EUROPEAN ATOMIC ENERGY COMMUNITY

EURATOM

THE COMMISSION

Documentation

attached to the

NINTH

General Report

on the

Activities of the Community

(March 1965 - February 1966)

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DOCUMENT No. 1 NUCLEAR FUEL FABRICATION AND GUARANTEES

I. Foreseeable expansion of nuclear fuel element market and pressure of foreign competition

There should be a brisk expansion of the nuclear fuel element industry in the Community during the period 1966-1975, to meet the growing nuclear power output. The growth forecasts mentioned in the report on the target programme (article 40) provide a basis for estimating the annual fuel element requirements for the Community nuclear power plants up to 1975 and calculating the proportion of this total that can be supplied by the Community element-manufacturing industry. Investigations by the Commission have yielded the following approximate figures :

Year	Annual turnover ('000,000 EMA u.a.)	Cumulative turnover as from 1966 ('000,000 EMA u.a.)
1966	21	21
1967	14	35
1968	38	73
1969	24	97
1970	26	123
1971	45	168
1972	49	217
1973	84	301
1974	55	356
1975	96	452

The above figures do not include the cost of the raw fissile material ; they relate to "fabrication" only, i.e., to the conversion of that material into thoroughly inspected clad elements of specified geometry. They do, however, include the share of turnover accounted for imported fuel-elements, which is liable to be substantial.

So far, about half the fuel elements used in the Community have been manufactured in non-member countries. If this state of affairs should continue or grow worse, the

Six countries will have let slip the opportunity for a great industrial expansion. Of course there is no question of any kind of European autarky, but on the other hand it is hardly conceivable that, with a turnover growth of this scale, the whole of the Community's fuel element market should be cornered by non-Community firms. It must be possible to strike a proper balance. If the conditions for such a balance are still unsuitable today, this is due not least to the problem of guarantees.

II. Guarantees

In order to reduce the present margin of error on assessments of nuclear fuel performances (far wider than the margin for non-nuclear fuels), quality control processes will have to be established, based on high-precision experiments that would call for four or five years of work. Owing to the pace of technological progress it is impossible to carry out this sort of experiment, so that the margin of error on performance estimates will remain wide ; in fact, expressed as a percentage of the fuel value, it will be greater than the customary manufacturer's profit margin.

To draw up fuel element supply contracts under these conditions means accepting a risk. The purchasers, alive to this situation, tend more and more to pass this risk on to their suppliers by demanding guarantees on the fuel they buy and, where the price is the same, giving preference to the supplier offering the highest performance guarantees. Many manufacturers in their turn would like to transfer this risk to some insurance system, but as things are at present this is not possible. Thus some manufacturers are faced with a harsh dilemma, as, on a single order, the sums involved by this margin of uncertainty are extremely high. Such difficulties would be removed if the "guarantee risk" could be made insurable, at least for the initial ten- or twenty-year period, until the industrial firms have grown large enough to take care of their own insurance.

III. Work carried out - Studies planned - Computer simulations

The question of whether the nuclear fuel guarantee risk is insurable in theory is an actuarial problem, and has been studied as such by the competent departments of Euratom conjointly with the computer laboratory of the Statistics Institute, Free University of Brussels.

It emerged that there was no need to bring proof of insurability with respect to all past and future guarantee risks, but only to nuclear fuel risks in the Community for the period 1966-1975. Assuming that the risks in question were insured by a hypothetical "Guarantee Fund", this Fund's activities, individual contracts and annual accounts were computer-simulated, as also the expansion of nuclear power plant capacity in the Community ; this was repeated a great many times, each time drawing at random a set of incidents involving the insurance mechanism, and also varying a great many times the Fund's assumed strategies as to actuarial policy — choice of premium rates, franchise rates, rebate rates — the aim being to discover by which strategies such a Fund, starting with a given capital, would be least likely to go bankrupt.

The results of this experiment proved that under the conditions considered, where the number of insured events stays fairly low in the first years, the guarantee risk is a special insurability case. It is a borderline case which falls in a most interesting manner outside the usual scale of time and number of events typical of the ordinary branches of insurance.

Indeed, this guarantee risk is only insurable subject to the following conditions : first, the territorial field of activity must be Community-wide rather than State-wide; secondly, the financial machinery must be such as to allow of offsetting fluctuations from year to year as appropriate, the stabilization period being some ten times as long as for the normal branches of insurance. The best recommended franchise rate is 20 %, and the best recommended premium rate 3 % of the insured value. Under such conditions the redistribution of an overall profit of over 4 million EMA u.a. for the entire branch is a 75 % probability. Assuming a deficit, on the other hand, there is a 90 % probability that the sum of 2 million EMA u.a. would meet it. A financial reserve of 8 million EMA u.a. to absorb risk fluctuations appears to be the most suitable figure, it being understood that the likelihood of having to expend this sum is extremely small.

IV. Formation of a study group of Community manufacturers

Having found that, at the cost of slightly readjusting current insurance practices and working on a Community-wide scale, it is possible to insure the guarantee risk, the Commission considered that it was time to find a concern which would be willing to accept this rather unusual insurance business, or else to set one up and obtain certain arrangements from the public authorities to facilitate the carrying on of such business. For the purpose of studying these questions a number of Community firms, under the aegis of the Commission, formed an international working group in which they are all represented. This group is actively engaged in laying the groundwork for an effective solution.

DOCUMENT No. 2 PROVEN-TYPE REACTORS

I. Light-Water Reactors

The swift rise in the number of nuclear power plants equipped with light water reactors confirmed the outlook for a big industrial market for this type. A number of units aggregating approximately 6,700 MWe were ordered during the year by several American electricity suppliers and are scheduled to be in operation in the period 1970-71.

Light water plants are also building in various European countries and in Japan.

This is obviously the result of the sustained development effort on the part of the USAEC over the past ten years but the big American corporations have also been quick to take full advantage of the possibilities offered.

Close competition continues between the pressurized water and boiling water types and indicates that, in their present stage of development, the choice between the two cannot be made solely on technical grounds.

With simplified design and improved performances, reductions in capital and operating costs of these reactors may be expected.

The main objective of the Euratom/US Cooperation Agreement, it will be remembered, was to acquaint Community nuclear industry with American light water reactor techniques. As that cooperation enters its seventh year, various manufacturing groups — chiefly in Germany — can be said to have gained sufficient knowledge and experience to meet direct competition from manufacturers in non-member countries on their own domestic market.

Undoutedly Community help, as provided by the nuclear power plant construction programme under the Euratom/US agreement, the Euratom participation programme and the creation of a number of Joint Enterprises, has facilitated this development.

At the same time the Community research programme has led to new reactor designs original enough to be called European variants of the light water piles.

A.D. 2

1. *Joint Euratom/US Programme*

In 1965 the Joint Board gave the go-ahead for the negotiation of 9 contracts in the Community, including 5 extensions, and 23 contracts — including 10 extensions — in the United States. This brings the number of contracts concluded since 1959 in member countries and the United States to 134 and 66 respectively, representing commitments totalling around 54.5 million u.a. — 28.5 for the Community side and 26 million for the US.

The agreements for exchange of technical information obtained in the field of two-phase flow and plutonium recycling were extended to cover a major programme of research into damage to structural materials caused by radiation. These exchanges are greatly valued by specialist laboratories in the two continents and make an important addition to the research programmes carried out in accordance with the Euratom/US Cooperation Agreement.

Unfortunately, owing to the limited personnel available, it has again not been possible to back up cooperation with American laboratories with adequate participation by Community engineers. The gap was to some extent bridged in 1965 by Community industry agreeing to assume the cost of participation by a number of its engineers in certain contracts carried out in the United States. Twelve specialists made a lengthy stay there in this way, while Euratom sent three members of its staff during the same period.

2. *European variants of light water reactors*

One variant under study at the SNECMA laboratories since 1960 involves the development of a twisted-tape fuel element assembly (VORTEX). Inserted between uranium oxide rods, the twisted tapes induce vortical coolant flow which in practice causes the water to be thrown on the fuel elements, thus affording effective cooling of the heating surfaces and avoiding formation of poor-conductivity steam cushions. Careful investigation of the thermodynamic-hydrodynamic properties of the VORTEX system in a high pressure loop has shown that with water at between 0.7 and 1.4 m/sec. linear velocity and a slightly positive steam quality at the channel inlet, the peak burnout flux in a VORTEX assembly is three or four times greater than the rate obtained in a fuel rod assembly of conventional design.

In 1965 AEG joined forces with SNECMA to pursue these researches, which are currently directed to the parameter study of overall cost per kWh in relation to the power density of a boiling water reactor, to be followed by optimization studies for a reactor design using VORTEX fuel elements. The heat transfer data indicate that a specific power of the order of 80 kW/1 can be reached without danger.

It is planned to install a VORTEX fuel assembly in the Kahl reactor next autumn. This will enable the mechanical strenght of the system to be tested and in particular its resistance to friction-induced corrosion in a reactor.

The data so far obtained are promising for the development of a core of advanced, original design supported by welltried technology as regards the other reactor components and possessing economic advantages in comparison with the present generation of boiling water reactors.

The second variant concerns the design of a boiling water system incorporated in a prestressed concrete vessel. This research is being conducted jointly by the Société d'étude et d'équipement d'entreprises (S.E.E.E.) and the General Electric Co., under contract with Euratom and the USAEC respectively, and has already shown the prestressed concrete method to possess economic advantages for various boiling water reactor designs. The direct cycle forced circulation system with injection-pump and water/steam separation by surface evaporation (without separators) offers the greatest advantages and its technology has been tried out on an industrial scale. Preliminary design studies for a reactor project to develop 1000 MWe are in hand.

3. *Experiments on power reactors*

It is planned to carry out a measurements programme on the Garigliano power plant during 1966. Community industry assigned several engineers to take part in the detailed planning of the tests and the fabrication of the four instrumented fuel assemblies ; this job was performed mainly by General Electric under a USAEC contract.

Installation of a data logger computer unit at the Garigliano power plant was satisfactorily completed and the trials carried out show good agreement between calculated predictions and test data.

In addition, negotiations are currently in hand with ENEL for a vast programme to be carried out on the Enrico Fermi pressurized water power plant at Trino Vercellese. It will embrace researches into changes in reactivity as a function of burn-up in a boric-acid-poisoned core, the effect of acidity on reactivity, nucleate boiling experiments in the most highly stressed channels, as also a series of performance trials of the main auxiliary plant items. Apart from its direct value in connection with pressurized water plants now building at Chooz and Obrigheim, this programme should yield technical safety data on the basis of which an increase in the power of the Trino Vercellese reactor can be considered. It will be backed up by analysis of a series of fuel element assemblies suitably selected from the three core enrichment areas of the power plant. This evaluation study, along with others relating to the detailed analysis of changes in reactivity as a function of pH and the xenon effect in a large capacity core, was recently entrusted to the Westinghouse company by the Euratom/US Joint Board. As in the case of the programme on the Garigliano power plant, electricity suppliers and nuclear industry in the Community will be invited to participate in this complex of research studies.

4. *Nuclear fuels and materials*

Due to the reduction in the appropriation under the Community's second five-year research programme, Euratom has had to confine activity to the completion of current studies in this sector, vital to the nuclear industry.

They include the forthcoming incorporation into the Kahl reactor of a fuel assembly using Zr-Nb3-Sn1 as cladding. This alloy was developed under contracts entered into with the Metallgesellschaft and the Gesellschaft für Kernenergieverwertung in Schiffbau und Schiffahrt. Fabrication has gone ahead smoothly and irradiation testing will, it is hoped, corroborate the laboratory results.

A ZrCr1 Fe6 016 alloy, still known as "Valloy" has also been developed in the United States under a contract signed with the USAEC. This material presents far better hydridation resistance and high-temperature mechanical properties than Zircaloy-2, to the extent of resisting prolonged contact (up to 15,000 hours) with steam heated to 450 °C.

If irradiation tests of several Valloy-clad fuel assemblies in the Big Rock Plant boiling water reactor confirm the data obtained from out-of-pile tests, this material may provide the answer to an extremely tricky problem. As things stand, the corrosion resistance of Zircaloy is insufficient for it to be used as cladding for fuel elements subject to heat fluxes appreciably greater than those currently obtained in water reactors, other fuel element characteristics remaining equal.

Stainless steel corrosion studies are proceeding very well. The part played by chemical impurities, heat treatment and internal structure of these materials is coming to be better understood as a result of fundamental research in progress in various Community laboratories. At the same time the relationship between surface treatment of stainless steels and high-nickel-content alloys and the temperature of the water or steam to which they can be exposed has been confirmed, and finishing processes suitable for industrial-scale application are now being developed.

5. *Plutonium recycling*

This question has gained in importance recently, under the stimulus, more especially, of electricity suppliers operating power reactors on slightly enriched uranium. The conclusions of the Edison Electric Institute's study in the United States are now unanimously accepted there, and several electricity supply companies in the Community are now taking an interest in the matter.

Thus action initiated in the Community as far back as 1959 will, it is hoped, enable both the nuclear power plant construction industry and the electricity supply industry to find appropriate solutions in optimum conditions.

In this context, the research programme entrusted to the CEN/Belgo-Nucléaire association is now centred on the theoretical and experimental study of a plutonium recycling scheme in the peripheral area of the SENA core. This study is likewise of direct interest to the Trino Vercellese and Obrigheim pressurized water power plants. Moreover, development of a fuel rod fabrication process using a UO_2-PuO_2 mixture is being actively pursued, since an industrial-scale technique will have a decisive influence on the overall economics of plutonium recycling in thermal reactors. These studies are buttressed by in-pile performance testing of samples in BR 2 and of prototype assemblies in BR 3.

Loading of about a third of the SAXTON reactor core with mixed UO_2-PuO_2 fuel was effected during the last quarter of 1965 and following a series of neutron measurements at zero power the plant has been operating at the rated load of 23 MWe since the beginning of 1966. The plutonium-containing fuel will be irradiated up to a mean burn-up of 12,500 MWd/t ; sub-assemblies will, however, be withdrawn from the pile at regular intervals to check changes in reactivity and the isotope composition of the uranium and plutonium. This programme will make it possible to bring into line with experimental results the schemes used for the exact determination of plutonium-charged reactor core characteristics.

The Joint Board also recently authorized the conclusion of a contract between USAEC and General Atomic on the experimental determination of the neutron flux distribution in UO_2-PuO_2/light water systems by the time-of-flight method, the neutron source being supplied by a LINAC-type accelerator. This investigation is supplementary to the work in hand at General Electric on measurement of fission rates of the various plutonium isotopes in a well-defined neutron spectrum.

Lastly, the studies on uranium/plutonium/graphite and uranium/plutonium/heavy-water systems entrusted to the CEA by the Joint Board have entered thier final phase. Substitution and oscillation experiments in the various graphite (MARIUS, CESAR) and heavy-water (AQUILON II) critical assemblies are going ahead fast, along with analysis of isotope composition of the uranium and plutonium in a number of fuel cells after irradiation in the Marcoule reactors under well-controlled neutron flux and temperature conditions.

Together these studies will enable exact formulae to be evolved for the calculation of long-term reactivity changes in natural uranium reactors.

6. *Thermodynamica and hydrodynamics of fluids*

In view of the quality of research and industrial laboratories in the member countries the Community rates high in this field, but here too the cut in the five-year appropriation has been felt. Whereas in 1965 the programme embraced the closely coordinated activities of eight laboratories, the number has lately been halved. Work in hand is mainly in the field of hydrothermodynamic instability in pressurized water reactor channels and in two-phase water/steam flow systems.

These studies are of considerable importance for the safety of such plants and are also closely bound up with the development of systems like the VORTEX, designed to arrive at a higher peak burnout flux.

7. *Structural materials*

Research continues in this field along the lines of the previous programme.

