, textbooks, reports, patents, etc.). As this mass is now increasing at the rate of over 100,000 new units a year, the traditional methods are no longer capable of dealing with it, and the CID was asked to design and operate an automatic documentation system based on the use of an electronic computer, for the benefit of the Commission's research scientists and also for persons and enterprises of the Community.

The CID therefore proceeded, often through contract, to select, analyze, encode and then store in a computer memory all the information so far published in sectors connected with nuclear matters. Two-fifths of this information is taken from the bibliographical journal "Nuclear Science Abstracts", published by the USAEC, and are encoded directly by the USAEC on behalf of the CID; other information is passed to Euratom under two contracts concluded respectively with the Dutch foundation Excerpta Medica (for material concerning nuclear medicine) and the French firm of Brevatome (for material concerning patents of nuclear interest); other information, again, is selected directly by the CID from some forty secondary information sources which are methodically scanned for anything of nuclear interest. Altogether the CID culls some 70,000 items of nuclear interest from sources other than the "Nuclear Science Abstracts"; an automatic data-processing system eliminates duplication.

The storing of all nuclear information published since 1948 in "Nuclear Sciences Abstracts" was practically terminated in 1966, and a good start was made on storing the data extracted from other sources. Before mid-1967 the work of feeding old material into the system will be completely finished, and the CID will be able to offer users a service based on a collection of about 550,000 nuclear publications. As only new documents will then need to be fed in, the CID will devote most of its activity to operating the system — receiving documentation "requests", translating them into key-words, feeding the key-words into the computer, and sending out "replies" in the form of photostat summaries of relevant documents.

In the second stage of its documentation programme, which will probably be ready to start in 1967, the CID will periodically supply users with summaries solely of new documents that interest them; the computer will periodically supply reference lists of documents covered by the "interest profile" of each user, as defined once and for all by a combination of key-words.

2. *Conventional Documentary Research*

Alongside its semi-automatic documentation system, which only covers nuclear science and technology, the CID will carry on traditional methods of documentary research to meet the requirements of researchers at the JRC establishments, the Patents Office, and the Commission's associates or contractors.

Except as regards the Patents Office, these conventional researches deal increasingly with paranuclear matters which are thus not covered by the automatic system.

In 1966, 154 bibliographical retrievals were effected by conventional methods, to which must be added 68 "periodical" retrievals, by which the documentation available on given subjects is regularly kept up to date.

3. *Non-Nuclear Information Sources*

With the same object of being in a position to provide the Commission's research workers with bibliographical information in non-nuclear sectors, the CID has been at pains to collect exact details on the documentation centres, libraries and specialized periodicals in the various provinces to which nuclear technology has to resort to solve certain special problems. This continuous survey of non-nuclear sources led the CID to establish contact, before the end of 1966, with nearly 500 Community centres that specialize in fields bordering on the nuclear domain.

4. *Libraries*

The Euratom Commission has five libraries, at Brussels and at the four JRC establishments at Ispra, Karlsruhe, Geel and Petten. The activity of these five libraries is supervised by the CID, notably as regards the dovetailing of acquisition and automation policies governing the various ordering, cataloguing, etc., operations. Under this system, the Ispra and Karlsruhe libraries do their own ordering, whilst the Brussels library is the purchasing centre for Geel and Petten and also serves Euratom personnel employed outside the Institution's premises, for instance under contracts of association.

II. Scientific and technical information

Following the principles it set out before the Council of Ministers on 1 April 1963, the Commission continued in 1966 to disseminate the knowledge acquired in the course of the research programme; this is done by two different channels —"publications", which are widely disseminated, and "communications", the circulation of which is restricted because these documents contain information of immediate industrial value and priority of access to them is therefore reserved to persons and enterprises in the Community whose legitimate interest in them can be duly substantiated.

1. *Non-Periodical Publications, Euratom Reports, "Euratom Communications" (Article 13) and Conference Proceedings*

In 1966 the Commission made public a total of 502 scientific and technical reports. During the same period, 589 texts were published in scientific periodicals or presented at conferences by officials of the Commission or under research or association contracts signed by the Commission. In addition, 297 "Euratom communications" were distributed to persons, enterprises and Member States of the Community by the Commission, through national correspondents nominated in each Member State. Lastly, in 1966 the CID published the proceedings of eight conferences (1). Work was begun on the publication of the proceedings of a ninth conference during the year.

2. *Periodicals*

The three periodicals published by the CID came out regularly in 1966. These are:

Euratom Information, a monthly account, in the form of abstracts with bibliographical data, of the research programme and new research or association contracts and, especially, of the Commission's technical and scientific publications relating to its own research programme or contractual research, and of the models and patents filed. An index covering the whole of 1966 was published, in a form giving access to the data for the year under several headings.

Transatom Bulletin, a monthly publication, which in 1966 listed 11,745 translations, completed or in hand, of scientific or technical papers on nuclear questions in the less common languages. As well as the usual bibliographical references, *Transatom Bulletin* gives detailed information on how to obtain these translations. Since 1 January 1966, moreover, under a contract signed with the Kernforschungsanlage Jülich, *Transatom Bulletin* has been publishing a monthly selection of East European and Oriental nuclear documents acquired by the Eastatom Centre which have not yet been translated into a Western language and of which persons interested can obtain a translation on request.

1) "Cibles pour accélérateurs destinées à la production de neutrons", Grenoble. "Viertes Kolloquium über die Versicherung von Kernrisiken", Berlin. "Symposium on Megagauss Magnetic Field Generation by Explosives and Related Experiments", Frascati. "Rupture fragile et la sécurité dans les cuves de réacteurs nucléaires", Brussels. "Fuel cycles of high-temperature gas-cooled reactors", Brussels. "Situation et perspectives de l'énergie nucléaire dans la Communauté européenne", Brussels. "Labelled Proteins in Tracer Studies", Pisa. "Aspects pratiques de l'analyse par activation au moyen de particules chargées", Grenoble.

The five-year index also came out in 1966. This is a new Euratom publication designed to fill a gap in the scientific documentation available in the West. It will facilitate the search for nuclear works published in East European and Oriental countries and translated into the Community languages and English.

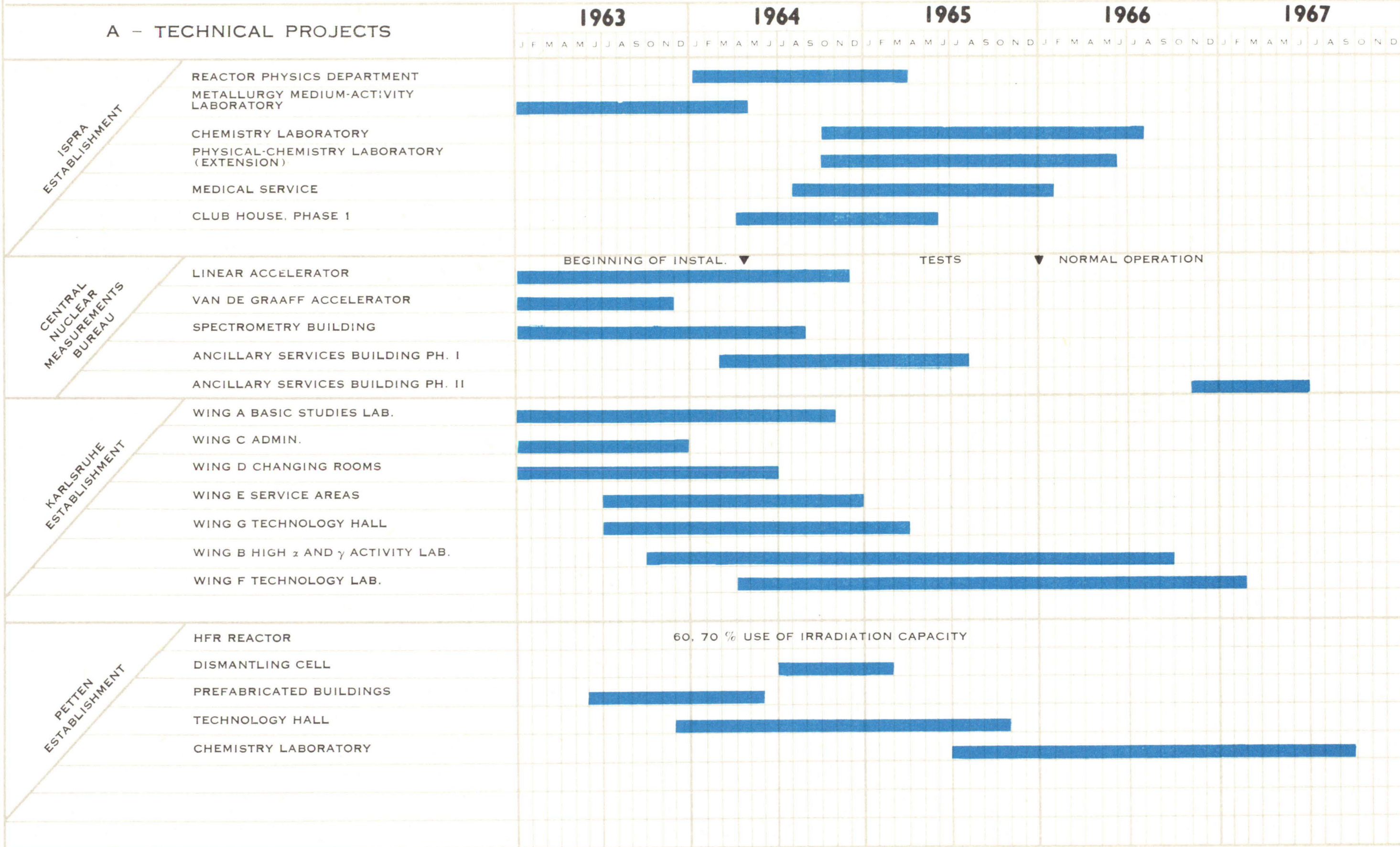
Euratom Bulletin, a quarterly review, is issued in five editions, Dutch, French, German, Italian and English. It deals, in a form suitable for a very wide public, with matters connected with the peaceful uses of nuclear energy and the Commission's activities. Numerous items of information published in this review have been quoted by the press and several articles were reproduced in their entirety by other publications.