As ergards problems relating to the preparation of steels for reactor vessels, a far-reaching study of traditional welding processes has been completed as also a laboratory study of stainless plating by the "strip" process. Work on electroslag welding has demonstrated the potentialities of this process in nuclear construction, having yielded valuable data on the improvement of the metallurgical properties of welds and the technique of perfect girth junctions, as well as on the nature and distribution of the residual stresses induced. Regarding the properties of heavy-gauge steels for reactor vessels, which have to be allowed for in the interests of operating safety, there have been major advances in the understanding both of the phenomena of brittle fracture, hot creep and plastic fatigue and of the means for reducing their incidence. Studies as to non-destructive control tests for the prevention of certain kinds of damage have gone ahead very well also.

The practical importance of work on the way in which the properties of pressure vessel steels are affected by irradiation is now apparent. Fundamental research into the mechanism governing the radiation-induced increase in the transition temperature of steels is now in its second and last stage, viz : the in-pile irradiation of alloys that have been exhaustively studied and defined. Meanwhile the search for practical methods of limiting irradiation damage has led to the isolation of certain significant parameters of metals and indicated the lines to be followed in these researches, which form part of a greater whole embracing, for instance, a major study, entrusted to an American laboratory, on the influence of sub-structures.

Other researches on steel reactor vessels recently undertaken are aimed at new designs to give greater safety or a fuller understanding of their behaviour by simulating the pressure conditions encountered in service. During the year, two symposia were held, the one on problems of creep and the other on questions of brittle in heavy-gauge steels. The latter was attended by more than 300 specialists from the Community and many non-member countries.

II. Graphite-Gas Reactors

Further positive experience in the operation of graphite-gas natural uranium power reactors was gained during the period under review. The capacity of the Latina plant, biggest of all the nuclear power plants currently operated by the Community, was raised above its rated power with a high load factor.

In pursuing its activities in this field the Commission concluded some new development contracts to complete its programme. It is not proposed to initiate fresh research projects. For the remainder of the period of the second five-year programme it will endeavour rather to extract maximum benefit from investments and results under the research programme so far in respect of proven-type natural-uranium graphite-gas reactors.

1. *Development of fuel elements*

The development programme on ternary uranium alloys led to the selection of the following alloys, evaluation of which will be continued by irradiation of small samples :

U - 1 % Nb - 0.1 - 0.25 % Cr
U - 0.3 % Mo - 2 % Zr
U - 0.5 % Mo - 0.5 % Nb

The choice so far has been made on the grounds of structural properties, thermal stability and thermal cycling stability. Irradiation of samples is due to start in 1966.

Work on the fabrication of Latina-type fuel elements with a ternary uranium alloy has been completed at the Casaccia centre and the same laboratory is studying the fabrication of tubular elements (hollow uranium rods sealed at both ends).

Lastly, research on a metal bond between magnesium canning and uranium alloy fuel has led to the choice of titanium, which besides effecting the bond between fuel and canning should form an efficient anti-diffusion barrier.

The study of the fabrication of magnesium alloy "herringbone" cans by casting is going well as regards both the high-pressure and low-pressure technique. The clads produced are not yet up to the necessary standard and the study of their defects and ways of remedying them will mark the end of the current programme.

At the same time, optimum possibilities have been determined for machining very long monobloc cans with particular regard to depth, thickness and the number of fins in the case of four- and eight-segment cans. The complete can is fabricated from a single extruded blank, thus obviating assembly work. Three prototype cans were machined and subjected to thermal and aerodynamic testing in CEA piles with a view to being used in the Latina reactor. The one selected, with heat transfer properties 15-30 % better than cans presently in use, was then put into pilot series production and a firm order for this type of cladding should follow.

2. *Heat transfer*

Under a programme being carried out in liaison with the Jülich research centre in the Land North Rhine-Westphalia, Euratom is now carrying out thermo- and aerodynamic development work on a tubular fuel element with internal and external fins for use in graphite-gas natural-uranium reactors. With these fuel elements it will be possible to improve reactor specifications and to exploit to the utmost the potential of prestressed concrete pressure vessels.

The research began with the designing of pilot high-pressure test installations and making with the Community firms and institutions concerned. It is intended that the research programme should be complementary to and coordinated with other current studies.

Much progress has been made in the matter of fundamental knowledge of the natural convention of carbon dioxide at high densities. Existing formulae of general application have been shown to be inapplicable in this particular case, the absorption of radiation by the gas at high densities constituting an important factor. A provisional formula has been evolved pending results of further investigations.

Knowledge of convection phenomena is vital for developing thermal insulation systems for prestressed concrete vessels. Two insulation research projects are currently in hand, one for adapting the "water screen" method to the graphite-gas technology and the other for applying "honeycomb" metal-cell insulating materials to the same purpose. Trial installations for both are under way and should yield data before the end of the year.

3. *Structural materials*

Preparations for and construction of a test loop for the BR 2 high-flux reactor with a view to studying radiation-induced graphite corrosion have advanced to the point where a trial start-up can be expected within a few months. Special attention has been paid to operational safety of the test section, to the choice of samples to be examined and the problem of reaction damping.

Study of the thermal and irradiation stability of concrete used in pressure vessels continued. During the period of the report, new methods were tried out for the measurement of specific properties — thermal, mechanical and plastic — of structural materials and the necessary test rigs were built. Initial data from irradiated test pieces show that thermal doses of up to $10^{19}n/cm^2$ are far from producing the same effects as temperature. The irradiation tests will be extended to higher integrated flux values and the effect of fast neutrons will receive special study.

4. *Reactor technology*

A new method for unloading graphite-gas reactors has now been developed. A "loft" to house the fuel element loading and unloading gear is located in the upper part of the reactor core inside the concrete vessel. This loft, which is separated from the core by a concrete slab for purposes of heat insulation and radiation shielding, is kept in a pressurized CO_2 atmosphere at moderate temperature. There are various advantages with this set-up, notably, lightness and simplicity of the equipment, reduction in cost and simpler refuelling, due particularly to the fact that the machine has direct access to each channel by means of simple movements. Promising results were obtained from operating tests on a full-size mock-up of this equipment. Fragile or sensitive parts of the equipment (position indicators, control group for motors, cables, oils and greases) have been tested in operating temperature, pressure and irradiation conditions and in each case a satisfactory solution has been found. New control devices, working by means of chains and small enough to be fitted easily into a thin concrete slab, are also being subjected to pressure and temperature testing under this same project.

From general studies on the different types of steam cycle it has proved possible to express their thermodynamic efficiencies versus their parameters and to draw comparisons. Specific studies of certain of these cycles now under way will make possible partial economic optimization of the conventional part of graphite-gas nuclear power plants.

Preparatory work under the contracts relating to prestressed concrete pressure vessel development has reached the point where construction can shortly begin of scaled-down models of the reference vessel. On the basis of numerous loading trials, actual stress ratios and safety measures to be taken in various operating conditions will be determined, for subsequent comparison with the figures calculated theoretically. This development programme will probably be completed during the coming year to provide technical and economic data which can then be compared with the methods now applied.

DOCUMENT No. 3 HEAVY WATER AND ORGANIC LIQUID REACTORS

I. The ORGEL Project

1. *Technical and economic features*

In the Fifth General Report the Euratom Commission set out the reasons motivating its decision in 1959 to canvass thoroughly heavy-water-moderated organic-cooled reactors and to give this research pride of place among Ispra's activities.

This decision, ratified by the Council of Ministers when the second five-year programme was approved, provides for an international division of work, since parallel studies on heavy-water/heavy-water and heavy-water/gas variants are in progress in countries such as Canada, France and Germany. The technical and economic considerations listed hereunder indicate that in the medium term the ORGEL development series is capable of making a valuable contribution to the solution of Europe's energy supply problem :

— as things stand at present, reactors which can use both natural and enriched uranium offer a flexible solution to the Community's fuel supply problems ;
— the capital costs for an ORGEL power plant are fairly low, since with this type wide use can be made of proven techniques and cheaper construction materials and also because of the low pressure in the reactor vessel ;
— the fuel cycle cost is very low, does not necessitate used fuel reprocessing in order to make it a paying proposition and hence is unaffected by the uncertainties with which the costing of enriched-uranium fuel cycles is usually fraught, such as the buy-back price of plutonium and the reprocessing price ;
— the general economy of a natural uranium ORGEL type reactor compares favourably with that of other types ; in addition, a high specific power version would certainly appear to offer special economic advantages ;
— moreover, since the design allows of extrapolation for high power levels without any particular difficulty, the specific investments can be further reduced and the potential applications of the development series extended beyond that of electricity production ;
— in view of the high coolant outlet temperature, a good electrical efficiency can be expected, provided that the correct steam cycle is used ;

— in ORGEL-type reactors the utilization factor of both the fissile and the fertile materials is substantially higher than in other existing natural uranium reactors ; at the same time the specific plutonium output is particularly large.

2. *ORGEL study*

During 1965 the Project Group studied the essential features of a prototype power reactor. It continued the economic study of the ORGEL design and discovered the potentialities of a high specific power variant. The programme as a whole was explained and discussed at a symposium attended by 120 people at the Community's invitation on 26, 27 and 28 October 1965. The use of thorium was investigated and further exploratory studies were launched in collaboration with the Ispra research centre.

Two prototypes of 80-125 MWe and 250-300 MWe respectively, were examined and compared with a high power plant (500-600 MWe) to appraise the problems which extrapolation of the prototype to future power plants of this series would involve. It is already possible with a medium-power prototype to design and manufacture equipment which can be relatively easily extrapolated to reactors of more than 300 MWe at minimal financial risk, and this has been selected as the reference prototype.

Earlier studies on this line of development have been revised with a view to the construction of the 100 MWe prototype (thermodynamic cycle and coolant temperature, channel and fuel element, fuel management, dynamics of the power plant).

Two versions of the prototype reactor have been devised, one with only slightly divided fuel at a degree of enrichment just sufficient to attain a burn-up of 10,000 MWd/t identical to that of a large-scale natural uranium reactor of this series (compensation for size), the other having a more divided fuel and a greater coolant cross-section in the channel, so as to derive maximum advantage from the combination of uranium carbide and organic coolant in extracting high specific powers (60 W/d and over). In this latter variant the degree of enrichment is slightly higher than in the former.

It has indeed been shown by studying the economic prospects that, while a natural uranium power plant of the ORGEL series compares favourably with other types of heavy water power plant, a high specific power plant in fact goes much further in economy and simplicity of construction by reason of the greatly reduced number of reactor channels.

The Joint Research Centre establishment at Ispra went on contributing to all aspects of research on this reactor system throughout 1965, while collaboration on the project with research laboratories and industrial concerns in the Member States continued.

3. *Research and development programme*

a) *Chemistry*

The study of the behaviour of polyphenyls exposed to heat and radiations remains a vital element of the programme.

In the field of chemical analysis, considerable progress has been recorded, by combining all analytical methods for identifying substances in the decomposed organic fluid. It is now possible by means of analysis to examine decomposition products with very high boiling point, such as ∅ 16.

There has been a decisive advance in research into the mechanism of coolant decomposition resulting from cumulative observations of in-pile irradiation in several loops. The experiments were conducted under a contract with the CEA at Grenoble, using two organic loops capable of operating at 450 °C and at different fast-neutron-flux/gamma ray ratios.

The radiolysis mechanism differs greatly from that of pyrolysis. While the kinetic value of radiolysis is of the order of 1.5, in pyrolysis it equals unity. To reach a value of 0.25 for the n/gamma ratio the Siloë reactor was used. These data are essential for evaluating organic liquid consumption for an ORGEL-type reactor.

In investigating the various methods of coolant purification, Attapulgus clay has proved unsuitable ; this product is used chiefly as a hydrocarbon cat-cracking and isomerizing agent. The method based on the kerosene solubility differential of polyphenyls appears cheaper and will shortly be tried in an in-pile loop.

b) *Physical chemistry*

The basic research mentioned in the Eighth General Report was continued at Ispra.

The search continued for a zirconium alloy intrinsically compatible with the organic liquid in typical service conditions for the pressure tube or cladding. Experimental data indicate that the behaviour of alloys developed to resist superheated steam is better in terphenyl than in steam at the same temperature, provided that the chlorine concentration is below 0.1. ppm. A simple method has been discovered for doing this.

Further studies were conducted into the use of graphite as filler for the ORGEL channel. Graphite was impregnated with metals and alloys (e.g. Mg and Al) to render it completely impermeable. The addition of 15-20 % by volume of metal improves the mechanical properties two- and three-fold.

Lastly, prolonged research resulted in the discovery of corrosion preventatives which afford most effective protection for magnesium when added to the terphenyl.

Apart from existing out-of-pile installations, the KID organic loop of the Ispra-1 reactor has been completed.

c) *Neutron physics*

Research on organic-liquid/heavy-water/uranium carbide lattices continued to be based on an extensive experimental programme. On the theoretical side, two new calculation codes for heavy-water/organic-liquid lattices (PLUTARCO and PINOCCHIO) were adopted in place of the CAROLINE code employed since 1962.

On the experimental side, the neutron parameters of the following fuel element clusters were measured :

— nineteen 12-mm diam. uranium metal pins
— seven 25.2-mm diam. uranium carbide pins
— four 30.9-mm diam. uranium carbide pins.

Various coolants, ranging from biphenyl (organic liquid) to light water, heavy water and air, were used.

The measurements were carried out on :

— the Ispra exponential assembly (Expo),
— the French Aquilon-II pile at Saclay,
— the ISPRA-1 reactor at Ispra,
— the Bologna (Italy) RB 1 reactor.

There was excellent agreement between the data obtained from these measurements and from the calculation codes.

Finally, a complete range of measurements of neutron density distribution in the ORGEL clusters was effected at Saclay on Aquilon-II.

As regards irradiated lattices, an oscillation study of plutonium-containing lattices is in preparation.

d) *Heat transfer*

Most of the work, carried out at the Ispra establishment, concerned problems of heat transfer relating to the fuel element. One existing organic-liquid loop was fully automated to enable long-term trials to be made ; on the second one, studies were effected on the peripheral variation of the heat exchange coefficient about a heating rod simulating a fuel pin for different centrings in the channel.

In the context of investigations connected with the fuel element cluster, experimental study of corrugated surfaces showed a 60-70 % rise in the exchange coefficient for a 15-20 % pressure drop increase. A technique was perfected for measuring the coolant mixture between the separate fuel pins.

e) *Fouling study*

Research directed to analysis of the mechanism of fouling has reached an impasse owing to the very numerous parameters involved coupled with the difficulty of control.

However, minimum conditions of purity which have to be observed to prevent fouling deposits are known, and the objective is rather to obtain less rigid specifications. In particular it has been observed that :

— chlorine is an important factor, but only in the inorganic form ($FeCl_2$),
— fouling is qualitatively related to the electrical conductivity of terphenyl, which itself is strongly influenced by the LEWIS acids ($FeCl_3$, $AlCl_3$, etc.).

Overall experiments will be continued in existing installations.

f) *Technology*

The activities of the Ispra Technological Service are largely devoted to the ORGEL project. Data on the pumps, valves and measuring apparatus operating in an organic medium at 400 °C are available in a sufficiently large number from the installations put into use in 1962 for statistical evaluation to be feasible.

Research has been centred on two types of channel, the SAP hot pressure tube reference channel and the zirconium hot pressure tube channel protected against hydrogenation ; in the latter case an aluminium lining appears promising. A special effort has been directed to full-scale tests in an out-of-pile loop, the prototype channel for testing in the ESSOR reactor has given satisfactory results in tests lasting more than 2,000 hours.

The installation for the study of safety problems in pressure-tube reactors was used to carry out further channel-burst experiments and evaluate the dynamic effects of temperature changes in the core of an ESSOR-type reactor.

g) *Metallurgy and fuel elements*

The bulk of this part of the programme is being carried out at the Ispra establishment, where it accounts for 90 % of the activity of the Metallurgy Service, which also administers numerous contracts, the most important of these being aimed at the industrial development of methods for fabricating uranium-carbide fuel pins and SAP products.