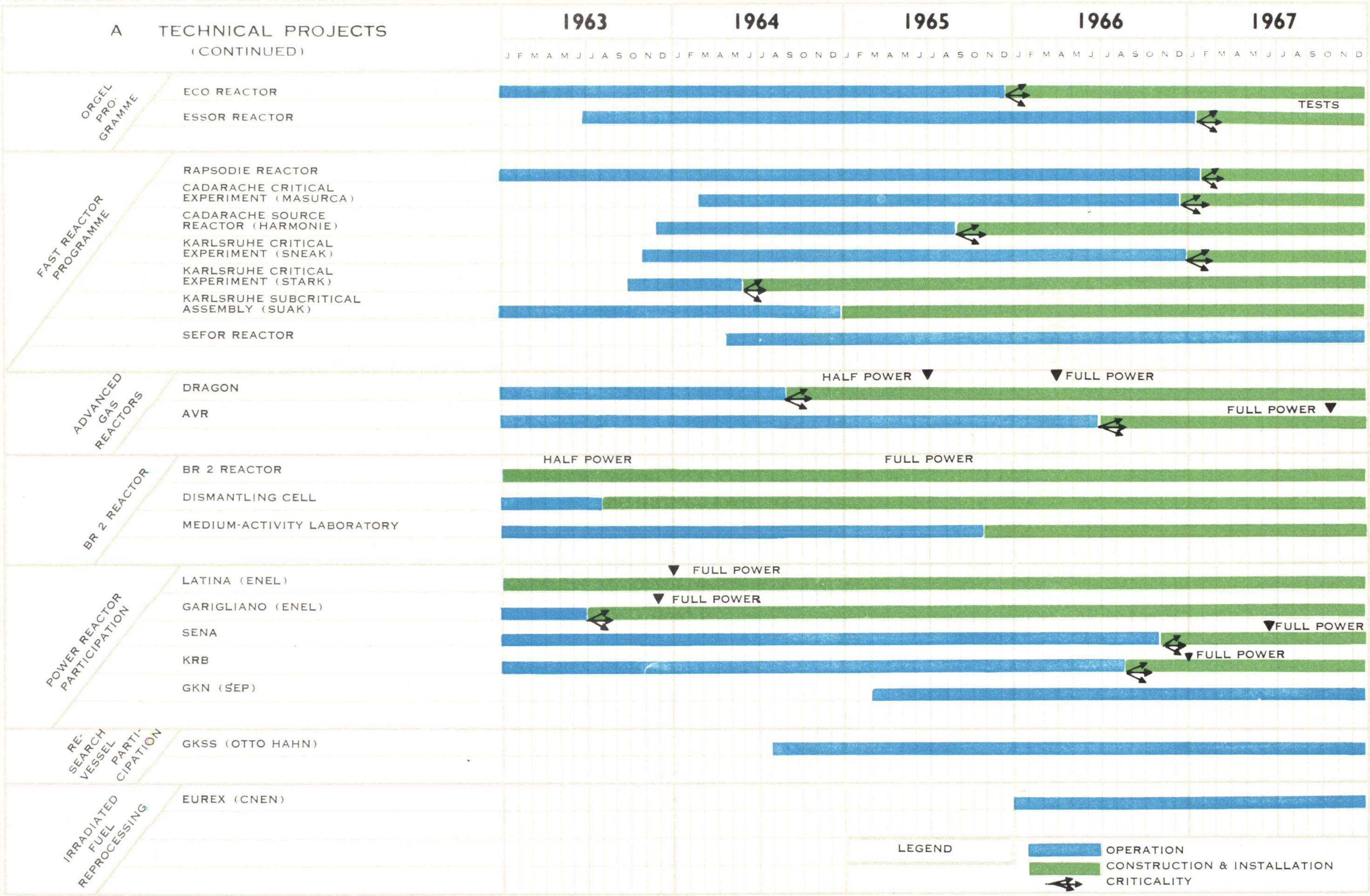
DOCUMENT No. 35

SCHEDULE FOR EXECUTION OF LARGE-SCALE PROJECTS PROVIDED FOR UNDER THE SECOND FIVE-YEAR PLAN

SCHEDULE FOR EXECUTION OF LARGE-SCALE PROJECTS PROVIDED FOR UNDER THE SECOND FIVE-YEAR PLAN

STATUS AS ON 1 APRIL 1967




A TECHNICAL PROJECTS
(CONTINUED)
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1965
1966
1967
J F M A M J J A S O N D
ORGEL PRO- GRAMME
ECO REACTOR
ESSOR REACTOR
TESTS
FAST REACTOR PROGRAMME
RAPSODIE REACTOR
CADARACHE CRITICAL EXPERIMENT (MASURCA)
CADARACHE SOURCE REACTOR (HARMONIE)
KARLSRUHE CRITICAL EXPERIMENT (SNEAK)
KARLSRUHE CRITICAL EXPERIMENT (STARK)
KARLSRUHE SUBCRITICAL ASSEMBLY (SUAK)
SEFOR REACTOR
ADVANCED GAS REACTORS
DRAGON
HALF POWER
FULL POWER
AVR
FULL POWER
BR 2 REACTOR
BR 2 REACTOR
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FULL POWER
DISMANTLING CELL
MEDIUM-ACTIVITY LABORATORY
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KRB
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GKN (SEP)
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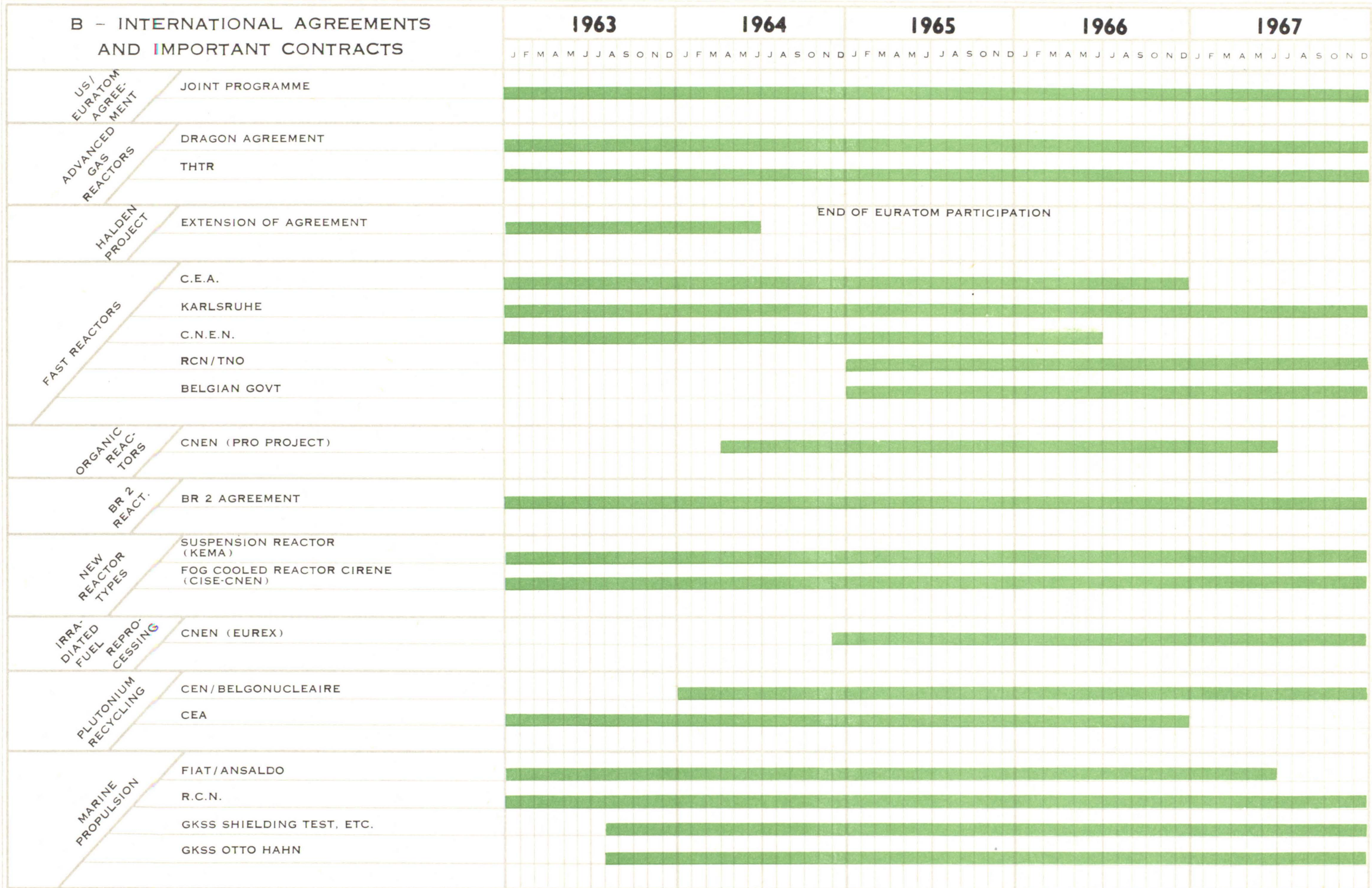
GKSS (OTTO HAHN)
IRRADIATED FUEL REPROCESSING
EUREX (CNEN)
LEGEND
OPERATION
CONSTRUCTION & INSTALLATION
CRITICALITY


B – INTERNATIONAL AGREEMENTS AND IMPORTANT CONTRACTS
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ORGANIC REACTORS
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BR 2 REACT.
BR 2 AGREEMENT