A.D. 3

Uranium monocarbide, the reference fuel for the ORGEL series, has become an industrial fuel ; a new development contract has been signed with a view to lowering the cost. An initial result of significance is the casting of perfect rods up to 50 cm long.

A solution has been found to the problem of UC storage. Work has begun to ascertain whether the properties of the carbide can be improved, the first subject of study being mixed UC/ZrC with a low zirconium content.

SAP continues to be the reference structural material.

With regard to the fabrication process, it can be stated that the supply of smooth or finned cladding tubes no longer raises any significant problems, the quality of the finished products now being satisfactory. The same does not yet quite apply to the pressure tube.

Much effort has been concentrated on research into the development and the mechanical, thermal and hydraulic behaviour of prototype fuel elements, as well as their fabrication and quality control, viz.

— cluster of seven SAP-clad uranium carbide pins (G-7 type element),
— variant consisting of graphite matrix pierced by four subchannels in which are separately fitted four SAP-clad uranium carbide pins (M-4 type element). Results are satisfactory and the elements are to be tried out in the ESSOR reactor.

The irradiation programme has made further progress and uranium carbide irradiations continued despite some trouble with thermocouples (HFR, GETR, EL-3, Mélusine, Siloë reactors).

Investigation of the in-pile behaviour of canned fuel pins proceeded chiefly under the Euratom/Canada agreement. Two experimental bundles were irradiated (experiments X 716 1 and 2) in the NRX reactor.

At Ispra, the DIRCE organic loop is operating normally in the Ispra-1 reactor after some initital troubles and the first fuel pins are to be inserted early in 1966.

The irradiation of a fuel element in the Canadien WR 1 reactor was the subject of a complete irradiation proposal and was discussed at the Whiteshell Centre ; insertion in the pile is scheduled for some time in 1966.

The medium-activity laboratory (LMA) is nearing completion. The cell construction stage will have been terminated at the end of 1966 and some cells are in non-active operation.

Lastly, following studies for a fuel pin with liquid thermal seal for high power densities, the first lead-jointed pins have been fabricated.

4. *Studies and constructions*

The ORGEL critical and exponential assemblies

In May 1965 the Ispra centre took over the completion and finalization of the ECO reactor, up to that time in the hands of a contractor. The reactor went critical on 11 December 1965.

ESSOR (ESSai ORgel) test reactor

Construction work on ESSOR proceeded according to plan during 1965. The rough structures inside the containment shell, together with the shell ring for the latter, were completed in the course of the year. The lining of the storage pond has been manufactured and fitted and the outside buildings are 70 % complete.

Orders for the construction of the various reactor subassemblies were placed throughout the year and the manufacturers have started to work on them. Only a few instrumentation contracts have yet to be concluded. Development work on the ESSOR channel was continued and the results of the various studies and tests enabled the data on this important ESSOR component to be finalized. The studies carried out by the Belgian Nuclear Studies Centre (CEN) at Mol for the purpose of finalizing the feed-zone fuel elements yielded satisfactory results and, following a call for tenders, the order for these fuel elements was placed at the end of the year.

All the major civil engineering works and a large proportion of the secondary works have been completed. Leak testing of the containment shell has given very satisfactory results. A start has been made on installing internal assemblies ; acceptance tests have been carried out on the diesel auxiliary station ; high- and medium-tension stations and the cooling pond are almost finished. Inside the containment shell the essential parts of the pile block, namely pressure vessel and tube block, have been positioned within the deadlines laid down in the original schedule.

The last of the construction contracts have been negotiated, manufacture at works is progressing well and acceptance tests at works have already taken place in many cases.

Development and fabrication of feed-zone elements, ORGEL test elements and pressure tubes are proceeding according to schedule.

The preliminary safety assessment by the ORGEL project team was considered by the Ispra establishment internal safety committee and after recasting has become the "interim" safety report. The next stage in the procedure has still to be decided.

A.D. 3

Although the criticality date has not yet been set, the experimental programme has been drawn up. The equipment and temporary modifications necessary in order to effect the criticality operations have likewise been determined.

The assembling of an operating team involved consideration of a thousand applications ; two hundred candidates were interviewed and a hundred recruited.

At the end of the year the theoretical strength numbered 108, of whom 29 were engaged in construction and 54 loaned to various departments at the Centre while some thirty others had received letters of appointment but not yet taken up their duties.

5. *The Euratom/Canada agreement and tripartite co-operation Euratom/Canada/United States*

The agreement for technical cooperation signed in October 1959 between Atomic Energy of Canada Limited (AECL) and Euratom expired in October 1965 and was renewed for a further year. Collaboration centred in particular on irradiation of uranium carbide fuel elements and here good results have been obtained.

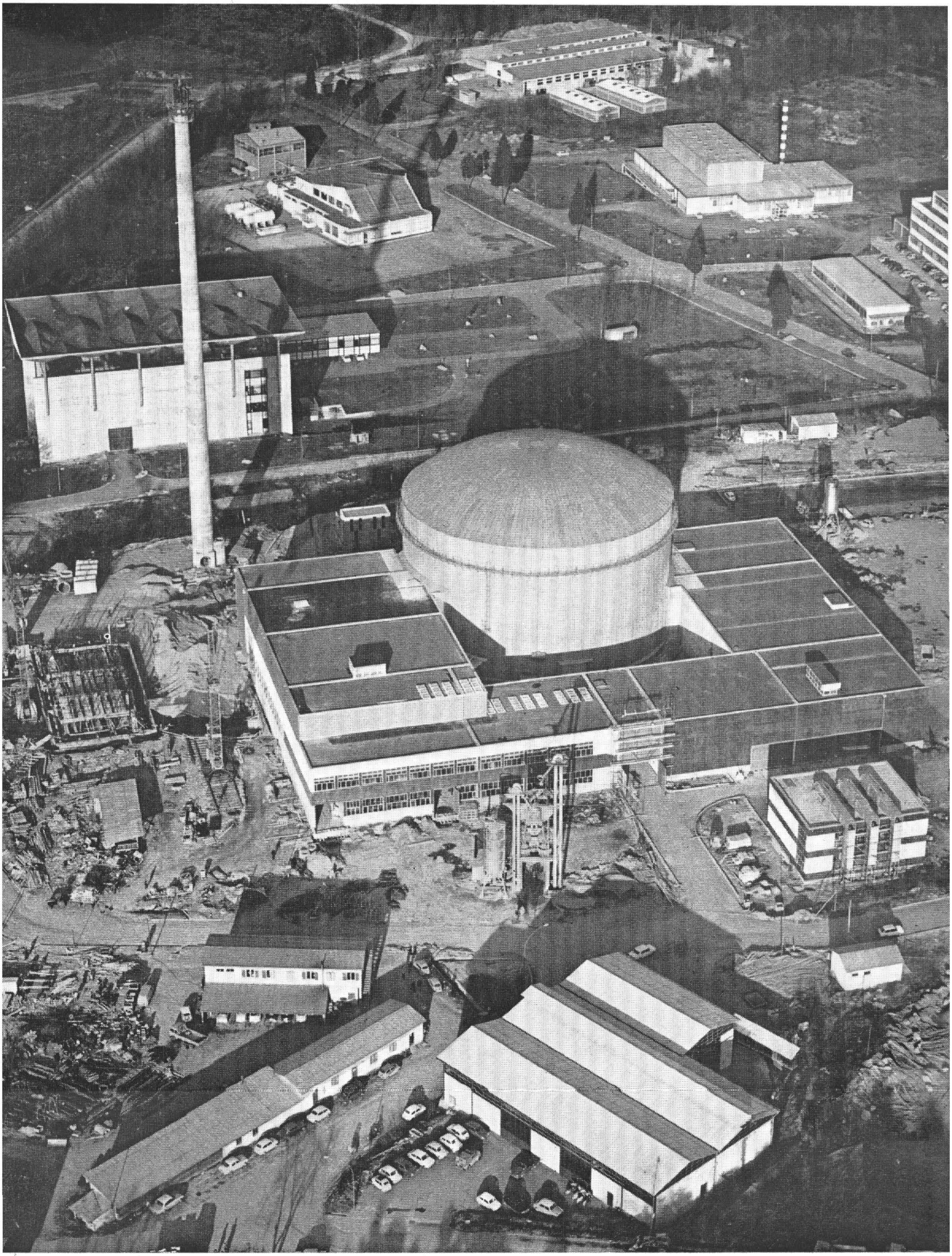
The USAEC's decision to conduct researches into heavy-water/organic-liquid reactors (HWOCR, ORGEL) with a view to the speedy assembling of information necessary for building a prototype led to a proposal from America in 1964 to extend existing Community/US cooperation to this field. The Council of Ministers adopted a resolution in June 1965 to the effect that the Euratom Commission should enter into exploratory conversations with the USAEC to obtain further information.

II. The PRO Project

Experimental research related mainly to the following points :

— Heat transfer in an organic medium : critical flux measurements in a sub-saturated boiling state were effected with test sections of stainless steel tubing, varying the diameter of the section, the rate of flow and the degree of sub-saturation of the liquid at the inlet. The capacitative method and the attenuation method for measuring the void fraction were studied. Visualization tests of steam bubble growth in sub-saturated water or in carbon tetrachloride were carried out, using an ultra-fast film camera.

— Development of a rack-and-pinion drive mechanism for control rods . construction of all components has been completed. Testing of the whole mechanism in a specially designed loop, called "pro-ba", has been postponed for safety reasons but will be undertaken very shortly.



ISPRA (Italy) — ORGEL PROJECT — BIRD'S-EYE VIEW
OF THE TEST REACTOR ESSOR AND THE CRITICAL EXPERIMENT ECO

— Construction and operation of the CIRO in-pile irradiation loop : the loop was installed in the Ispra-I reactor on completion of the construction and assembly of the various loop components and the hot state acceptance of the circuits was effected. The safety report was considered and certain modifications to the loop were required. The experiment was studied from the neutronics angle by irradiation of various mock-ups simulating test sections ; finally a first test section was prepared and inserted in the pile.

— Study on the production of uranium carbide sol-gel : laboratory-scale trials were carried out on two methods of preparing spherical granules of uranium carbide by converting into carbide UO_2 granules immersed in carbon powder and granules already containing carbon. Other carbide production processes are under study, as is the determination of optimum technical processing conditions to be adopted.

— Research on purification of terphenyls : construction work has begun on a distillation column and an electrostatic filtration plant for the Ispra Joint Research Cenre Establishment.

DOCUMENT No. 4 HOMOGENEOUS REACTORS

The Commission's activity in the homogeneous reactor field continued under the association with KEMA, with particular reference to heavy-water suspensions of uranium and thorium oxides for the attainment of adequate burn-ups. The scope of the investigations, confined during the early years of the project to stable colloidal suspensions of approximately 5 /u-diameter particles, was extended to take in colloidally unstable suspensions of possibly much smaller particles. Meanwhile, with a view to bettering the irradiation behaviour of the 5 /u particles, the project team has started to contemplate coating techniques. In addition, the fuel fabrication processes developed under this association agreement could prove important for the manufacture of fuel elements for other reactor types.

DOCUMENT No. 5

FOG-COOLED REACTORS CIRENE PROGRAMME

As mentioned in the Eighth General Report, a research contract was signed in the summer of 1965 between Euratom and the CNEN (Comitato Nazionale per l'Energia Nucleare) of the one part and the CISE (Centro Informazione Studi ed Esperienze), Milan, of the other part. Under its terms the CISE undertook with the technical assistance of Euratom and the CNEN, to carry out the following work within the context of the present five-year plan :

— to conduct a research and development programme relating to a power reactor of the heavy-water pressure-tube type fuelled with natural uranium and cooled by a light-water fog, known as the CIRENE project ;
— to study a reference design for a high-power CIRENE reactor ;
— to draw up a preliminary design for a fairly high-power prototype reactor.

The value of the CIRENE concept resides in the fact that it combines the advantages of the heavy-water pressure-tube reactors burning natural uranium and those of the boiling-light-water direct-cycle reactors. Moreover, it rests largely on experience gained with the proven-type water series as far as the core materials are concerned. Lastly, the cooling process envisaged could, as in the case of the boiling-water reactors, lead to nuclear superheating.

1. *Design studies*

During the year under review, much effort has been concentrated on comparing the merits — from the point of view of economy, development potential and feasibility — of the two reactor versions using the two types of fuel originally envisaged for a CIRENE reactor, namely, Zircaloy-2-clad UO_2 pins in clusters, and bundles of uranium metal tubes with internal cooling. The comparison resulted in the choice of uranium oxide which alone will, as far as circumstances permit, be developed. The studies demonstrated that :

— Economically, neither version possesses distinct advantages over the other, assuming optimum burn-ups of the uranium metal to be attainable. While capital costs are lower for the uranium metal version, refueling costs are higher. Burn-ups acceptable from the neutronics angle are lower for this version, because of the system of fuel handling during shutdown required in connection with this geometry.

— As regards feasibility, the use of natural uranium metal presents two major problems. The first concerns burn-up permissible from the standpoint of irradiation stability, which would at present appear to be appreciably below the optimum economic figure. The second concerns compatibility of the uranium metal with the coolant in the event of a canning burst. Out-of-pile tests have shown that while the consequences of such an accident are not catastrophic, in order to limit them it is necessary to develop a fast means of detection and to remove the damaged element quickly.

  But from the dual aspect of safeguards and control, particularly vital in a reactor with a positive power coefficient, the UO_2 version offers less advantages, particularly in view of the higher water content of its power channels. The difficulties would not seem to be insurmountable, however.

— The development potentialities of the UO_2 variant seem better, as regards possible fuel enrichment and adaptability to nuclear superheat.

To carry out the comparative study of the two variants, it was necessary to work out relatively elaborate designs for the corresponding reactors and proceed to an optimization of their performance and evaluation of the cost of energy generated. Fabrication coasts were determined for many components on the basis of offers from and discussions with potential suppliers.

2. *Research and development programme*

a. *Neutron balance*

Work continued on developing calculation codes for forecasting the neutron balance in a CIRENE lattice and the evolution thereof as a function of fuel depletion. These codes were used in the comparative study mentioned above. The sub-critical assembly for measurement of the cell parameters, completed during the previous year, have come into operation.

b. *Thermal and hydrodynamic balances*

Burn-out studies continued on heating elements simulating rod cluster geometries and internally-cooled tube geometries.

The tests relating to cluster geometries were carried out on the Genoa loop prior to its transfer to Piacenza, where it will be put into operation again in the spring of 1966. The aim was to ascertain the influence of various parameters — e.g., diameter of heating rods, clearance dimensions, etc., and of the spacers.

The tubular geometry tests were conducted on a loop at Piacenza and concerned the effect of twisted tapes or spirals fitted inside the heating tube with a view to increasing the extractable critical power. The number and positioning of these spirals were the subject of optimization studies. Employment of these devices, while substantially improving the thermal performance of the channel, is accompanied by an appreciable increase in coolant pressure drop. Further series of measurements were also made on heat transfer where the critical flux is exceeded.

Coolant density measurement in hot channels was carried out, during on-power tests in cylindrical piping, by the so-called dilatometric method which gives the integral density of the coolant in the channel. The cluster geometry tests were carried out in the cold state in adiabatic conditions pending the entry into service of the new Piacenza loop, where on power testing can be effected and which will have a heating capacity of 6 MW to draw on.

c. *Fuel*

The main effort was again concentrated on experimentation with the tubular uranium-metal fuel element.

Firstly, the compatibility of the uranium metal with the coolant in the event of a canning burst was investigated in a circuit faithfully reproducing the thermal and hydrodynamic conditions of a reactor channel. Contact of the coolant with the uranium through a hole drilled in the can caused deformation of the can (which also acts as pressure tube) through the uranium swelling and formation of extremely dense UO_2, and destruction of the metal bond between fuel and can. However, the reaction was relatively slow.

Secondly, two rigs were prepared, containing uranium metal tubes, for irradiation in the Halden reactor by virtue of CNEN's participation in the association agreement on the operation of this reactor. The trial tubes, fabricated by Nuclear Metals, were inserted in the reactor in March 1966.

In addition, technological trials were undertaken by the Società Ricerche Impianti Nucleari on uranium metal tube samples to obtain data on materials srtucture, fabrication tolerances and surface states etc. Thermal cyclings were likewise effected on similar samples to test the stability of the fuel canning diffusion barrier in conditions simulating power reactor cyclings.

As indicated above, work on uranium metal is for the most part to be discontinued.

Last bot not least, the detailed preliminary design study on a loop for the irradiation testing of CIRENE channels to be installed in the ESSOR reactor was completed and orders have been placed for certain components. The loop is designed to take fuel elements identical in size with those selected for a high capacity reference power plant. It is scheduled to come into operation at the same time as the organic coolant loops at ESSOR. An interim safety report has been drawn up and examination of the document by the competent authorities at the Ispra Centre has begun.

d. *Dynamics and stability*

On the theoretical side, a number of calculation codes have been developed for digital computers and models for analog simulation of the dynamic behaviour and stability of a CIRENE power plant. Power instabilities may stem from a positive power coefficient or from Xe oscillations. The codes and models were employed in the above-mentioned investigations into the stability of the two reactor versions.

Detailed studies have also been carried out regarding start-up of such a plant and its operation at reduced load.

On the experimental side, construction of a circuit for testing a liquid control rod system has started. The tests will be carried out in close collaboration with the Ispra Centre (ORGEL programme) where a circuit will be installed for research on liquid safety rods.

Still in connection with safety work, analog simulation of certain of the main accidents characteristic of a CIRENE power plant, such as throughput drop and coolant loss, has been effected and a start made on investigating the containment problem.

e. *Chemistry and physical chemistry*

In-pile dynamic corrosion tests on Zircaloy-2 samples in contact with dispersed water/steam mixtures were resumed when the Avogadro pile at Saluggia started up again. Static tests in out-of-pile autoclaves were continued.

Out-of-pile studies on fouling of heating surfaces showed that deposition of corrosion products, almost negligible in normal conditions, is very high when the critical (burnout) flux is exceeded.

DOCUMENT No. 6 ADVANCED GAS REACTORS

I. Dragon Project

1. *Operation of the reactor*

The most outstanding event in the DRAGON project was the power run-up of the reactor experiment, completed during the summer of 1965, and the progress of the power trials according to schedule. The reactor power output reached 740 MWd by the end of the year. The reactor operated regularly at 10 MW, with a scheduled shutdown period through October and November 1965 during which two feed zone fuel-elements were replaced by two elements with higher U-235 content, so as to reproduce the effects of an irradiation at rated power (20 MW) while the reactor is still not operating at more than 10 MW. These two special elements will be replaced by normal elements during the first quarter of 1966, and the reactor will thereafter be brought up to the rated power of 20 MW. One result of irradiating these special elements was that it was possible to achieve the maximum temperatures of 1040 °C at the graphite surface and 1450 °C in the centre of the fuel elements. The two feed zone fuel-elements unloaded in October 1965 were inspected and found to be in perfect condition. Their handling occasioned no difficulties ; contamination of the handling gear was less than $10^{-3}/\mu c/cm^2$. During the same shutdown period a control rod was replaced by a segmented element as, owing to a mistake in design, some friction had been observed during movement of the control rods in hot conditions. It is now considered that all the control rods will have to be replaced in the next shutdown period in January 1966. The irradiation programme however, has not been and will not be noticeably affected by this. The replacing of the control rods afforded an opportunity, moreover, of verifying that the reactor handling gear was all in perfect running order and of observing the low contamination level inside the primary circuit. Surface contamination on the replaced control rod was found to be of the order of 5×10^{-4} $\mu c/cm^2$.

The primary circuit total activity is about 10 mc. This demonstrates yet again the very low rate of fission product release by the fuel elements and the perfect functioning of the helium cleanup plant. The fission product release rate/production rate ratio was estimated to be in the range of 10^{-8} to 10^{-9}, while from the chemical standpoint the primary circuit impurities are about 2 ppm, i.e. at the limit of sensitivity of the monitoring equipment.

The primary circuit leaktightness gives no cause for anxiety. The total helium loss during normal reactor operation is now of the order of 0.4 kg/week, which at the current helium price amounts to about 20 EMA u.a. a week. It may be useful to recall here that the total helium content of the primary and the cleanup circuit is about 180 kg and that the primary circuit volume is over 70 m^3, under a pressure of about 20 atm.

2. *Study of a prototype power reactor*

The evaluation studies for the series were continued, to establish the general outline of a power plant of integrated design and a power of about 500 MWe. The reactor and the heat exchangers arranged around the core are contained in a prestressed concrete vessel. The turbine/generator unit is of purely conventional design.

The fuel cycle chosen for the reference project is of the "U-235 - Th-232 FEED and BREED" type, with on-load refuelling of the FEED section. The advantage of this cycle is that the core handling operations can be simplified as only 25 % of the core needs to be loaded or unloaded during operation. At the same time, extremely high average burnups can be obtained, of the order of 100,000 MWd/t and over.

An open cycle of this type would give rise to fuel costs of about 1 mill/kWh, whilst a cycle with reprocessing could be substantially cheaper assuming a reprocessing cost of about 150 EMA u.a./kg.

The investment costs will not be known with any certainty until near the end of the evaluation work. It must be remembered, however, that all the studies carried out so far have given very good grounds for hoping that the investments required for the high-temperature power plants will be low enough to form one of the major attractions of this type of reactor.

3. *Research programme*

Since the startup of the reactor experiment, activity on the DRAGON project has centred more and more on the engineering problems and operation of the plant, while the research programme has dwindled considerably and will gradually be wound up in the next few years. The 1965 programme was focussed on certain problems that must be solved before the operation of a power reactor can be guaranteed under industrial conditions. One of the main difficulties is the irradiation behaviour of graphite at high dose rates. The project continued studies of graphites developed in the preceding years and at the same time kept in touch with firms working on advanced isotropic graphites. Studies of a more fundamental nature were pursued as part of the irradiation research at Petten, in collaboration with the THTR Association. Development work on a particle-coating technique met with success. The latest work was concerned particularly with perfecting new fabrication techniques (e.g. the sol-gel method) and coatings of high-density pyrolytic isotropic graphite. A start was made on developing a plutonium-based fuel.

Fuel irradiations were continued in the various reactors already envisaged in previous years ; certain irradiation facilities were exploited jointly with the THTR Association. Irradiations outside the DRAGON project will fall off considerably, however, since the DRAGON reactor will itself be increasingly used as testing facility. Owing to the large amount of space available for fuel and graphite irradiations, it has been considered that DRAGON might also be used as a test reactor for fuels developed outside the project. The THTR Association proposes to use DRAGON for various irradiations of coated particles and pebbles.

The post-irradiation examination of fuel started in the cells built at Winfrith. By this arrangement the findings on the special fuels placed in the reactor,as mentioned above, will be quickly available.

Fuel reprocessing studies for high-temperature reactors have been pursued under contracts with British and Italian concerns.

Work has been performed on graphite corrosion and the depositing of carbon on heat-exchanger steels, with a view to deciding what type of material to use for a power reactor heat-exchanger.

Various fuel cycle studies were carried out and published when the Symposium on Fuel Cycles was held by Euratom in June 1965 (see below). The use of plutonium as sole fissile fuel was studied with particular thoroughness.

II. THTR Association

Alongside the DRAGON project, which studies prismatic fuel-elements in particular, the Community signed in 1964 a contract of association with the Kernforschungsanlage des Landes Nordrhein-Westfalen and the firm of Brown-Boveri/ Krupp, to develop a pebble-bed reactor using thorium, a project enjoying the indirect financial participation of the Federal 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 AVR reactor elements will be fabricated in the United States for delivery at the beginning of 1966.

The general specifications for the make-up fuel to be fabricated in the Community are similar to those for the first American fuel tested in the Oak Ridge reactors. The THTR fuel-element development programme was therefore planned in two stages : first, to prepare fuels in the Community, equal or superior in quality to the American fuel ; and then to develop fuels suitable for operating a 300 MWe THTR power reactor.

Because of the very special requirements of a pebble-bed reactor, with particular reference to its mechanical properties, to withstand numerous drop-impacts in the reactor, and to the chemical purity needed to avoid any corrosion by water in the reactor, the Association's first move was to draw up a specification for the pebble graphite and make a selection from various graphites manufactured in the Community.

Promising materials were exposed to high-temperature irradiation in the BR-2 reactor, with a view to a second choice. Certain irradiation tests are still in progress, but it is certain that several substances already available or developed in the Community are of suitable quality for coating pebble fuels.

The second part of the fuel-element programme was centred on the development of coated particles. These particles consist of a kernel of uranium and thorium carbide (thorium/uranium ratio 5/1) covered with layers of pyrolytic carbon and, in some cases, a layer of silicon carbide. The studies have dealt with the development of various particle-fabricating techniques, certain of them differing from the DRAGON project techniques (e.g. the particles are normally melted instead of being sintered), and the preparation of layers of pyrolytic carbon, whose isotropy and density characteristics make them satisfactorily irradiation-resistant. The first irradiation tests on these particles, in various Community and non-Community reactors, have given favourable results, but it is essential to carry this work further in order to determine the effect of heavy doses of fast neutrons and high thermal loads on the behaviour of the particles.

The object of part three of the fuel-element programme was to develop various fuel geometries for use either in the AVR or in the THTR. As to the AVR reactor, it seems almost certain that the "Tapeten" type will be proposed as make-up fuel. In this fuel the coated particles adhere to the inside of the hollow graphite sphere so that they are brought into the closest possible contact with the coolant. Other solutions under study for the THTR reactor include :

— a fuel pebble inside which the coated particles are packed free instead of in a graphite matrix ;
— a synthetic fuel obtained by pressing coated particles set in a graphite matrix which contains certain graphite-free materials.

Most of the fuel development work is carried out by NUKEM, under contract to the Association. This firm hopes to be able to deliver elements at a better price than the first American fuel, especially if the synthetic fuel can be adopted for regular use in the THTR reactor.

As regards fuel cycles, the THTR Association is conducting parallel studies, on a reactor system using pebbles of like composition with a 10/1 thorium uranium ratio, and on a "FEED and BREED" system which would use two different types of pebble, one containing uranium only, diluted with e.g. carbon, the other containing thorium and uranium in a 40/1 ratio.

Hitherto the THTR Association has devoted its main efforts to the development of carbide fuels, with the object of reproducing the same characteristics as those of the first fuel element developed by the Union Carbide Corporation. In the light of data obtained from the DRAGON project and at Oak Ridge, however, the THTR Association will in 1966 be turning its attention to the use of uranium and thorium oxides. With oxides it is possible to simplify fabrication in some respects, notably by the use of the "sol-gel" chemical method, and they appear to afford remarkably low rates of contamination of coated particles (fission product release/production ratio in the 10^{-6} - 10^{-7} range up to temperatures of 1600 °C for xenon-133 or krypton-88).

b. *Reactor physics*

A number of neutron calculations were effected to take into account the various fuel-loading possibilities and determine the influence of various control rod positions in the reactor. Certain recent tests suggest that control rods could be inserted directly into the pebble-bed without using any graphite or metal liner. In that case there would be no need for the 1.5 - 2 metre-long graphite projections provided, in the initial reactor design, for the insertion of the rods into the reactor core. This new concept would also allow of better distribution of the various control rods in the core ; it would then be possible to have a single pebble outlet at the bottom of the reactor, instead of the numerous outlets planned in the first design, as the pebbles would move more easily if the graphite projections were eliminated.

c. *Reactor technology*

Loading and unloading circuit

Studies were carried out, with the aid of reduced-scale models using steel balls, to take account of the various configurations of control rod positions and pebble outlets. This reduced-scale simulation is very useful, since a THTR reactor will have some 700,000 pebbles and the core will be approximately 5 m in diameter and 6 m high. For the AVR reactor, with its far smaller core, a 1/1 scale simulation had been possible. The chief concern was to discover the routes travelled by the pebbles in order to determine the retention time according to their position in the reactor. Recently, following the novel proposal to abandon the control rod projections and have only one pebble outlet, the range of pebble retention times appears to have narrowed considerably.

One major challenge with the pebble-bed reactor is the need to develop a method of distinguishing the various kinds of pebbles at the reactor outlet (pebbles with fissile fuel, with fertile fuel, made of graphite, with boron carbide, experimental types, etc.) and feeding the data very quickly to a computer which must decide where each pebble is to be sent after passing through the measuring device. As a result of exploratory work in German, Danish and American reactors, it now seems almost certain that it will be possible to use a low-power reactor as a selector. Provided that its critical mass is sufficiently low, a reactor of this type reacts very sensitively to the introduction of small quantities of scattering, fissile or absorbent substances. Thus a signal could be obtained in a few tenths of a second. A circulation rate of about 1000 pebbles an hour would be possible, which should be an advantage during reactor startup ; for normal operation a rate of 200-300 pebbles an hour should be enough. Additional experiments are to be carried out with a small homogeneous liquid reactor which will be set up at Jülich towards the middle of 1966.

Prestressed concrete reactor vessel

As a result of comparative studies on steel and prestressed concrete reactor vessels, it was finally decided to adopt the prestressed concrete vessel. A group composed of Indatom/ENEL/Krupp was instructed to study various heat-exchanger configurations and the effect of various penetrations on the dimensioning of the vessel. The first part of this vessel study was completed in 1965, but the detailed calculations will be made in 1966 as the principal reactor characteristics were not established until the end of 1965.

Heat Exchangers

The BBK company carried out a European survey among various firms, enquiring particularly into the influence of different geometrical tube configurations. Optimum utilization of the exchange surface is important, for the reactor is designed with heat exchangers that can be removed from the reactor vessel. It is therefore important to reduce their bulk as far as possible so that the penetrations in the prestressed concrete vessel can be kept to the lowest practicable diameter.

Blowers

A comparative study of gas-bearing and oil-bearing blowers was carried out. Some experience of gas-bearing blowers was obtained in the context of the DRAGON project, but the extrapolation of these blowers to a power capable of cooling the THTR reactor entails certain modifications. It was decided to regard the wholly built-in oil-bearing blowers as now developed (i.e. with blower motor inside the prestressed concrete pressure vessel) as the reference solution for the reactor design. If and when it is decided to build the prototype it will be possible to canvass the various specialized industrial firms and then decide finally which type of blower to adopt.

d. *Reactor chemistry*

Work has borne mainly on the study of carbon transport by corrosion or by carbon depositing in the exchangers, and on the cleaning of the primary coolant gas, these two problems being closely related. The most original work was done mainly in the helium cleanup field ; as against the usual cleanup methods, which involve cooling the gas as it leaves the heat exchanger to a temperature which admits of absorption either on molecular screens or in active carbon traps, this work dealt with the possibilities of cleaning the helium — i.e. absorbing the CO, CO_2, oxygen, hydrogen and their compounds — on chemical compounds, at the same temperature at which the gas leaves the heat exchangers. The proposed solution consists of three stages :

— oxidation of the CO and hydrogen on a copper oxide bed,

— removal of the CO_2 by reaction with a calcium hydroxide bed,

— removal of the water by reaction with a barium oxide bed.

The work, which has hitherto been performed only on laboratory scale, will be continued with the main object of clearing up the problems of kinetics and of extrapolation to a semi-industrial scale.

If these experiments are successful, it will be possible to work out a helium cleanup method that will be simple and cheap even at high "bypass" rates.