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FOG COOLED REACTOR CIRENE (CISE-CNEN)
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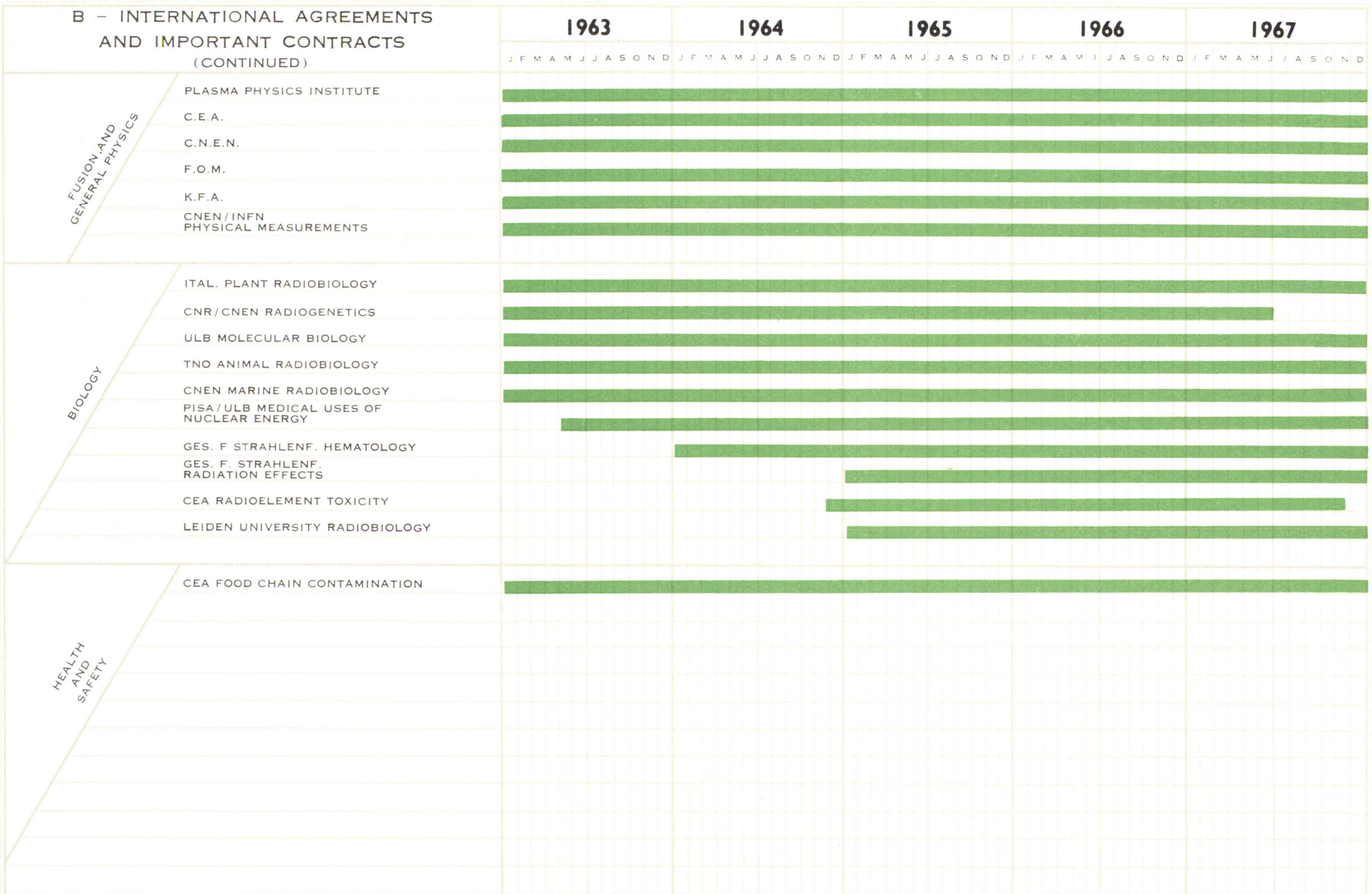
CNEN (EUREX)
PLUTONIUM RECYCLING
CEN/BELGONUCLEAIRE
CEA
MARINE PROPULSION
FIAT/ANSALDO
R.C.N.
GKSS SHIELDING TEST, ETC.
GKSS OTTO HAHN


B – INTERNATIONAL AGREEMENTS AND IMPORTANT CONTRACTS (CONTINUED)
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K.F.A.
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BIOLOGY
ITAL. PLANT RADIOBIOLOGY
CNR / CNEN RADIOGENETICS
ULB MOLECULAR BIOLOGY
TNO ANIMAL RADIOBIOLOGY
CNEN MARINE RADIOBIOLOGY
PISA / ULB MEDICAL USES OF NUCLEAR ENERGY
GES. F STRAHLENF. HEMATOLOGY
GES. F. STRAHLENF. RADIATION EFFECTS
CEA RADIOELEMENT TOXICITY
LEIDEN UNIVERSITY RADIOBIOLOGY
HEALTH AND SAFETY
CEA FOOD CHAIN CONTAMINATION

DOCUMENT No. 36

SCIENTIFIC AND TECHNICAL PUBLICATIONS STEMMING FROM THE EURATOM RESEARCH PROGRAMME*

(from 1 January to 31 December 1966)

INDEX

1. BIOLOGY AND MEDICINE

AGAROSSI G. DORIA G.	Hemo-agglutinin response of isologous spleen cells in irradiated mice thymectomized in adult life EUR 3219 e (MF)
ALBERTINI A. TIBONI O. CIFERRI O.	Relations between tryptophan configuration and actinomycin biosynthesis Art.: Journal of Labelled Compounds, Vol. 2 (1966), No. 1, pp. 90-101

Abbreviations : EUR = Euratom report; MF = microfilm; Art. = Article; XXX = anonymous.