2. *Prototype design*

In 1965, after the comparative studies on a reactor with steel pressure vessel and with prestressed concrete pressure vessel, it was decided to set the electric capacity of the prototype at 300 MWe. This value was chosen as allowing of a sufficient size to profit from the economic advantages of the prestressed concrete vessel, and at the same time keeping the capacity at a minimum level which would avoid excessive capital investment for an initial prototype. Moreover, from this scale extrapolation can be made to a higher capacity without any radical changes.

In view of the experience already gained with the AVR reactor and of the general trend of modern reactor development, the THTR decided to go ahead with the integrated reactor concept, i.e. in which the heat exchangers are housed inside the prestressed concrete vessel. Various configurations were studied, especially in connection with the direction of coolant gas circulation. It seemed advisable to adopt a top-to-bottom direction, largely so that power densities would not be affected by the risk of floating pebbles. As a result of this decision, the heat exchangers are to be arranged round the reactor instead of at the bottom, so that if necessary they can be removed during operation. Downward cooling also simplifies the design of the upper reflector and the control rod drive gear. A disadvantage, however, is that the lower reflector, which will thus be heated to the maximum gas temperature, will have to be exceptionally strong. It is proposed to counter this by using a 100 % graphite support grid.

The helium pressure selected is 40 atm. The maximum gas temperature is limited to 750 °C, for a number of reasons, the chief ones being :

- to limit the temperature of the lower reflector, so as to avoid excessive dimensional variations in the graphite during irradiation,
- to limit corrosion of the graphite and carbon transport,
- to facilitate heat exchanger design by limiting the thermal stresses therein. Six 2 MW blowers are needed, each blower being coupled to a heat exchanger.

3. *Utilization of AVR reactor*

The construction work is coming to an end at Jülich and the reactor is expected to go critical in the spring of 1966. After various physical and operating tests of the reactor components, a power run-up is scheduled for the end of 1966 or beginning of 1967.

The THTR Association is kept informed of the criticality approach procedures and of the startup programme.

The specifications for the make-up fuel for this reactor are being studied by the THTR Association. The decision as to purchase of this fuel will be taken in 1966.

III. Evaluation studies

During 1965 Euratom worked on a special evaluation study of the high-temperature series, the object being a critical comparison of the prismatic core (DRAGON) and the pebble-bed (THTR) concepts. It is not yet possible to forecast the conclusions of this study, which is carried out in step with the evaluation studies at DRAGON and THTR. It takes into account the fact that the fuel cost forms a relatively small fraction of the cost per kWh, especially with low annual rates of plant utilization, whereas the financial charges account for a major proportion.

It is worth while assessing how far the high-temperature series, in both prismatic and pebble-bed versions, can be made competitive even with rather a low annual utilization rate. For this reason more importance is attached to low investment costs than to the fuel cycle costs which, in this series, already look extremely attractive.

IV. Symposium on HTGR fuel cycles

On 10 and 11 June 1965 the Commission held a symposium at Brussels, on fuel cycles for the HTGR reactors.

The numerous participants included representatives from the DRAGON project, the THTR Association, the Oak Ridge laboratories and General Atomic, to mention only the main parties. In addition, all the DRAGON and THTR contractors concerned with fuels were present, as well as numerous observers from official Community, British and American nuclear organizations. In all there were some 250 participants.

Session I : "Fuel-element fabrication methods and costs"

A number of fabrication techniques have been developed and there is already a well-established technology for fuel-element manufacture on a semi-industrial scale. Efforts are now being made to cut costs.

In the short term fabrication costs are expected to be about 200-250 EMA u.a. per kg of metal, assuming a production capacity corresponding to 2000 MW installed electrical capacity.

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Session II : "Refabrication and reprocessing methods and costs"

The process of extraction by solvent (Thorex) and refabrication by a sol-gel method is regarded as the most suitable for high-capacity automated plants. The large capacity of the plant appears to be a vital economic factor. Assuming a capacity of about 2000 t/year, it is estimated that total reprocessing and refabrication costs will be 180 EMA u.a./kg of metal. A plant of this size ought to serve a group of reactors totalling about 15,000 MW installed electrical capacity.

Session III : "Burnup and conversion : economic appraisal"

It is not possible to obtain a high burnup and a high conversion rate at one and the same time.

The short-term (cheap natural uranium) trend is towards the open cycle with the highest possible burnup (100,000 MWd/t and over) and consequently rather low conversion rates ($\pm$ 0.7). One advantage of such cycles is that no investment in reprocessing and refabrication plant is needed and they can be adopted straight away. The costs are estimated at about 1.2 mill/kWh.

In the medium term (natural uranium growing dearer, and gradual building of reprocessing and refabrication plants) the tendency would be to recycle uranium-233. The cycles would be optimized for burnups of about 50,000 MWd/t and conversion rates of about 0.9. Costs are estimated at about 0.9 mill/kWh on the basis of present natural uranium prices, and about 1.2 mill/kWh with natural uranium at 24 EMA u.a./lb.

The long-term tendency would be to resort to breeding, if necessary. Costs have not been estimated as the question is not particularly urgent. The physical data, on the other hand, are already known. It is estimated that by adopting every improvement, including beryllium oxide in the fuel elements, the HTGR might achieve a doubling time of about 15 years with quite high burnups (about 30,000 MWd/t). This would fit very well with the very long-term requirements, as the doubling times for electricity consumption will tend to lengthen to 20-30 years and more.

Session IV : "Plutonium as initial load and/or make-up fuel"

The use of plutonium in thermal reactors is a valuable short-term prospect. The value of plutonium, assuming that an open cycle is adopted, is almost the same for the HTGR reactors as that of uranium-235.

DOCUMENT No. 7 FAST NEUTRON REACTORS

1. *CEA/Euratom association*

Construction of the large RAPSODIE, MASURCA and HARMONIE installations proceeded according to schedule.

HARMONIE went critical for the first time in August 1965. Construction is finished and the reactor is ready to go into continuous service as from the beginning of 1966.

MASURCA is practically complete as far as the large installations are concerned ; final completion and criticality with a plutonium core are scheduled for July-October 1966.

RAPSODIE will be finished at the end of 1966, and will go critical at that time. Fabrication of the UO_2-PuO_2 pellets forming its core is practically complete.

The 5 MW loop for steam-raising studies at Grand-Quevilly was commissioned in the middle of 1965.

Further research on large-scale sodium-cooled reactors led to a conceptual design for a 100 MWe unit as a reference for studies of rather less ambitious reactor prototypes (100-300 MWe) as well as for detailed physical and kinetic studies, fuel and structural material development studies and component development studies.

2. *GFK/Euratom association*

The position regarding the large installations under this association agreement is as follows :

STARK went critical mid-1964. It has been in normal operation and employed chiefly on perfecting the noise-analysis method using two successive sub-critical fast cores.

SUAK became operational in the autumn of 1965 and is used for U-235 sub-critical assembly analysis.

SNEAK will be completed in the middle of 1966, when it will go critical with a U-235 core ; subsequently a plutonium core will be used. The 3 MW steam loop (Loeffler cycle) started operating at the end of 1965. Work on large-scale reactors mainly concerned the steam-cooled variant and the design of a 1000 MWe reactor which economic and safety studies have shown to be of interest. Conceptual studies for a sodium reactor were also taken a step further with the start on designing the 300 MWe reactor derived from the Na-1 concept (1000 MWe) dating from the end of 1964. As in the case of the CEA/Euratom association, these reactor design studies serve as guidelines for the whole range of research and development work in each particular field.

3. *CNEN/Euratom association*

Experiments were conducted mainly on the development of fuel elements with apertures for the release of fission gases during irradiation and on the use of sodium, to obtain data for application in reactor safety studies.

The design study for a fast materials testing reactor has been established. Parameter studies of large-scale reactors continued, with a view to enabling the several variants at present under study to be compared.

Detailed studies of steam generators were begun.

4. *Belgian State/Euratom association*

The convention for association between the Commission and the Belgian State was signed in December 1965.

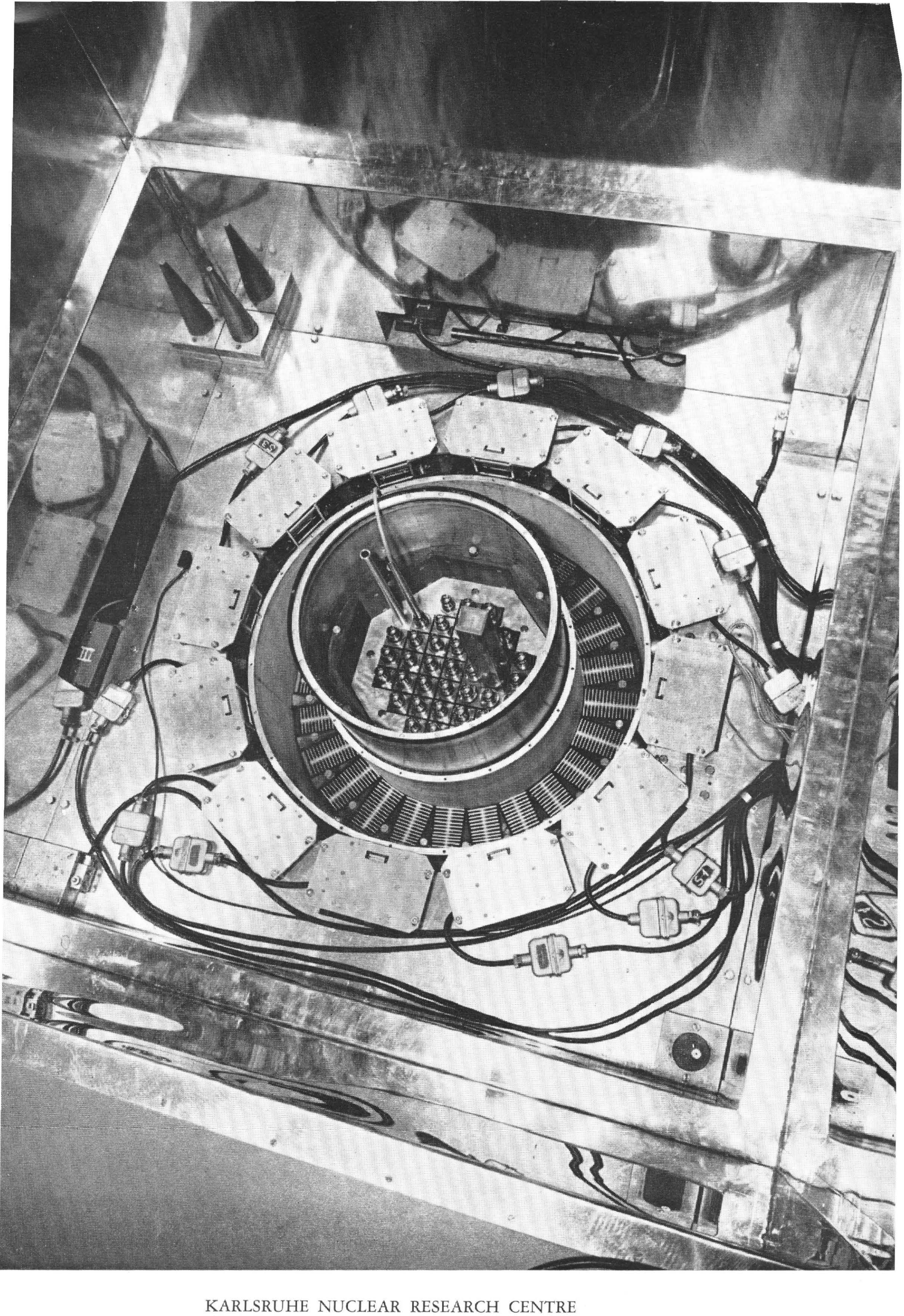
The work programme is intimately bound up with that of the GFK/Euratom association, its particular objectives being studies of U-235/sodium reactors and safety studies of steam reactors. In addition, the association is contributing to the Pu fuel development programme for the FERMI reactor by taking on fabrication studies, and then the fabrication of fuel pins for irradiation in that reactor.

Finally, the association is investigating the adaptation to fast reactor fuels of dry reprocessing methods developed for thermal reactors.

5. *TNO-RCN/Euratom association*

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

The work programme, closely bound up with that of the GFK/Euratom association, is concentrated on the development of materials and parts (pumps and heat exchangers) for sodium systems.



KARLSRUHE NUCLEAR RESEARCH CENTRE
VIEW OF THE CORE OF THE STARK REACTOR

(See other side of page for caption)

The STARK reactor, which is of the ARGONAUT combined fast-thermal type, went critical in mid-1964. Operation of this reactor is keyed mainly round the development of a method for the analysis of pile noise on two subcritical fast cores.

6. *Miscellaneous*

a. In December 1965 the Commission signed a contract for irradiation in the American FERMI reactor for its own account (Transuranium Institute) and for account of the associations with CEA, GFK and CNEN. In-pile insertion is scheduled for late 1966- early 1967.

b. The Transuranium Institute continued, in close collaboration with the CEA/Euratom and GFK/Euratom association programmes, its work on perfecting Pu fuel element fabrication for MASURCA and the adaptation to plutonium of various fuel fabrication data established by the GFK/Euratom association.

c. The JRC establishment at Ispra likewise pursued its specialist researches in the fast reactor field, in particular boiling regime studies on sodium, which are being closely coordinated with the GFK/Euratom association studies,as well as work on the dry reprocessing of fuel.

DOCUMENT No. 8 CONTROLLED THERMONUCLEAR REACTIONS

Theoretical and practical work on the problems of plasma confinement and stability, mentioned in the 1965 Report, continues to occupy the Commission's attention.

Regarding the behaviour of a low-pressure plasma in open-ended systems, the theoretically predicted efficiency of the "magnetic wells" in removing major instabilities in mirror geometries has been borne out by experiment, a result which represents an outstanding success in view of the prospects it opens up.

According to the theory, however, the plasma in such configurations is still liable to a number of instabilities of various origins, a fact which, in view of the high loss rate inherent in these devices, means that their development into thermonuclear reactors is problematical ,without detracting from their usefulness as research tools.

So far, the theta pinch has proved the best if not the only method of obtaining a high-density, high-temperature plasma. Its chief drawback, again from the thermonuclear standpoint, lies in the end losses. The problem of how to cut out or reduce these losses without resorting to unstable configurations or devices of prohibitive size and cost continues to be a major worry.

As to toroidal devices, even in configurations where stability is predicted, the diffusion rate is still abnormally high by comparison with the theoretical rate for confined plasma, in spite of the efforts exerted, mainly in the USA and the USSR. This pump-out phenomenon, whose origins are not clear, persists tenaciously in spite of the removal of one presumed cause after another.

All the more interesting, therefore, are the results obtained in recent months at Munich, which seem to show an absence of pump-out in two different toroidal configurations.

Furthermore, the success of the magnetic wells in open-ended systems gives grounds for hope that the application of similar principles (mean minimum magnetic field) may substantially improve confinement in closed-line systems. Large-scale activities in this sphere may be expected in the coming years.

I. Theoretical studies

The theorists have pursued their work on various topics, either general or directly connected with experimental problems.

Work of a general nature has included the thermodynamic description of a plasma and its applications to stability (Jutphaas), research on statistical mechanics and a study of micro-instabilities (Fontenay-aux-Roses).

A great deal of attention has been devoted to toroidal configurations. At Fontenay-aux-Roses, the research pursued on the magnetodynamic stability of a plasma "cord" has confirmed the inadequacy of certain schematic descriptions.

Further work has been performed on the calculation of stable magnetic systems and on studies of equilibrium configurations and their stability. An extensive programme of numerical calculations on these configurations is being prepared.

The theorists have studied the stability conditions of M + S tori in relation to certain deformations and the dynamics of linear and toroidal theta pinches.