* Current information on publications, as well as patents and contracts, is provided in the monthly *Euratom Information.*

ALESCIO T.	Response to X-irradiation of mouse embryonic lung cultured *in vitro* — Radiation effect on the epithelium growth rate Art.: Experimental Cell Research, Vol. 43 (1966), pp. 459-473
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APELGOT S. THAM G.	Actions létales comparées des rayons X et des bêta du tritium sur *E. coli* Art.: International Journal of Radiation Biology, Vol. 10 (1965), No. 5, pp. 495-508
APPLEYARD R.K.	Towards the biology of tomorrow Art.: Euratom Bulletin, Vol. 5 (1966), No. 4, pp. 98-105.
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BACHI C. PEGORARO L. PILERI A. GAVOSTO F.	Influenza dell'ARN normale e leucemico sul metabolismo proteico di cellule di leucemia acuta Art.: Bollettino della Società Italiana di Biologia Sperimentale, Vol. 41 (1965), Fasc. 13, pp. 739-741
BACQ Z.M. BEAUMARIAGE M.L. VAN CANEGHEM P.	Importance for radioprotective effect in mammals of pharmacological and biochemical actions of cysteamine and related substances Art.: Annali dell'Istituto Superiore di Sanità, Vol. 1 (1965), pp. 639-645
BACQ Z.M. VAN CANEGHEM P.	The influence of cystamine administered by mouth to mice irradiated with gamma-rays at a low dose-rate Art.: International Journal of Radiation Biology, Vol. 10 (1965), No. 6, pp. 595-599
BAGLIONI C.	Ontogenesis of erythrocytes and haemoglobin formation Art.: Journal of Cellular Physiology, Vol. 67 (1966), No. 3, Suppl. 1, pp. 169-184
BAGLIONI C. COLOMBO B. FELICETTI L.	The use of some amino acid analogues and antibiotics in the study of haemoglobin synthesis Art.: Biochemical Journal, Vol. 95 (1965), No. 3, p. 61
BAGLIONI C. LA VIA M. VENTRUTO V.	A study of immunoglobulin structure (I) Art.: Biochimica et Biophysica Acta, No. 111 (1965), pp. 479-484
BALNER H.	Histocompatibility testing in primates Art.: Vox Sanguinis, Vol. 11 (1966), pp. 306-314
BALNER H. DERSJANT H.	Iso-antibodies against leukocytes as a tool to study histocompatibility in monkeys Art.: Histocompatibility Testing, (1965), Munksgaard, Copenhagen, pp. 103-111
BALNER H. DERSJANT H.	Neonatal thymectomy and tumor induction with methylcholanthrene in mice Art.: Journal of the National Cancer Institute, Vol. 36 (1966), pp. 513-521

BALNER H. DERSJANT H.	An application of the serological recognition of transplantation antigens on leucocytes Art. : The Lancet, July 16 (1966), pp. 148-150
BALNER H. DERSJANT H.	Sex difference for immune depression and runting in neonatally thymectomized mice Art. : Nature, Vol. 209 (1966), No. 5025, pp. 815-816
BALTUS E. QUERTIER J.	A method for the extraction and characterization of RNA from subcellular fractions of *Acetabularia* Art. : Biochimica et Biophysica Acta, Vol. 119 (1966), pp. 192-194
BARIGOZZI C. DOFINI S. FRACCARO M. REZZONICO-RAIMONDI C. TIEPOLO L.	*In vitro* study on the DNA replication patterns of somatic chromosomes of *Drosophila melanogaster* Art. : Experimental Cell Research, Vol. 43 (1966), No. 1, pp. 231-234
BARRAI I. CANN H.M. DE NICOLA P.	Segregation Analysis of hemophilias Art. : Atti Associazione Genetica Italiana, Vol. 11 (1966), pp. 322-325
BARTSCH G.G. GERBER G.B.	Incorporation of acetate-1-^{14}C into lipids by the perfused liver of normal X-irradiated, or partially hepatectomized rats Art. : Journal of Lipid Research, Vol. 7 (1966), pp. 204-209
BAUGNET-MAHIEU L. GOUTIER R. SEMAL M.	Effet isotopique du tritium, sous forme de thymidine tritiée, sur l'activité de l'ATP : thymidine-5'-phosphotransférase purifiée Art. : Archives Internationales de Physiologie et de Biochimie, Vol. 73 (1965), No. 3, pp. 556-557
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BERG A. GRIMALDI E.	Study on the biology of the fish in the Lago Maggiore with the aim of collecting data as a basis for forecasting the possible interactions between these fish and the radioactivity present in the Lake water (Annual Report 1965). - II. Genus *Alosa*. - III. Census of the Commercial fish catches EUR 2956 e
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10. PHYSICS

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DOCUMENT No. 37

PATENT APPLICATIONS FILED BY THE COMMISSION AND ITS CONTRACTORS TO SAFEGUARD INVENTIONS DEVELOPED UNDER THE EURATOM RESEARCH PROGRAMMES

(from 1 January to 31 December 1967)

File No.	Title of Patent	Inventor	Holder	Origin
I/494	Apparecchio per il deposito di allumine o geli in strati sottili su lastre di vetro per cromatografia	Ceresoli (EUR)	Euratom	Ispra
I/524	Verrouillage d'emmanchement de sécurité	Van Nieuwenhausen (CEN) Lenaerts (CEN)	Euratom	CEN Mol GEX BR-2
I/534	Obturateur à fente orientée	Jansen (EUR)	Euratom	Ispra
I/564	Control rod system for nuclear power excursion reactors	Galli di Paretesi (EUR)	Euratom	Ispra
I/686	Improvements in or relating to prestressed concrete pressure vessels - Pressure vessel with toroidal section	Hosegood (UKAEA) Kinkead (UKAEA)	UKAEA	Dragon case 124
I/690	Tube chauffable electriquement de manière indirecte	Nijsing (EUR) Hufschmidt (EUR)	Euratom	Ispra
I/701	Improvements in or relating to the manufacture of graphite bodies - One-step moulding of fuel cartrigde having unfuelled region	Houdaille (UKAEA)	UKAEA	Dragon case 78
I/702	Improvements in or relating to thermocouples - Thermocouples incorporating pyrolytically deposited substances	Conde (UKAEA) Jaques (UKAEA) Kingdon (UKAEA) Wade (UKAEA)	UKAEA	Dragon case 103

File No.	Title of Patent	Inventor	Holder	Origin
I/703	Metallizzazione di allumine per giunzioni metalloceramica a tenuta di alto vuoto per temperature di lavoro superiori a 1200 °C	Cappelletti (EUR)	Euratom	Ispra
I/712	Verfahren zum anodischen Schutz von Gegenständen aus Zirkonium und Zirkoniumlegierungen gegen Korrosion	Schleicher (EUR)	Euratom (previously Metallgesellschaft)	Acquired by Metallgesellschaft
I/721	Anordnung zur Erzeugung von Neutronenimpulsen		Institut für Plasmaphysik	IfP 003 FUAD
I/722	Teilchenbeschleuniger		IfP	IfP 003 FUAD
I/724	Canale di raffreddamento per reattore nucleare a isolamento solido interno	Farfaletti-Casali (EUR) Dufresne (EUR) Volta (EUR)	Euratom	Ispra
I/729	Procédé pour la soudure de tubes en matériaux composites métal-oxyde, particulièrement pour la fermeture de gaines d'éléments combustibles pour réacteurs nucléaires	Musso (EUR) Klersy (EUR)	Euratom	Ispra
I/731	Barres liquides de sécurité pour réacteur nucléaire	Galli di Paratesi (EUR) Genet (EUR) Ghiurghi (EUR) Agazzi (EUR) Broggi (EUR)	Euratom	Ispra
I/750	Mécanisme de commande d'un mouvement rectiligne vertical	Gérard (CEA) Palomo (CEA)	CEA	CEA 006 RAAF
I/768	A Photometer with mechanical registration	Kalshoven (RCN)	RCN	RCN 001 + 002 SUAN RCN
I/769	Dispositif de découpage en cellule chaude de capsules d'irradiation	Schaller (EUR)	Euratom	Petten
I/775	Procédé et dispositif d'incinération et d'évaporation de résidus radioactifs	Amavis (EUR) Krawczynski (EUR) Vannuzzi (EUR)	Euratom	Ispra
I/791	Verbindungsschiene für Stoßstromanlagen (improv. of I/792 GF)		BBC and KfA	KfA 006 FUAD