At Jutphaas, the stability of toroidal alternating pinch and of diffusion was studied. At Fontenay-aux-Roses a major item was the study of open-ended configurations (effects of an electric field and of the Larmor finite radius, collision effects, etc.). As regards plasma heating, shock-waves are under study at Frascati and magnetic pumping at Jutphaas. The use of electromagnetic waves for producing, heating and confining a plasma, as also the emission of electromagnetic waves by a plasma, are being investigated at Saclay. Other researches concern the limit layer between a plasma and a magnetic field (Jülich) or between plasmas (Frascati). The use of lasers has been further investigated. Studies have been conducted at Garching on the generation of harmonics and their possible diagnostic use, and at Fontenay-aux-Roses and Frascati on the production of plasma from a gas or a solid. In connection with the MIRAPI and MAFIN experiments, studies were carried out at Frascati on the behaviour and dynamics of a solid or plasma liner, the limitations to the production of extremely high magnetic fields, the triggering of fusion reactions by fast macroparticle impact. Several calculations were effected with the aid of CETIS (Ispra).

II. Experimental pinch research

The zeta-pinch experiment TA 2000 (Fontenay-aux-Roses) was discontinued after having served for an important range of work that yielded a great many spectroscopy results and information on magnetic field distribution.

Also at Fontenay-aux-Roses, the "Harmonica Zero" device, designed to reveal a singularity of equilibrium beyond a certain threshold, started operating at the beginning of the year. Initial results already seem to indicate two regimes, the one relatively calm and the other turbulent on both sides of the said threshold.

Numerous theta-pinch experiments have been carried out for the purpose of studying stability and heating and energy-loss mechanisms. The large-scale device "ISAR" at Garching (maximum installed energy 2.6 MJ, max. magnetic field 180 kg auss, half-period 20 μ/sec) came into service in 1965. The first readings, submitted at the International Conference at Culham in September, announced an electron temperature of approximately 4 million °C and an ion temperature of 40 million °C. Shortly afterwards, the impurity rate in the main discharge was lowered by improving the pre-ionization zeta-pinch ; ion and electron temperatures of 60 million °C and 20 million °C were then obtained, thus confirming that electron cooling is largely due to impurities. These results as a whole mark a distinct step forward, although the confinement time is still very short.

At Frascati, the "CARIDDI" experiment has yielded information on the shock-wave method of heating plasma.

At Jülich, using devices with capacitor banks ranging from 4.5 kJ to 600 kJ, it was observed, with cylindrical geometry, that instabilities occur at the start of the discharge and, as predicted by the theory, disappear when the discharge energy is big enough and the density not excessive. In a cusp-configuration theta pinch at Jülich, no sign of instability was detected. A detailed study was also effected of the preheating phase during which a cusp-shaped plasma has already been built up, and the optimum conditions were determined for the subsequent magnetic compression.

With regard to toroidal closed-line configurations, several experiments produced important results at Garching. On Stellarator (Wendelstein) devices particle losses were studied on thermal alkaline plasmas (caesium) ; the average particle lifetime was found to be some 30 times longer than in the case of pump-out. Using alkaline plasmas for the time being, the "Octopole" experiment, in which four internal annular conductors provide a purely poloid magnetic field, likewise showed a loss rate far lower than the pump-out loss rate. In all the cases mentioned, the losses may be accounted for by resistivity diffusion and recombination on the surface of the supports for the plasma sources or the conductor rings.

A device of M + S configuration with superimposed hexapolar field (max B = 12 kG, max T = approx. 500,000 degrees, n = $10^{16}/cm^3$) seems to indicate a toroidal equilibrium position at high beta-value for 120,000 °C > Te > 450,000 °C and losses compatible with the hypothesis of resistivity diffusion, i.e., absence of pump-out. The significance of these results has already been pointed out ; further experiments in the same direction are under way.

The helicoidal pinch experiment at Jutphaas has not shown, during the 10 μ/sec confinement time, the instabilities predicted by theory.

As to tubular pinch, the "STATOR" device (tubular toroidal pinch) came into service at Fontenay and has already provided experimental confirmation that tubular-pinch stability conditions are practically the same with toroid as with cylindrical geometry. The plasma lifetime (200-300 μ/sec) seems still to be limited by various incidental effects (gradual ionization of the neutral gas in the dead space of the container, etc.).

III. Magnetic-Mirror Machines

The experiments on plasma build-up and confinement in magnetic mirrors or in more complex configurations were pursued.

1. *Energetic ion injection*

At Fontenay, after the injection system had been improved (ion current 200 mA) a density of 2×10^8 trapped ions per cm^3 was attained, but the charge exchange losses limit the lifetime to about 50 μ/sec. No low-frequency instabilities or micro-instabilities were observed, however, as in the experiments of the same type described at the Culham Conference.

At Jutphaas, when the ion current injected into a cusp configuration was increased, a rapid change was observed in the behaviour of the plasma when a critical value of the product of the injected current and the pulse duration was exceeded ; it took the form of an apparent lengthening of the confinement time (30-50 μ/sec). The reason for this situation is still unknown, however (burn-out, electrostatic effects).

2. *Plasma injection and plasma guns*

At Fontenay-aux-Roses, the improvements effected on DECA II enabled a confinement time of 150 μ/sec to be achieved, with ion densities of 10^{13}/cm^3, thus demonstrating the stabilizing effect of the four-pole bars which create a magnetic well. The instabilities characteristic of this type of configuration and predicted by the theory have not been observed.

In the light of conclusions drawn from the work reported at Culham, the scheme for a new DECA III machine is being thoroughly reconsidered.

Research on plasma guns has been actively pursued.

With a guide field of 1,500 gauss, the coaxial gun at Fontenay-aux-Roses supplied plasma bursts with an average longitudinal energy of 15 keV and a transversal energy of about 700 eV. It was shown that a plasma jet can be cleaned by channelling it along a magnetic field with S-shaped lines of force, as the impurities run off course at the bends.

At Jutphaas, injection into a plasma cusp accelerated by radial gun was hindered by the low electron temperature caused by titanium contamination from the gun. The injection system was therefore modified.

At Jülich, the guns fitted with a progressive-wave plasma acceleration system yielded measured results in excellent agreement with the theoretical models, and work is continuing along two lines — the production of high-energy bursts (> 10 keV) and of continuous plasma jets.

At Fontenay-aux-Roses the "Bille-en-Tête" experiment, a two-gun device for effecting plasma-bunch collisions, was employed for density and temperature measurements in preparation for the use of a pulsed heating system. The first heating tests showed a definite absorption of energy by the plasma.

3. *Rotating plasmas*

At Amsterdam, two experiments are using injection into a mirror configuration with crossed electric and magnetic fields to obtain rotating plasmas. On KRUISVUUR 1, measurement of the growth rate of a flute instability due to centrifugal force showed that this rate is lower than that predicted by the simple hydromagnetic theory, owing to a finite density gradient. On KRUISVUUR 2, which was commissioned in May and has a better vacuum system (ion pumping), the theoretical interdependence between the diamagnetism of the plasma and the applied electric and magnetic fields was verified under specific conditions ; it is proposed to shorten the plasma build-up time by pre-ionization and injection of an electron beam.

IV. Build-up of very high density plasmas

The production of very high density plasmas still forms a major part of the Frascati laboratory's activities. The MIRAPI experiment, on rapid compression of a thin cylindrical layer of plasma, showed that a hot dense plasma of pure deuterium can be confined by inertia by an adjacent envelope of relatively cold and very dense plasma. A second experiment with a larger capacitor bank is being designed, for a detailed study of energy transfer from the liner to the central plasma cord. The MAFIN group (plasma compression by implosion of a metal liner by means of chemical explosives) has been chiefly occupied in fitting out a new bunker for explosions using up to 100 kg of explosive. The new installation includes a fast 200 kJ capacitor bank.

The HOT-ICE experiment (where a plasma is formed by concentrating a powerful (300 MW)laser light-beam on a small volume of solid deuterium) produced a plasma which, owing to the presence of plasma jets with an energy of several keV, was highly anisotropic, demonstrating thereby that radiation pressure plays a fundamental part in the process.

At Fontenay-aux-Roses (IRMA experiment on interaction of lasers and matter), the breakdown of the gas in the focal space was investigated ; the development versus time and the analysis of the light emitted by the gas indicate three distinct phases — pre-ionization, actual breakdown maintained by the laser beam, and fading after the end of the laser pulse.

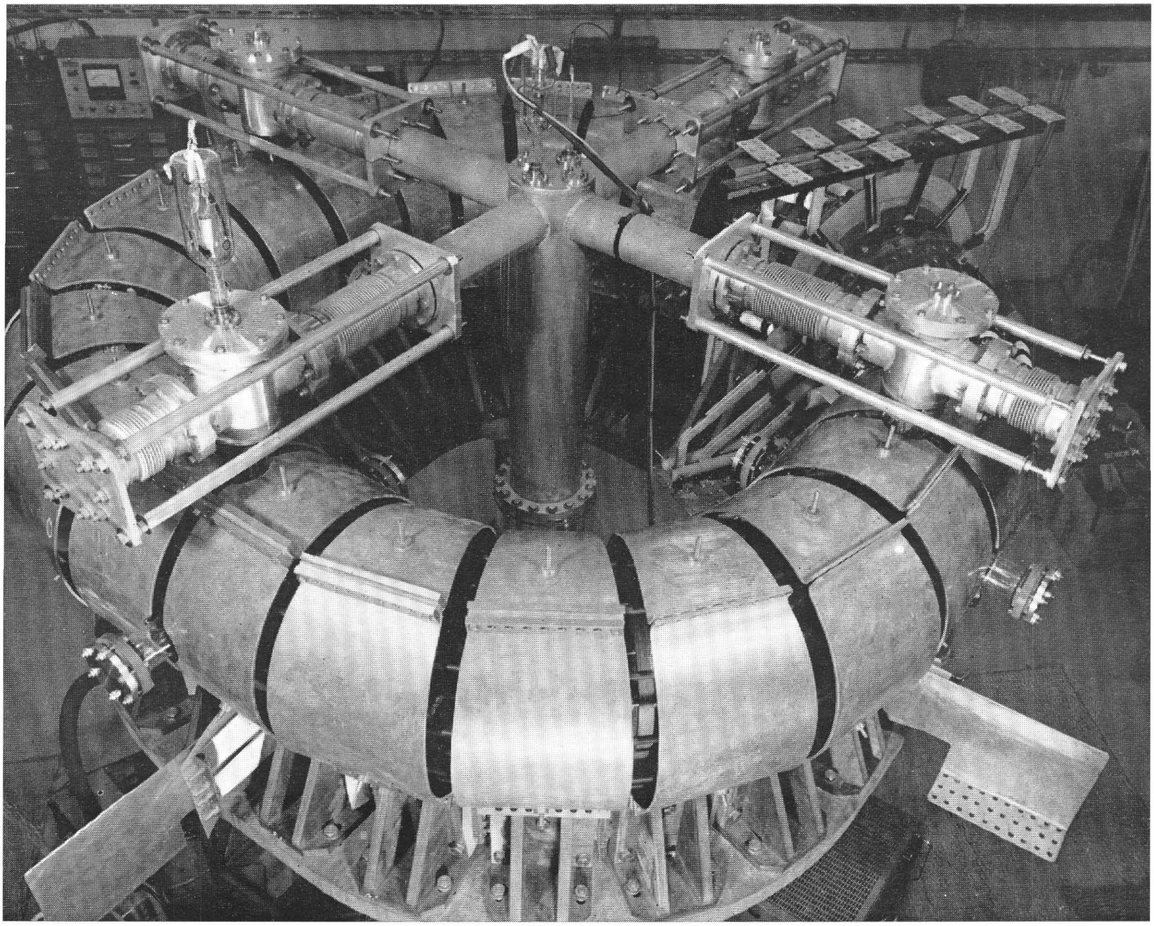
V. Build-up, confinement and acceleration of a plasma by high frequency - Miscellaneous research

At Saclay, various experimental assemblies with continuous power levels ranging from 300 W (10,000 Mc/s) to 5 kW (1,200 Mc/s) and pulsed power of 2 MW (1,200 Mc/s), were used to accelerate and accumulate relatively dense, hot plasmas ($10^{13}/cm^3$ — $T_i = T_e = 1{,}000{,}000$ °C) with roughly 50 % efficiency of energy transfer to the plasma, as predicted by the theory. No instability was observed during accumulation ; devices with greater H.F. capacity (10 kW continuous) and improved vacuum have now been built.

At Garching, microwave build-up experiments were pursued with success and experiments on heating by cyclotron resonance have been started.

At Jutphaas, the experiment on plasma confinement by high frequency was modified to obviate the secondary emission which derives from the cavities and is responsible for the parasitic energy peaks observed in the electron distribution function. Research on the influence of cyclotron resonance on plasma has led to a better understanding of the plasma's dielectric behaviour in the vicinity of the resonance. In particular, the non-linear behaviour of the trigger process is due to relativistic effects.

The basic properties of a plasma are being studied in research on stationary or quasi-stationary plasmas. At Garching, the build-up and heating of high-density



FONTENAY-AUX-ROSES (France) — STATOR EXPERIMENT
TOROIDAL TUBULAR-PINCH DEVICE WITH METALLIC CENTRAL CONDUCTOR

(See other side of page for caption)

The toroidal version of this device forms the sequel to the MEST and EPPE machines. It does not have the disadvantages of the electrodes in these two machines, and in addition it can be used for examining tubular-pinch stability conditions in a toroidal geometry.

stationary plasmas to temperatures of 10-25 eV in an electric arc in the presence of an axial magnetic field enables the heat conductivity coefficients and broadening of lines to be measured.

At Frascati, studies are in progress on the abnormal resistivity of a caesium plasma in a cavity of incandescent tantalum (BRUNO) and on microwave diffusion by an alkaline plasma with unstable ion oscillations.

At Saclay, electron speed distribution and its correlations with the micro-instabilities which cause pump-out were studied in conventional discharges ; the DAPHNIS device, designed to have a quiescent plasma and an appropriate speed distribution, affords a means of studying the other causes that limit confinement , more especially the longitudinal leakage mechanism ; a "synthetic" plasma, produced by neutralizing an ion beam, has proved to be a useful research tool.

Studies continued on the interactions between an ion or electron beam and a plasma. At Fontenay-aux-Roses the EOS (stationary wave studies) experiment, using ion beams in a magnetic field, was carried out simply with two interpenetrating beams directed from opposite ends of the field, and also with one or two beams and the plasma produced by neutral gas ionization ; a very rich spectrum of electrostatic oscillations was observed. The generation of harmonics with gyromagnetic electron half-frequency was revealed by the use of electron beams (ECLAIR).

At Amsterdam, interactions between an electron beam and the plasma produced by its passage through helium were demonstrated in the vicinity of the plasma's own frequencies and the cyclotron frequencies of the ions and electrons.

VI. Diagnostic and technology

Measurement processes and the construction of apparatus call for a substantial effort in technology and diagnostic methods.

As regards the latter, they are being used and developed everywhere in various fields : probes, optical methods, electromagnetic radiation from microwaves to X-rays, particle spectrometry, etc. Examples are the methods of measuring electron speed distribution (perforated probes) and accelerated-particle flux and energy (pyrometric probes) at Saclay, and the optical methods employing a laser which are becoming more common, especially at Garching and Frascati, with growing efficiency.

A.D. 8

Technology has seen various developments in the fields, mentioned in earlier reports, of energy sources and their switching systems, vacuum techniques, conventional or superconducting magnetic installations and coils, explosives for the rapid build-up of very powerful magnetic fields. Mention should be made, inter alia, of the 2.6 MJ bank (ISAR) which was brought into service at Garching ; at Frascati, a fast H source (hydrogen desorption from palladium) and a method of exploding thin metal membranes to build-up magnetic fields with a very short rise-time ; and at Saclay, the construction of a magnetron and a plasma switch to produce intense oscillating magnetic fields.