File No.	Title of Patent	Inventor	Holder	Origin
I/792	Verbindungsschiene für Stoßstromanlagen (improv. of I/791 GF)		BBC and KfA	KfA 006 FUAD
I/793	Vorrichtung zur Überwachung des Zustandes einer zwischen leitenden Metallteilen angeordneten Isolationsschicht		BBC and KfA	KfA 006 FUAD
I/794	Aus einer Vielzahl von Batterieeinheiten durch Parallelschaltung aufgebaute Kondensatorbatterie zur Erzeugung großer magnetischer Feldstärken		KfA	KfA 006 FUAD
I/838	Procedimento per effettuare giunti con corpi in grafite impregnata, particolarmente grafite impregnata con metalli o leghe leggere fusi	Marengo (EUR)	Euratom	Ispra
I/839	Schutzvorrichtung für Reaktoranlagen	Braun (EUR)		Ispra
I/840	Installation de barre d'appoint ou de sécurité	Charles (EUR) Bouchet (PEROT)	Euratom	Ispra
I/841	Doppio sistema di isolamento termico in un reattore a tubi di forza in lega di Zirconio	Montagnani (EUR) Farfaletti-Casali (EUR)	Euratom	Ispra
I/842	Schwimmer für Flüssigkeitspegelmessungen	Becker (EUR) Gatti (EUR)	Euratom	Ispra
I/843	Apparecchio di lettura di radiocromatogrammi	Wagner (EUR) Forcheri (EUR)	Euratom	Ispra
I/844	Elektronischer Serien-Parallelwandler	Becker (EUR)	Euratom	Ispra
I/845	Dispositif d'exploration par rayons gamma d'éléments radioactifs	Bazzoni (EUR) Cauwe (EUR) Schürenkamper (EUR)	Euratom	Ispra
I/846	Vorrichtung und Verfahren zum Füllen eines Handschuhkastens mit reiner Atmosphäre	Stingele (EUR) de Cat (EUR)	Euratom	Petten
I/850	Funkenstreckenanordnung	Marx (KfA) Koch (KfA)	Prof. MARX	KfA/BBC 006 FUAD
I/851	Dispositif et procédé de décontamination radioactive du lait	v.d.Stricht (EUR)	Euratom	Euratom

File No.	Title of Patent	Inventor	Holder	Origin
I/856	Protection du magnésium ou de ses alliages contre la corrosion dans les liquides organiques (improv. of I/569 Be)	de Beni (EUR)	Euratom	Ispra
I/865	Canale per reattore nucleare	Dufresne (EUR) Farfaletti-Casali (EUR) Henry (EUR)	Euratom	Ispra
I/877	Door vloeibaar of gasvormig medium gekoelde kernreactor voorzien van een binnen het reactorvat aangebracht straaltoestel voor het doen circuleren van het koelmedium	Wilman (RCN)	RCN	RCN 007 PNIN
I/879	Anordnung zur Regelung einer Messgröße	Kemeny (EUR) Olthoff (EUR)	Euratom	Petten
I/886	Verfahren zur Beeinflussung der Reaktivität eines Kernreaktors mit einer Schüttung vorzugsweise kugelförmiger Betriebselemente	Rausch (BBK)	BBK	BBK 003 RGAD
I/899	Inrichting voor het verhinderen van radio-actieve contaminatie van een bij een reactor aangebrachte ruimte	Hermans (RCN) v.d.Berth (RCN) Luyten (RCN)	RCN	RCN 001 NTAN 007 PNIN KEMA 002 NTAN
I/905	Dispositif à ultra-sons pour la mesure de la position du niveau d'un liquide	Buis (EUR)	CEA	CEA 006 RAAF
I/907	Liquid phase extrusion for forming refractory materials	Stoops (North Carolina State College)	USAEC	USAEC R and D (North Carolina State College)
I/908	Durchflußmengenregler	Müller (IfP)	IfP	IfP 010 FUAD
I/909	Procédé de contrôle non destructif par courants de Foucault de tubes conducteurs de l'électricité et appareil correspondant	Dujardin (EUR)	CEA	CEA 006 RAAF
I/910	Appareil auxiliaire pour l'exploitation des plaques spectrales	Becker (EUR) Drawin (EUR)	CEA	CEA 012 FUAF
I/911	Procédé de séparation du strontium	Aubertin (CEA) Lefebvrè (CEA)	CEA	CEA 025 RISF

File No.	Title of Patent	Inventor	Holder	Origin
I/912	Elektrische Verzweigungs-schaltung	Becker (EUR)	Euratom	Ispra
I/914	Procédé pour le soudage de matériaux frittés	Musso (EUR) Portal (EUR)	Euratom	Ispra
I/916	Lega alluminio-niobio e metodo relativo di preparazione	Beghi (EUR) Piatti (EUR)	Euratom	Ispra
I/917	Réacteur nucléaire et dispositif de fixation d'éléments combustibles	Farfaletti-Casali (EUR) Dufresne (EUR) Buzzi (EUR)	Euratom	Ispra
I/920	Gerät zum Fräsen und Bohren von Nuten und Senklöchern in die Innenwandung von Rohren	Mahler (EUR)	Euratom	Ispra
I/922	Procédé d'imprégnation de bobines supraconductrices à l'aide d'un imprégnant hétérogène	Bonnin (CEA) Weil (CEA)	CEA	CEA 007 FUAF
I/923	Elément combustible pour réacteur nucléaire	Schmitt (CEA) Storrer(EUR)	CEA	CEA 006 RAAF
I/924	Procédé de préparation de l'acide polyantimonique et produit obtenu	Aubertin (CEA)	CEA	CEA 025 RISF
I/925	Einrichtung zum Erzeugen eines heißen Plasmastrahles	Brederlow (IfP) Hoss (IfP) Mihatsch (IfP)	IfP	IfP 010 FUAD
I/926	Improvements in or relating to thermometers	Mobsby (UKAEA)	UKAEA	Dragon case 127
I/927	Einrichtung zum Entfernen von Alkalimetalldampf aus einem Gasstrom	Brederlow (IfP) Borde (IfP)	IfP	IfP 010 FUAD
I/929	Improvements in or relating to fluidized bed apparatus - Fluidized bed furnace	Lanaspeze (UKAEA) Tannenberger (UKAEA)	UKAEA	Dragon case 120
I/930	Improvements in or relating to the manufacture of nuclear fuels - PuO_2C particles	Horsley (UKAEA)	UKAEA	Dragon case 122
I/931	Schaltungsanordnung zur Amplituden-Diskriminierung	Stanchi (EUR)	Euratom	Ispra
I/932	Strömungsmessgerät	Müller (IfP)	IfP	IfP 010 FUAD

File No.	Title of Patent	Inventor	Holder	Origin
I/933	Organe de structure pour réacteur nucléaire refroidi par circulation de sodium fondu	Josso (CEA) Conte (CEA) Sannier (CEA)	CEA	CEA 006 RAAF
I/934	Organe de structure de réacteur nucléaire refroidi par circulation de sodium fondu	Josso (CEA) Conte (CEA) Sannier (CEA)	CEA	CEA 006 RAAF
I/935	Organe de structure pour réacteur nucléaire refroidi par le sodium	Josso (CEA) Conte (CEA) Sannier (CEA)	CEA	CEA 006 RAAF
I/936	Verfahren zur Herstellung von sphärischen oxydischen Kernbrenn - oder Brutstoffpartikeln	Hackstein (NUKEM) Venet (EUR)	NUKEM	BBK/KfA 003 RGAD
I/939	Vakuum-Druckmessgerät	Visser (FOM)	Euratom	FOM 014 FUAN
I/940	Inrichting voor de stabiele opsluiting van een plasma	Braams (FOM)	FOM	FOM 014 FUAN
I/947	Verfahren zum Herstellen eines Formkörpers aus Beton	Bremer (Krupp) Böhmert(Krupp)	Krupp	Krupp 048 TEGD
I/950	Noodkoelsysteem voor een kernreactor-installatie	v.d.Bergh (RCN)	RCN	RCN 007 PNIN
I/951	Improvements in or relating to electrical resistance furnaces - Tube resistance furnace with uniform temperature distribution	Jaques (UKAEA)	UKAEA	Dragon case 119
I/952	Improvements in or relating to a method and apparatus for detecting the presence of minute amounts of oxygen/water vapour or like gaseous material in a gas - Method of detecting water vapour concentration using semi conductor P-type material	Gray (UKAEA)	UKAEA	Dragon case 105
I/954	Zirkoniumlegierungen	Imarisio (EUR)	Euratom	Ispra
I/957	Greifervorrichtung an einer Lademaschine für Kernreaktoren	Hanke (EUR)	Euratom	Ispra
I/960	Als kombinierter Sollwertgeber - Messwertumformer aufgebautes Gerät für die Einstellung und Messung von Gasdrücken in Betriebsanlagen	Kottowski (EUR) Warnsing (EUR)	Euratom	Ispra

File No.	Title of Patent	Inventor	Holder	Origin
I/965	Procédé de préparation de réglettes de peroxyde alcalin gaine	Backs (EUR) Birault (CEA) Angleys (CEA) Juste (CEA) Reynaud (CEA)	CEA	CEA 006 RAAF
I/966	Installation de transfert de liquide	Raggenbass (CEA) Dufrene (CEA) Fradin (CEA) Gaudichard (CEA)	CEA	CEA 025 RISF
I/967	Procédé pour la manutention d'assemblages d'éléments combustibles dans un réacteur nucléaire refroidi par liquide opaque	van Divoet (BelgoNucléaire)	Belgo-Nucléaire	Belgo-Nucléaire 015 RAAB
I/968	Perfectionnements apportés aux réacteurs nucléaires (réacteur à modules juxtaposés)	Fossoul (BelgoNucléaire)	Belgo-Nucléaire	Belgo-Nucléaire 015 RAAB
I/969	Perfectionnements apportés aux réacteurs nucléaires à neutrons rapides	van Divoet (BelgoNucléaire)	Belgo-Nucléaire	Belgo-Nucléaire 015 RAAB
I/970	Perfectionnements apportés aux réacteurs nucléaires	Egleme (Belgo-Nucléaire) Michel (Belgo-Nucléaire)	Belgo-Nucléaire	Belgo-Nucléaire 015 RAAB
I/971	Einrichtung zum Zuführen von Alkalimetalldampf in einen Arbeitsgasstrom eines MHD-Generators	Brederlow (IfP) Reinhold (IfP) Hodgson (IfP)	IfP	IfP 010 FUAD
I/972	Improvements in or relating to the preparation of nuclear fuel elements - Bonded coated particles in other than dispersed fuel compacts	Redding (UKAEA)	UKAEA	Dragon case 125
I/973	Perfectionnement à la fabrication de combustible pour réacteurs nucléaires	Aerts Bairiot van Asbroeck (BelgoNucléaire)	Belgo-Nucléaire et CEN	Belgo-Nucléaire 015 RAPB
I/974	Combustible pour réacteurs nucléaires	Draulans Jonckheere (BelgoNucléaire)	Belgo-Nucléaire	Belgo-Nucléaire 015 RAPB

File No.	Title of Patent	Inventor	Holder	Origin
I/975	Assemblage combustible pour réacteur nucléaire et procédé de fabrication d'un tel élément	Mousscz (SNECMA) Rosuel (SNECMA) Bramaud du Boucheron (SNECMA)	SNECMA	SNECMA 070 TEEC
I/976	Pompe doseuse	Andre (CEA) Fradin (CEA) Pesneau (CEA)	CEA	CEA 025 RISF
I/977	Dispositif de verrouillage d'un assemblage combustible dans un réacteur nucléaire	Defreyn (EUR) Ladagnous (CEA) Plessy (CEA)	CEA	CEA 006 RAAF
I/978	Assemblage combustible pour réacteur nucléaire	Defreyn (EUR) Martin (CEA)	CEA	CEA 006 RAAF
I/979	Procédé et dispositif d'injection ou de sortie de très grandes puissances en très hautes fréquences	Cadart (CEA) Bize (CEA) Consoli (CEA)	CEA	CEA 012 FUAF
I/980	Procédé de production et d'interaction de plasma et dispositif de mise en œuvre dudit procédé	Consili (CEA) Legardeur (CEA) Slama (CEA)	CEA	CEA 012 FUAF
I/981	Procédé de production d'accélération et d'interaction de faisceaux de particules chargées et dispositif de mise en œuvre dudit procédé	Bardet (CEA) Consili (CEA) Geller (CEA) Jacquot (CEA)	CEA	CEA 012 FUAF
I/982	Werkwijze ter bereiding van een stabiel mengsel van zeswaardig uraan en vierwaardig thorium en gelen, oxiden en carbiden die hieruit bereid kunnen worden	v. d. Plas (RCN) Kanij (RCN) Noothout (RCN) Hermans(RCN	RCN	RCN-KEMA 001-002 NTAN
I/983	Verwendung von Zirkoniumlegierungen des Zr-Fe-V-, Zr-Fe-Cr- und des Zr-Cr-Typs	Imarisio (EUR)	Euratom	Ispra
I/984	Caisson zum Anschluß an „Heiße Zellen"	Samsel (EUR) Werner (EUR) Karman (EUR) Ferring (EUR)	Euratom	CCR Karlsruhe
I/985	Procédé de production et de confinement de gaz ionisé et dispositif en faisant application	Consoli (CEA) Dupas (CEA) Leroy (CEA)	CEA	CEA 012 FUAF

File No.	Title of Patent	Inventor	Holder	Origin
I/986	Schaltungsanordnung zum Erzeugen von Impulsen sehr kurzer Anstieg- und Abfallzeiten und hoher Amplitude	Steinhausen (IfP)	IfP	IfP 010 FUAD
I/987	Vorrichtung zur schnellen Entdeckung von Dampfrohrbrüchen	Forster (EUR)	Euratom	Euratom
I/988	Entrained fluidized bed coating apparatus and method thereof	Flamm (UKAEA)	USAEC	Dragon case 128
I/991	Verfahren und Einrichtung zum Bestimmen eines Magnetfeldes	Steinhausen (IfP)	IfP	IfP 010 FUAD
I/992	Perfectionnements apportés aux procédés et appareils pour le comptage des neutrons	Romano (EUR)	CEA	CEA 012 FUAF
I/993	Procédé d'association de deux bobines supraconductrices et bobinage supraconducteur en comportant application	Lecomte (CEA) Weil (CEA)	CEA	CEA 012 FUAF
I/994	Kontroll- und Regelelement zur Steuerung der Reaktivität in Kernreaktoren	Nickel (KfA)	KfA	BBK/KfA 003 RGAD
I/995	Improvements in or relating to neutron flux detectors - Gamma compensated ionization chamber	Wade (UKAEA)	UKAEA	Dragon case 126
I/996	Improvements in or relating to thermocouples - A thermocouple for use in contact with carbon at high temperature	Sturge (UKAEA)	UKAEA	Dragon case 121
I/997	Vakuumspektrograph	Steinhausen (IfP)	IfP	IfP 010 FUAD
I/998	Einrichtung zum Prüfen von Spaltstoffelementen in einem Versuchsreaktor	Bojarsky (GfK) Häfner (GfK)	GfK	GfK 009 RAAD
I/999	Einrichtung zum Abführen von Spaltgasen aus Kernreaktorbrennelementen	Hagen (GfK)	GfK	GfK 009 RAAD
I/1000	Brennelementbündel für Kernreaktoren	Müller (GfK)	GfK	GfK 009 RAAD
I/1001	Verfahren zur Herstellung von beschichteten, sphärischen Kernbrenn- und Brutstoffpartikeln	Venet (EUR) Hackstein (NUKEM) Wolff (NUKEM)	NUKEM	BBK/KfA 003 RGAD