DOCUMENT No. 9

STUDIES RELATING TO REACTOR DEVELOPMENT SERIES

I. Radioactive waste processing

Researches were actively pursued along two lines to discover suitable sites for permanent storage respectively at surface level in desert regions and within stable geological formations such as derelict salt mines or salt domes. They have led to the identification in particular of an area suitable for hollowing out an experimental cavity in a salt formation nearly 500 m below ground. Soundings and excavation by water-injection will be carried out in the course of the year and the fitting out of the cave to take radioactive residues in carefully controlled conditions will then follow.

This method of permanent storage is likewise under study in the United States in an experimental cavern and results so far obtained vindicate the Community's work in this field.

At the same time, limited studies for developing methods of processing highly radioactive effluents is mainly directed to selective extraction of a few elements with long half-life (Sr-90, Cs-137 etc.), absorption of residues in a stable inorganic carrier or mass concentration by lyophilization.

Of these processes, the first is at present most highly developed and is of great economic interest, since it makes possible the production of intense sources of pure radioisotopes which the Community will undoubtedly need, while at the same time effecting decontamination of the highly active effluents to a degree that greatly simplified their subsequent processing and storage.

II. Chemical reprocessing of irradiated fuels

The programme aimed at the development of chemical reprocessing of irradiated fuels by fluorination continued along the lines mapped out in earlier reports.

There have been further delays in installing the hot laboratory pilot unit owing to unexpected hold-ups in the delivery of certain items. All the equipment has now been delivered and assembly work is in progress. The first hot tests should start at the beginning of next year.

The facility specially installed for handling fluorinated plutonium compounds in large quantities (100 g) is ready and plutonium volatilization trials will begin shortly in a small fluid-bed reactor. This facility constitutes an essential instrument for studying the formation and gasification of uranium and plutonium hexafluorides from UO_2/PuO_2 mixtures in the presence of various reagents such as fluorine and chlorine trifluoride.

A fuel assembly processing unit of at least 50 kg capacity has been designed and will be built by the end of the year. It will be used to develop chemical stripping (hydrochloric acid and hydrofluoric acid/oxygen attack for zirconium and stainless steel clads respectively) and uranium volatilization techniques on non-irradiated fuel elements containing no plutonium but representative of assemblies used in power plants.

This unit will furnish significant data for the design of a pilot industrial-scale plant, which if present expectations work out, will be the next stage in developing the fluorination process.

Likewise deserving of mention is the close cooperation established between this programme and the Euratom/GfK Karlsruhe association for fast neutron reactors.

Studies are being carried out at the JRC establishment, Ispra, on the development of a technique for the electro-refining of uranium and a method for pre-treating MTR fuels giving a remarkable concentration of uranium in the form of the intermetallic compound UAl_3. This method has the advantage of considerably reducing the fuel dissolution time in solvent extraction processes and of greatly increasing the uranium concentration in the solution, and hence the capacity of the plant, while producing a far smaller volume of radioactive effluent than the conventional method of dissolving MTR platelets.

DOCUMENT No. 10 IRRADIATED FUEL REPROCESSING

I. Eurex facility

The Convention signed at the end of 1964 with the CNEN on the Eurex project is now being implemented.

On 20 December 1965 the CNEN signed a contract with the Bomprini Parodi Delfino company for the construction of the whole plant.

The research programme undertaken by the CNEN in 1965 has been directed to developing the chemistry and technology aspects of the proposed Eurex process together with the equipment, sampling system and instrumentation. Numerous laboratory reports have been prepared on this research.

The CNEN has sent Euratom much documentary information including all the plans and technical specifications for the Eurex facility, the contract signed with Bomprini Parodi Delfino, as well as the periodical reports and the safety assessment submitted to the competent national authorities.

These documents are available for communication to Member States, persons and enterprises in accordance with Article 13 of the Treaty. Furthermore, personnel from Community organizations and undertakings may be assigned to the plant to keep in touch with the construction work.

II. Negotiations with Eurochemic

Euratom negotiations with Eurochemic on the reprocessing of BR2 and HFR fuels led to the signature of a contract for the reprocessing in 1967 and 1968 of 1500 kg of uranium + aluminium from the HFR and 2500 kg of uranium + aluminium from BR2.

Materials recovered can be returned to the USAEC or re-used in the Community. Specifications have been laid down, for the latter case, in collaboration with Community manufacturers of MTR type fuel elements and the reactor operators concerned.

III. Other activities

Euratom participated in the work done by different Eurochemic organs in respect of the directives for that concern's operations.

Also during the period covered by the present report, Euratom examined investment projects, communicated to it under the terms of Article 41 of the Treaty, in connection with reprocessing.

DOCUMENT No. 11

LABELLED MOLECULES AND RADIOISOTOPES

I. Labelled Molecules

The purpose of the labelled molecules programme is :

— to make rare or commercially unobtainable compounds available to users,
— the encourage research on the synthesis of new compounds for which there is a demand,
— to develop contacts between producers and users so as to balance production and satisfy as wide a range of demand as possible,
— to circulate information on available substances and promote the exchange of knowhow on the synthesis and use of labelled molecules.

The programme is being carried out along the following lines, as described in the Eighth General Report :

1. *Labelled molecule bank*

Commercially unobtainable compounds required for advanced biological research were delivered to users in the Community countries and the United States.

2. *Research contracts*

Contracts concluded with universities or industrial concerns in the Community cover the preparation of new substances by conventional methods, the developing of new general synthesis methods and the improving of techniques so as to obtain products of better quality and lower cost.

The substances prepared chiefly concern biological and medical research, more especially in the following fields ;

— protein synthesis
— the mechanism of hormone activity
— the growth of the normal or pathological cell
— stimulation of plant growth
— transmission of the genetic code.

Other compounds labelled with stable isotopes are for use in research into the fundamental mechanisms of chemical reactions :

— radical reactions

— ion reactions, etc.

The principal bodies collaborating in this work are :

in Belgium : the Nuclear Study Centre (CEN), Mol

in France : the Universities of Paris, Strasbourg and Dijon, the Collège de France and the Institute Gustave Roussy

in Germany : the Institute for Cancer, Heidelberg, and the Munich Institute of Technology

in Italy : the Universities of Milan and Pavia, the SORIN and MONTECATINI companies

in the Netherlands : the Centraal Laboratorium TNO.

These studies have been the subject of more than 50 publications or reports to scientific meetings.

3. *Liaison between producers and users*

A number of meetings were held, with the object of coordinating production. A major step in this direction is the index, now in compilation, of every isotope and labelled molecule produced in the Community.

4. *Circulation of information*

The information sheet "Labelled Molecules" continued in circulation and proved valuable as a pool of information on the availability of compounds. It is distributed to over 8,000 laboratories inside and outside the Community.

5. *Meetings of experts*

A working group was set up to deal with the obstacles that impede the use of labelled molecules in pharmacology.

Meeting of experts were held to establish specifications for labelled molecules used in medical research.

A working group was formed for the purpose of facilitating documentary research on the synthesis of labelled molecules. This group set up an Editorial Board which is to publish an Index containing over 10,000 bibliographical references.

6. *Relations with bodies in non-member countries*

Information was exchanged with organizations in more than 10 non-member countries. Numerous experts from such countries take part in the Scientific Conferences organized by Euratom.

Experts from the United Kingdom, the Scandinavian countries, Austria and Switzerland take part in the working groups.

A survey of the availability, utilization and quality of the labelled molecules in request is being carried out in collaboration with the IAEA.

7. *Scientific conferences and publications*

In March 1965 a conference, organized in collaboration with the Belgian Nuclear Study Centre, Mol, was held on the uses of tritium-labelled nucleosides, substances which are used in cancer and genetics research. The debates served to clear up certain contradictions and determine the conditions for use of these compounds.

An international conference, organized jointly by Euratom and the University of Pisa, was held in January 1966, with an attendance of over 150 participants from member and non-member countries. It afforded an opportunity of reviewing the technical and theoretical problems involved in the use of labelled proteins and threw light on the scope and limitations of the method.

The Commission launched the "Journal of Labelled Molecules", the only periodical devoted entirely to synthesis methods and allied problems, and takes an active part in its publication.

II. Research on radioisotopes

Cuts in the appropriations, resulting from the revision of the second programme, have put a brake on activities. In addition, 46 research proposals (including the labelled molecule programme) had to be suspended in 1965. The remaining appropriations were earmarked for work in hand but, even so, in most cases there was no prospect of being able to bring them to a successful conclusion.

As regards the improving of radioisotope production methods, the work in connection with the obtaining of stable isotopes was abandoned, whilst research on radioisotopes, such as carrier-free Na-24, Cl-36 of high specific activity, and tritium targets, was continued and even, as to the last-named, extended, without financial aid from the Commission.

The suspended projects included some highly interesting items, such as the production of P-33 and the large-scale manufacture of Th-228 and Ac-223 (sources for SNAP). Mention should be made of the international conference of experts held at Grenoble on 21 and 22 June 1965 on targets for accelerators to be used for neutron production, which was very well received by the participants.

The projects retained in the fission products field are those dealing with their recovery, from the fundamental and the technological standpoint (CEN and CEA). The research undertaken by the CEN on the development of new ion exchangers was continued after being transferred to the "Active Waste Processing" group, which is also concerned with this problem. The contract with the French Atomic Energy Commission (CEA) was extended for six months in view of the existing appropriations, though it will be financially out of the question to continue it after March 1966. This research — highly important from the technological angle, for the recovery of fission products on the scale of several hundred million curies (Sr-90, Ca-137, Ce-144, Pm-147, etc.) — could, with Euratom's backing, have led to an earlier and Community-wide solution to the weighty problem of storage and utilization of fission products.

Two research projects already planned, on the recovery of Kr-85 and of technetium, were able to go ahead in 1965 in spite of the financial situation. The project for development of an economic neutron source, using Ce-144 - Pr-144 of high specific activity, was pursued to the final laboratory stage, with the collaboration of the Biology Department. The results obtained give an expectation of 2000 - 5000 neutrons/sec in 4π geometry per Ce-144 - Pr-144 target, i.e. 10^7 n/sec in 4π per cm^3 of the Ce-144 - Pr-144 oxide mixture (10^8 with a more appropriate geometry). For lack of funds it was not possible to prepare the latter target.

As regards new applications for radioisotopes, only one research project, on photoactivation, could be undertaken in 1965.

A meeting on the "Practical Aspects of Activation Analysis Using Charged Particles" held at Grenoble on 23 June 1965 aroused lively interest.

Lastly, collaboration continues with the BR-2 Reactor Operation Group and the Direct Conversion Group at Ispra, on the development of a low-wattage SNAP device. Judging by the progress of the work, the generator will probably be completed in September 1966.

DOCUMENT No. 12 INDUSTRIAL APPLICATIONS OF RADIOISOTOPES AND RADIATIONS

Work of the Bureau Eurisotop

The widened use of radioisotopes in industry by means of applied research and the dissemination of technical and economic data aims at the modernisation of control and production techniques. The Bureau Eurisotop has gone ahead in this field, enlarging the compass of its activities in respect of the coordination and the legal and economic aspects of the use of radioisotopes in industry.

I. Contracts

Through the Bureau Eurisotop's participation, by way of contracts, in the research programmes of Community undertakings and laboratories, it has been possible to make further progress on existing projects and make a start towards solving many industrial difficulties by means of radioisotopes. The Bureau Eurisotop has supported the development and perfecting of processes and prototype devices relating to radiometry, radiochemistry and activation analysis, radioactive tracers and the use of intense radiation sources.

So far the Bureau has entered into 80 contracts bearing on such branches as metallurgy and steel manufacturing techniques, chemical processes, the textiles industry, oceanography, the food industry, fluorescent X-ray analysis and so on.

II. Information and documentation

With its specialist library and card indices containing an ever-growing mass of scientific and technical data concerning radioisotopes and their industrial applications, the Bureau endeavours to remedy the wide dispersal of literature covering this field and so to meet urgent needs for quick, reliable information.

The communication of scientific and technical information constitutes the principal link between applied research and economic exploitation of the results, and the

Bureau has accordingly concentrated on the issuing and circulation of appropriate technical publications and works of popularization.

The "Nouvelles du Bureau Eurisotop" along with the "Notes Documentaires" — twenty-five issues to date — help to keep interested quarters informed of the Bureau's activities.

Nine "Cahiers d'Information" have supplied experts, users, firms and national bodies with precise data on specific aspects of the applications of radioisotopes in industry.

The Bureau has been associated with or shared in the arranging of a certain number of symposia and conferences and placed its information and documentation resources at the disposal of the participants.

III. Coordination

The Bureau has been responsible for coordination of research programmes worked out in the Member States so as to avoid overlapping, to supplement them by its own work and to head them in the direction of sectors where more research is needed.

An initial measure of coordination consisted in the comparative study of research proposals and negotiations for establishing projects and implementation programmes with an eye to maximum effect.

Next came regular meetings of working parties, restricted to the contract-holders and applicants, to review the technical position or consider possibilities of assistance.

That part of the textiles programme relating to study visits has been completed. It began in 1964, with a view to extending the use of radioisotopes and radiation in the Member States' textile industries. Three hundred and thirty-five textile enterprises and 40 radioisotope experts took part, the latter making 550 study visits in all.

On 2 and 3 June 1965 the Bureau organized a working meeting for 31 nuclear experts and 24 textile industry engineers to afford an opportunity for an exchange of information and a review of the potential applications of radioisotopes and radiations in the industry.

Following the study visits, a survey of participating firms revealed the success of the operation in giving the manufacturers a clearer idea of the possibilities of radioisotope applications in textile mills. Reports from the experts who carried out the visits are currently under study in order to compile a complete inventory of the potentialities and elaborate a European development programme.

Research contracts now in preparation concern the development of monitoring methods for the textile industry.

The Bureau is also considering a project for Community action to demonstrate and promote the use of the irradiation technique.

The Bureau's coordinating action extends also to aligning the programmes of national and Community agencies and associations.

IV. Legal and economic aspects of the use of radioisotopes

The Bureau has also initiated comparative studies on non-technical problems arising from the industrial use of radioisotopes. They concern the administrative procedures for obtaining the licences needed in order to employ radioactive sources.

They likewise cover the whole gamut of legal, social and organizational problems relevant to the use of radio-elements or liable to affect the promotion isotope techniques.

As regards economic aspects, a programme is in hand to enquire into the economics of radioisotopes in industry.

V. Cooperation with bodies in non-Community countries

The Bureau plays an active part in symposia, conferences and working party meetings within the framework of such international bodies as ENEA and IAEA.

DOCUMENT No. 13 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

By participating in the design, construction and operation of the research vessel "Otto Hahn", Euratom has been able to inform the Community's government experts and industries concerned of the design and technical characteristics of the project. The latter, indeed, were reviewed with approval not only in the Community but in certain non-member countries where information on the vessel was published. The interest aroused by the project prompted shipping circles to a closer investigation and assessment of the superior transport facilities that nuclear propulsion may bring to merchant shipping in the future.

Status of the work

The Kieler Howaldtswerke AG shipyard progressed with the internal fitting-out of the vessel. In the engine room, the supporting structures were completed and the main piping installed.

In April the secondary shield, consisting of concrete plates suspended against the reactor compartment walls, was poured on board. Its new and unusual design overcomes the problems raised by movements of the hull structure.

The storage pond for the fuel-element changing station was likewise installed on board and surrounded by shielding concrete. The mounting of the service crane was completed.

The safety containment, constructed at Messrs. Krupp's Rheinhausen works, was taken in a single 180-ton piece by water via Rotterdam to Kiel, where it was at once placed in position in the ship's hull.

Fabrication of the pressure vessel, which was entrusted to the Reisholz company, is nearly terminated.

The steam generator and pressure vessel internals are being constructed at the Friedrichsfeld works of the Deutsche Babcock & Wilcox-Dampfkesselwerke AG. The assembly of the spiral tubes into a hollow cylindrical nest is being carried out in a tent which provides the requisite conditions of cleanliness. The mounting of the steam generator, internals and primary pumps in the reactor vessel will also be effected in a tent at Friedrichsfeld, whilst the core itself will be installed on board.