File No.	Title of Patent	Inventor	Holder	Origin
I/1002	Objektiv für die Auflichtphotometrie oder dergl.	Dörmer (GfK)	GfK	GfK 031 BIAD
I/1003	Induktiver Stoss-Stromgenerator	Marx (KfA) Koch (KfA)	KfA	BBC/KFA 006 FUAD
I/1005	Zirconium Base Alloy	Klepfer (General Electric)	USAEC	General Electric USAEC (R and D)
I/1006	Verfahren zur Herstellung sphärischer oxidischer und carbidischer Kernbrenn- und Brutstoffpartikeln aus Schwermetallsalzlösungen	Hackstein (NUKEM) Fleischhauer (NUKEM) Knowak (NUKEM)	NUKEM	BBK/KfA 003 RGAD
I/1007	Assemblages combustibles pour réacteurs nucléaires	Michel (Belgo-Nucléaire)	Belgo-Nucléaire	Belgo-Nucléaire 015 RAPB
I/1008	Réacteurs nucléaires	Michel (BelgoNucléaire)	Belgo-Nucléaire	Belgo-Nucléaire
I/1009	Procédé et dispositif permettant l'obtention d'un signal électrique sinusoïdal dont la fréquence varie linéairement en fonction du temps	Bourbigot (CEA)	CEA	CEA 012 FUAF
I/1010	Dispositif de repérage d'un organe mobile parmi les éléments d'un réseau	Aubert (CEA) Fortin (CEA)	CEA	CEA 002 TEGF
I/1011	Dispositif de contrôle de la position d'un organe mobile par rapport à un repère fixe	Aubert (CEA) Fortin (CEA)	CEA	CEA 002 TEGF
I/1012	Stralingsdosimeter	Oberhofer (EUR) Jaspert (EUR)	Euratom	Ispra
I/1016	Dispositif pour mesurer le niveau d'un liquide	Lecoq (EUR)	Euratom	Ispra
I/1022	Passage étanche pour le transfert de produits nocifs	Godart (CEA) Pajot (CEA)	CEA	CEA 006 RAAF
I/1023	Dispositif d'évacuation de produits de fission pour réacteur nucléaire (improv. of I/883 Fr)	Costes (CEA)	CEA	CEA 006 RAAF

File No.	Title of Patent	Inventor	Holder	Origin
I/1024	Producing an oxidizing zone in a fluidized bed coator. Improvements in or relating to processes involving the pyrolytic deposition of carbon or other substances from a gas or vapour	Mayr (UKAEA) Flamm (UKAEA)	UKAEA	Dragon case 130
I/1025	Emergency start up of stand-by/peak load gas turbine generator sets in nuclear reactor power stations - Improvements in or relating to a gas turbine generating set	Hosegood (UKAEA) Stadie (UKAEA)	UKAEA	Dragon case 131
I/1026	Verfahren und Vorrichtung zur Behandlung giftiger oder radioaktiver Rückstände		GfS	GfS 006 WASD
I/1028	Einrichtung zum Vergleich zweier Differenzdrücke	Mauersberger (BBK)	BBK	BBK/KfA 003 RGAD
I/1029	Antriebsvorrichtung für einen frei in die Schüttung eines Kernreaktors eintretenden Abschaltstab	Heim (BBK)	BBK	BBK/KfA 003 RGAD
I/1031	Ventilkegel für vorzugsw. in Kernreaktoranlagen verwendbare Ventile	Schöning (BBK) Landwehr(BBK) Handel (BBK)	BBK	BBK/KfA 003 RGAD
I/1032	Vorrichtung zur Vereinzelung von kugelförmigen Elementen und zur Schrottabscheidung	Schöning (BBK) Landwehr(BBK) Beck (BBK) Handel (BBK)	BBK	BBK/KfA 003 RGAD
I/1033	Vorrichtung zur Abscheidung von Bruchstücken und Kugeln die ein bestimmtes Mindestmass unterschreiten aus einer Kugelschüttung	Schöning (BBK) Braun (BBK) Landwehr(BBK) Handel (BBK) Beck (BBK)	BBK	BBK/KfA 003 RGAD
I/1034	Vorrichtung zur Verteilung von Kugeln	Schöning (BBK) Landwehr(BBK) Handel (BBK) Beck (BBK)	BBK	BBK/KfA 003 RGAD
I/1042	Dampfgekühlter Kernreaktor	Müller (GfK) Schramm (GfK)	GfK	GfK 009 RAAD
I/1043	Vanadinbasislegierung hoher Zeitstandsfestigkeit	Böhm (GfK) Laue (GfK) Reddemann (GfK)	GfK	GfK 009 RAAD
I/1044	Einrichtung zum Feststellen der Füllstandshöhe von Flüssigkeiten in einem Behälter	Drechsler (GfK) Frees (GfK) Wild (Gfk)	GfK	GfK 009 RAAD

File No.	Title of Patent	Inventor	Holder	Origin
I/1045	Warmtewisselaar	Bonsel (RCN) Weevers (RCN)	RCN	RCN 007 PNIN
I/1046	Warmtewisselaar	Bonsel (RCN) Weevers (RCN)	RCN	RCN 007 PNIN
I/1048	Thermische of epithermische kweekcyclus	Boekschoten (RCN)	RCN	RCN 001 SUAN 002 SUAN
I/1049	Werkwijze voor het bereiden van een oxidische splijtstof die een metaalboride als verdwijnend gif bevat	Versteeg (PCN) Engel (RCN) Hamburg (RCN)	RCN	RCN 007 PNIN
I/1050	Xenon over-ride capability in highly rated thermal reactors	Hosegood (UKAEA) Rennie (UKAEA)	UKAEA	Dragon case 132
I/1051	Thermal Gradient Counter-flow Cooling System	Hench (USAEC)	USAEC	USAEC (RD)
I/1053	Vorrichtung zum Verformen von Blechen		Krupp	Krupp 037 TEED
I/1054	Procédé de mesure d'une quantité de gaz entraînée par un liquide	Wustner (CEA) Buis (EUR)	CEA	CEA 006 RAAF
I/1055	Compacted agglomeration fuel element forming method	Redding (UKAEA)	UKAEA	Dragon case 129
I/1056	Verfahren zur Herstellung von kugelförmigen Brennelementen aus Graphit	Spener (NUKEM) Hovrat (NUKEM)	NUKEM	KfA 003 RGAD
I/1059	Alliage à base de niobium	Champeix (CEA) Darras (CEA) Sannier (CEA)	CEA	CEA 006 RAAF
I/1060	Jet pump	Clabaugh (USAEC)	USAEC	USAEC (RD) General Electric
I/1061	Pressure vessel thermal insulation	Friis (USAEC) Hench (USAEC)	USAEC	USAEC (RD) General Electric
I/1063	Improvements in or relating to seals	Bateman (UKAEA)	UKAEA	Dragon case 133

File No.	Title of Patent	Inventor	Holder	Origin
I/1070	Vorrichtung zur Herstellung eines mehrlagigen Druckbehälters oder Druckbehälterteiles		Krupp	Krupp 037 TEED
I/1071	Dispositif d'équipement étanche dans une boite à gants	Godart (CEA) Huon (CEA) Pajot (CEA)	CEA	CEA 006 RAAF
I/1072	Dispositif d'étanchéité pour bouchon tournant de réacteur nucléaire	Gallo (CEA)	CEA	CEA 006 RAAF
I/1073	Perfectionnements apportés aux machines tournantes engendrant des courants électriques élevés sous faible tension, notamment aux génératrices homopolaires	Rebut (CEA) Torossian (CEA)	CEA	CEA 012 FUAF
I/1074	Perfectionnements apportés aux systèmes générateurs électriques, plus spécialement pour permettre de libérer de l'énergie électrique sous forme d'impulsions	Rebut (CEA) Torossian (CEA)	CEA	CEA 012 FUAF
I/1075	Perfectionnements apportés aux systèmes générateurs électriques, plus spécialement pour permettre de libérer de l'énergie électrique sous forme d'impulsions	Rebut (CEA) Torossian (CEA)	CEA	CEA 012 FUAF

DOCUMENT No. 38 IMPLEMENTATION OF BUDGETS

I. Research and investment budget

The Commission had the following fixed appropriation at its disposal for the financial year 1966:

	EMA u.a.
— 1966 research and investment budget adopted by the Council of Ministers on 21 March 1966	90,587,000
— Fixed appropriations carried forward from previous financial years pursuant to Article 4, Para. 1b of the Financial Regulation governing the establishment and implementation of the research budget	23,701,000
Total:	114,288,000

The fixed appropriations entered in the books as at 31 December 1966 amounted to 101,066,000 u.a., the breakdown being as follows:

Head	Chapter	Description	Fixed appropriations available in 1966	Amounts entered in books as at 31.12.1966
			u.a.	
I		*Staff expenditure*	19,977,000	19,423,000
II		*Operating expenditure*	5,675,000	5,582,000
III		*Joint Nuclear Research Centre*		
	30	Apparatus and equipment	7,074,000	6,087,000
	31	Real property investments	2,075,000	1,585,000
	32	Operation of HFR and services rendered by RCN for the account of the Petten establishment	2,472,000	2,269,000
	33	Operation of ISPRA-1 reactor	300,000	232,000
	34	Operation of large CNMB installations (linear accelerator and mass-spectrometers)	155,000	155,000
		Total under Head III	12,076,000	10,319,000

Head	Chapter	Description	Fixed appropriations available in 1966 (u.a.)	Amounts entered in books as at 31.12.1966 (u.a.)
IV		*Reactor development and construction*		
	40	Gas reactors	6,695,000	6,695,000
	41	Light-water reactors	510,000	500,000
	43	Organic reactors	18,230,000	15,603,000
	44	Homogeneous reactors	707,000	534,000
	45	Fast reactors	18,923,000	17,375,000
	47	Nuclear marine propulsion	2,082,000	2,026,000
	48	Research and applied technology relating to proven-type reactor development and construction	7,351,000	5,098,000
	49	Power reactors	585,000	213,000
		Total under Head IV	55,083,000	48,044,000
V		*Other scientific and technical activities*		
	50	High-flux irradiation	2,122,000	2,078,000
	51	Fusion - plasma studies	7,033,000	5,762,000
	52	Biology	3,376,000	2,763,000
	53	Radioisotopes	720,000	360,000
	53*a*	Miscellaneous research	3,808,000	3,125,000
	54	General documentation	1,030,000	952,000
	55	Training and instruction	381,000	359,000
	56	Reprocessing of irradiated fuel	2,051,000	1,867,000
	57	Processing of active effluents	956,000	432,000
		Total under Head V	21,477,000	17,698,000
		GRAND TOTAL	114,288,000	101,066,000

The payment authorizations covered by the 1966 budget, including the supplementary budget of 10 million u.a. for 1966, which was not finally approved until 9 February 1967, amounted to 115,302,000 u.a. A total of 103,031,000 u.a. had been paid out as at 31 December 1966.

The 10 million u.a. under the supplementary budget, which were only made available after the closing of the 1966 accounts, could not be utilized during that financial year.

Of the payment authorizations of 10,097,000 u.a. brought forward from 1965 to 1966, 10,035,000 u.a. were paid out.

II. Operating budget

For the financial year 1966, the sum of 9,743,840 u.a. was available to the Commission under the operating budget (Section III).

Expenditure commitments during the financial year totalled 9,627,328.17 u.a. Actual expenditure in respect of these commitments amounted to 8,795,834.71 u.a. as at 31 December 1966.

DOCUMENT No. 39 — STAFF BREAKDOWN UNDER THE RESEARCH AND INVESTMENT BUDGET ACCORDING TO PAYROLL (1)

(Posts filled as at 31.12.1966)

Budgetary Posting	A	B	C	D	Establishment personnel	Total
Ispra and Orgel	458	570	161	—	444	1633
Transuranium Institute	42	71	41	—	55	209
CNMB	48	64	19	1	30	162
Petten	55	64	26	—	45	190
Fast reactors	45	11	4	—	—	60
Advanced gas reactors	25	3	3	—	—	31
BR-2	16	19	7	—	—	42
Proven-type reactors	28	3	4	—	—	35
Irradiated fuel processing	4	—	—	—	—	4
Waste	1	—	1	—	—	2
New-type reactors	2	—	—	—	—	2
Marine propulsion	6	—	1	—	—	7
Radioisotopes	7	1	4	—	—	12
Fusion	64	24	7	—	1	96
Health and safety	8	3	1	—	—	12
Biology	49	9	7	—	3	68
Training	1	1	3	—	—	5
Directorate-General for Research and other programme	6	—	—	—	—	6
directorates	4	—	2	—	—	6
Dissemination of information	29	20	48	5	—	102
TOTAL	898	863	339	6	578	2684

1) The discrepancies between the figures given in this table and those in Document 40 are due to the fact that employees are not necessarily on the payroll of the establishment in which they work.

DOCUMENT No. 40 GEOGRAPHICAL DISTRIBUTION OF STAFF IN AND OUTSIDE THE COMMUNITY

I. In the Community

		Number or personnel
1. *Belgium*		
Brussels		209
CMB Establishment, Geel		132
Mol		46
	Total:	387
2. *Germany*		
Transuranium Institute, Karlsruhe		171
Günzburg		2
Munich		13
Frankfurt		2
Mannheim		7
Freiburg		3
Jülich		7
Hamburg		1
	Total:	206
3. *France*		
Fontenay-aux-Roses		57
Saclay		6
Paris		2
Cadarache		24
Genlis		1
Chooz		3
Dijon		1
Jouy en Josas		1
	Total:	95

4. *Italy*

Ispra Establishment		1218
Casaccia		2
Rome and Frascati		21
Bologna		3
Milan		1
Pavia		1
Latina		2
Fiascherino		1
Turin		1
Saluggia		1
	Total:	1251

5. *Netherlands*

Petten Establishment		129
Wageningen		8
Rijswijk		1
Amsterdam		5
Jutphaas		4
Arnhem		2
	Total:	149
	Total in the Community:	2088

II. Outside the Community

1. *Great Britain*		6
2. *United States*		11
3. *Canada*		1
	Total outside Community:	18
	Grand total [1]):	2106

[1]) Add to this total:

Establishment staff working at Ispra		447
Establishment staff working a Karlsruhe		55
Establishment staff working at Geel		30
Establishment staff working at Petten		45
Establishment staff working at Munich		1
	Total:	578

DOCUMENT No. 41 GRANTS TAKEN UP IN 1966

Sp. = Specialist's grant
Th. = Thesis grant
JP = Courses for young university teachers at nuclear research centres

Category	*Subject*	*Where working*
JP	Ricerche di biofisica e radiobiologia	Brussels University
Sp.	Studio sulla preionizzazione dell'idrogeno per mezzo dell'ultravioletto, utilizzabile come punto di partenza per θ-pinch	Garching
Sp.	Etude de l'évolution de la réactivité dans un noyau de réacteur à eau sous pression empoisonné par l'acide borique	Enrico Fermi (Trino Vercellese)
Sp.	Applicazione delle proprietà spettrometriche dei rivelatori a semiconduttori alla localizzazione *in vivo* di isotopi emettitori	Wageningen
Th.	Untersuchung der Rekristallisationsgeschwindigkeiten, des Kerngrenzenwachstums und der Kristallorientierung an Keramischen Systemen bei hohen Temperaturen	Petten
Sp.	Studio di tutti i parametri della fissione (somma delle energia cinetiche dei frammenti di fissione, emissione alfa ternaria) dell'U-235 e del Pu-239 nella zona di risonanza (1-100 eV) mediante acceleratore lineare	Geel
Sp.	Etude des séparations chromatographiques sur l'uranium et le plutonium	Geel
Sp.	Misure di precisione per la standardizzazione dei nuclidi ed a misure di spettrometria beta	Geel
Sp.	Développement d'un code de calcul des performances d'un réacteur de type ORGEL	Ispra
Sp.	Recherche expérimentale en vue d'une spécialisation dans le domaine de l'électronique nucléaire	Ispra
Sp.	Stabilità termomeccanica delle barre combustibili del reattore ORGEL	Ispra
Th.	Elektronen-Spin-Relaxation in freien Radikalen	Ispra

Category	*Subject*	*Where working*
Sp.	Statistica metodologica — linguaggi di programmazione	Ispra
Th.	Neutronenthermalisierung in ferroelektrischen Medien bei tiefen Temperaturen	Ispra
Sp.	Studio di leghe a fase dispersa tipo Al-Al_3-Nb	Ispra
Sp.	Calcoli di progetto di reattori relativi al flusso neutronici e ai coefficienti di temperatura	Ispra

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