The following firms have started production of the main components of the nuclear assembly :

— the NUKEM (German) / CERCA (French) group will supply the fuel-elements ;
— the French firm Pompes Guinard is building the primary pumps ;
— the Italian firm Bombrini Parodi Delfino is to supply the auxiliary circuits ;
— the Krantz (German) / Van Swaay (Dutch) group is responsible for installing the ventilation system ;
— the firm Hartmann & Braun will supply the electrical and electronic equipment.

The prototype control-rod drive mechanism, constructed by Interatom, Internationale Atomreaktorbau GmbH, Bensberg, passed its operating tests successfully. For the mechanical strength tests it is planned to use the rolling test rig at the GKSS Centre, Geesthacht.

II. Contract of Association with the Reactor Centrum Nederland

In 1965 as in previous years, the Reactor Centrum Nederland continued the drafting of construction plans for the NERO pressurized-water marine reactor.

An outstanding feature of the experimental work was the inaugurating of the high-pressure loop in the high flux reactor, for research on fuel-element cladding corrosion under irradiation. Parallel studies were carried out in this loop and the corrosion loop which has been operating continuously since the end of the preceding year.

Measured values were obtained with the aid of the PUK sub-critical assembly and used, in conjunction with the experimental readings obtained from the KRITO critical assembly, to develop computer codes. Although the KRITO programme was completed towards the end of the year, in accordance with the original timetable, it was found necessary to continue these experiments in 1966. The mounting and calibrating of the steam generator test-rig were finished at the end of the year, so that the test programme was able to get under way.

Only two experimental rigs now have to be completed, namely the NEPTUNUS, on which the working of the pressurizer will be studied, and the test loop for the natural-circulation stand-by cooling system.

So that the results of the current experimental research can be embodied in the final NERO reactor design, it was decided to extend the term of the contract to 31 December 1967.

Most of the theoretical work was concerned with assimilating these experimental results with those of the less extensive experiments conducted in the various Petten laboratories. As well as this value-adjusting work, activities on the development of plans for the auxiliary systems were stepped up.

As regards collaboration with industry, it was considered advisable to entrust work on components research and development to certain firms. The Stork company undertook the design of the primary pumps, the Hollandse Signaal Apparaten NV that of the control-rod drive mechanism, and the Werkspoor company is studying stress measurements in the heat exchanger.

Apart from these works directly connected with the actual reactor plant, the possibility has also been investigated of siting the leaktight containment abaft the ship's engine-room and above the shaft, as is usually done nowadays with modern boiler installations. It was found that the spherical shape of the safety containment allows of this solution, which promises to afford a more compact drive system.

III. Association Contract with Fiat-Ansaldo

The intermediate project for a tanker equipped with a pressurized-water reactor was finished in 1965. The studies carried out, with the support of the Italian Atomic Energy Commission (CNEN), by Fiat for the nuclear part and by Ansaldo for the marine part yielded sufficient data for an appraisal of the prospects and worth of the technical solutions envisaged.

The vessel's dimensions will allow it to pass fully loaded through the Suez Canal, when this is deepened in the near future. The 12.15 m draught with a displacement of 70,000 tons corresponds to a deadweight capacity of 53,450 tons. The reactor, operating at a maximum power of 82 MWth, will provide 22,700 shp during the outward voyage fully laden with cargo heating, and 29,000 shp for the return in ballast. The bottom has been specially designed to meet these two conditions. The scheduled speeds are 17.7 and 19.0 knots respectively.

The "compact" concept has led to a reactor design of reduced weight and bulk, and has also made it possible to use proven-type components for the primary circuit.

Evaluation of the data on the obtaining of a high power density and burnup with moderate fabrication and operating costs has shown the usefulness of this project's characteristics — core with two enrichment zones, two-channel cooling, reactivity control by chemical compensation and reactor regulation by rod clusters.

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

The fifth of the collision tests scheduled in the Ansaldo company's programme under this contract was carried out in May 1965. The CNEN test-rig, described in last year's report, was used on this occasion, but the draught conditions for the ship models were modified from those of the fourth test. It was again found that the anti-collision structures of the models were extremely effective. Nevertheless it was decided to defer further testing until the test-rig was altered to allow of an experiment in which the ramming model strikes the model equipped with anti-collision barriers at an acute instead of a right angle. This method will represent the collision conditions more commonly found in reality, as the speed of the rammed vessel will be simulated. As soon as the rig has been adapted to these new requirements, it is intended to start by reproducing a collision which occurred recently.

V. Shielding Tests (Contract of Association with the Gesellschaft für Kernenergieverwertung in Schiffbau und Schiffahrt mbH, GKSS)

As in previous years, the experimental and theoretical studies conducted in 1965 at the Geesthacht research centre will be published in the Euratom report series.

Numerous measurements were effected of the attenuation of radiation passing through shields made of various materials and designed in simple configurations. The fresh data acquired led to further improvement of the calculation methods.

The collaboration of the Commission's contract partners concerned chiefly with the optimization of marine reactor shielding — with the assistance of the Ispra JRC — made a substantial contribution to the effectiveness of the joint operations.

VI. Mechanical Tests on Marine Reactor Parts (Contract of Association with the Gesellschaft für Kernenergieverwertung in Schiffbau und Schiffahrt mbH, GKSS)

The loop simulating a boiling-water reactor, constructed and financed by the Allgemeine Elektricitäts-Gesellschaft (AEG), was subjected on the rolling-rig to accelerations comparable to those occurring in a vessel in a rough sea. The effect of the movements on boiling in the test section, represented by a fuel-element, was determined by measuring the electrical resistance of the water-steam mixture and, using a 50-curie caesium-137 source mounted on the rolling-rig, by measuring the attenuation of the radiation as it passed through the test section. The measured values, now being evaluated, showed that ship movements do not rule out the use of a boiling-water reactor for marine propulsion.

The requisite experimental rigs were developed for testing a prototype of the control-rod drive intended for the "Otto Hahn" research vessel's FDR reactor.

DOCUMENT No. 14 MATERIALS TESTING REACTORS

I. BR2

This reactor, which is operated at Mol (Belgium) jointly by Euratom and the Belgian Nuclear Study Centre (CEN), has been running since the end of 1963 at its 400 W/cm² specific rating with an 18-element core charge in a configuration which had enabled a reactor power level of 37 MW to be reached.

In July 1965 the core geometry was modified in line with experimental requirements. This third core configuration, which has a 26-28 fuel-element charge, gives a power level of 57 MW and a specific rating of 400 W/cm². At the same time, the reactor's operating cycle was altered from 21 to 28 days. In 1965, BR2 was on stream for 192 days, 35 days unscheduled downtime being occasioned by xenon-poisoning. The modified core geometry and the allied physical tests required one month's work ; the remainder of the shutdown period was needed for reactor maintenance and handling operations in connection with the irradiation experiments.

More than two-thirds of the services provided by BR2 and the associated laboratories in 1965 formed part of Community programmes, the total services showing a 50 % increase in relation to the previous year. The gas loop originally used by the Dragon project for studying graphite corrosion caused by helium impurities was employed for irradiation tests for the Jülich THTR project. The sodium-cooled loop built by the Mol technology laboratory was inserted in BR2, while the first irradiation of a Rapsodie fuel pin was performed successfully for the French Atomic Energy Commission (CEA). Nuclear fuel structural materials were irradiated in capsules and large quantities of radioisotopes, particularly cobalt-60, iridium-192 and transplutonium elements were produced in BR2 for the CEN, Euratom, the UKAEA and various Community customers.

A large number of the irradiation capsules were designed and made by the technology laboratory at Mol for these customers, especially the so-called "boiling water" capsules for fissile needles, capsules for steel tests in sodium-potassium and numerous capsules for radioisotopes. Furthermore, capsules fitted with heating elements and instrumentation originally designed for other reactors were adapted for use in BR2 conditions in collaboration with the CEA.

An acceptance test team examined all the experiments carefully before in-pile insertion to ensure good functioning during irradiation. The dismantling cell, which operates full-time, was equipped with a number of machines for active capsule disassembly.

The construction of lead cells and their accessories for the medium activity laboratory was completed and the laboratory came into operation this year and has been used for technological examinations of steel and metallographic examinations of fissile materials irradiated in BR2. In the 1000 curie cell, housed in the same hall, 2.5 g of americium from an irradiated pin have been chemically isolated.

II. The Petten HFR

One of the tasks of the Petten establishment of the JRC is to make available to clients a total irradiation service from the planning stage up to the analysis of results.

The high flux reactor at Petten operated at full load (20 MW) for 254 days altogether in the course of 1965.

In this year, the number of experiments showed a considerable increase. The 13 possible core sites were used to the extent of 66 %, while 53 % utilization was made of the 10 sites in the pool-side facility. Of the eight irradiation channels available, five were occupied the entire year.

With regard to non-fissile materials, various types of graphite were irradiated for a number of customers in the 150-1,300 °C temperature range up to an integrated dose of 1×10^{20} nvt, different steels in the 250-500 °C range up to a maximum integrated dose of $2\text{-}3.10^{20}$ nvt and zirconium hydride at 60 °C up to 10^{20} nvt.

For fissile material irradiations, use was made largely of the pool-side facility in which UO_2 fuel pins with different clads were tested at temperatures of 600-700 °C and at a specific power of 40 W/g at burnups of up to 10,000 MWd/t.

Apart from these fissile material irradiations in the pool-side facility, UO_2 irradiations were conducted in a low-pressure and a high-pressure loop. Furthermore, UC irradiations were performed at a specific power of 25 W/g, which corresponds to an average temperature of about 1,200 °C.

The technology hall was acceptance-tested in autumn 1965 and part of it is already occupied. Preparations have been completed for converting into offices the small provisional hall located in the prefabricated B building.

Thorough-going studies, bearing mainly on the system's behaviour under non-steady-state conditions during scram shut-down, have been carried out in connection with the problems concerning the proposed power step-up of the HFR from 20 to 30 MW. A final experiment with instrumented fuel elements will be performed, as the power rating increase is scheduled for April 1966.

The development of new capsules has centred mainly around high-performance fuel irradiations as well as capsules which can be reloaded with non-fissile materials. The standardization of capsule components was initiated. Among the other activities linked with HFR irradiations, mention should be made of the development and in-pile operation of calorimeters, continuous neutron measurements and thermocouple irradiation. The HFR dismantling cell has been brought into operation. Various remote-control processes have been evolved and applied successfully, with particular reference to the underwater dismantling of capsules containing the sodium-potassium eutectic.

The design study of an experimental loop for fused salts to be installed at Delft has nearly been completed and construction has started.

The construction of the Material's Department laboratory has commenced. The overall programme of this department is focused on the study of materials subjected to high temperatures. Part of the staff is at present working in provisional laboratories at Petten. Research is in progress on the mechanical, chemical and structural properties of graphite and pyrocarbon. These investigations relate mainly to the THTR reactor, at least with regard to graphite standardization. Work is proceeding actively on the development and improvement of high-temperature thermo-physical measurements. Some of the personnel of this department are still engaged at Ispra on studies of the electrical and electrochemical properties of solid and liquid electrolytes.

DOCUMENT No. 15

PLUTONIUM AND TRANSPLUTONIUM ELEMENTS

I. Plutonium

In 1965 the Commission's work was centred on studies of plutonium use in fast reactors and plutonium recycling in thermal reactors.

Research conducted at the Transuranium Institute into fuels for fast reactors yielded a number of significant results :

— The development of a process for preparing sinterable PuO_2 powders starting from nitrate solution.

— The development of a sintering process for UO_2/PuO_2 pellets. Very good accuracy is now being obtained without rectification on small batches of pellets (of the order of $\pm$ 3/100 mm). It is planned to produce an assembly for the ENRICO FERMI reactor by this method.

— The creation of an analytical chemistry section well up in the principal techniques of analysis. This section analyzed, by titration and emission spectroscopy, the impurities in plutonium samples and assayed their plutonium content for the acceptance of 180 kh of Pu for the MASURCA plant, within the 45-day limit laid down in the purchase contract. It has also contributed to the acceptance assay of plutonium for the SNEAK reactor.

On the same samples, the radiochemistry section determined the isotope content of the plutonium by mass spectrometry to a degree of accuracy at least equal to that of analyses done in the United States.

— The development of basic radiochemical processes : alpha and gamma spectrometry and spontaneous fission neutron count.

— The development of methods of examining plutonium compounds such as metallography, X-ray diffraction and autoradiography.

— The starting up of a facility for plutonium purification and recovery by ion exchange on a fixed resin bed. One kg of plutonium has already been purified in this installation, at the rate of 400 g a week.

A.D. 15

— The first thermal conductivity measurement on UO_2 - PuO_2 mixtures as a function of temperature in the 100 - 1000 °C range.

II. Transplutonium elements

Two grams of americium-241 which had been irradiated for a long period in BR2 were processed at Mol and 180 mg of Cl^{244} and just over 10 μg of Cf^{252} were produced.

DOCUMENT No. 16

CENTRAL NUCLEAR MEASUREMENTS BUREAU

I. Neutron data measurements

The CNMB programme of precision measurements of differential neutron data, set up on the basis of the request of reactor physicists and designers, is coordinated by the European-American Nuclear Data Committee and the Community's experts' panel.

Linear accelerator

The adjustment of the linear accelerator was completed and the tests prior to preliminary acceptance were carried out in August 1965. The specifications obtained are slightly better than those guaranteed (4.2 kW maximum beam power). The electron beam deflection device and the target handling facilities are being installed.

Nine neutron flight paths with nominal lengths of 30 to 400 m have been mounted, aligned, tested, and accepted. Experimental equipment has been further completed and successfully tested.

Preliminary time-of-flight measurements of total and fission cross sections have been carried out yielding valuable experience for the final measurements which will be performed in 1966. Preparations were made for measurements of total cross sections on ^{235}U, ^{238}U, ^{240}Pu, and Ca, of fission cross sections on ^{235}U and ^{239}Pu, and of capture cross sections on a number of nuclides.

It is intended that outside laboratories will for part of the time make use of the neutron flight paths and experimental facilities with which the linear accelerator is equipped. A group from CEN (Mol) will measure spins of resonance levels in fissile nuclides. One flight path might be used, in association with the CNMB, for capture cross section measurements by a team from KFA (Jülich) and another for spin determinations by a group from CNEN (Ispra).

The teleprocessing system linking the CNMB with CETIS (Ispra) via CID (Brussels) has been used extensively for data-processing, but it has proved quite inefficient in its present version and improvements have been elaborated.

Van de Graaff accelerator

Absolute activation cross sections have been measured with high accuracy for the following threshold reactions :

— $^{24}Mn(n,p)^{24}Na$ and $^{27}Al(n,\alpha)^{24}Na$ in the energy range 12.5 to 19.6 MeV using neutrons from the T(d,n) reaction.

— $^{58}Ni(n,p)^{58}Co$, $^{64}Zn(n,p)^{64}Cu$, $^{31}P(n,p)^{31}Si$, $^{32}S(n,p)^{32}P$ in the energy range 1.0 to 2.2 MeV using neutrons from the T(p,n) reaction.

— $^{24}Mg(n,p)^{24}Na$, $^{27}Al(n,\alpha)^{24}Na$, $^{56}Fe(n,p)^{56}Mn$, $^{59}Co(n,\alpha)^{56}Mn$, $^{60}Ni(n,p)^{60}Co$, $^{63}Cu(n,\alpha)^{60}Co$ in the energy range 6.0 to 8.2 MeV using neutrons from the $^{9}Be(\alpha,n)$ reaction.

The angular distributions of the T(n,p) and $^{9}Be(\alpha,n)$ reactions have been measured in the low MeV region. The results of these activation measurements have either been published already or will be appearing shortly.

The compilation of cross sections for neutron-induced threshold reactions has been kept up-to-date by the inclusion of eight new reactions in the 1965 supplement.

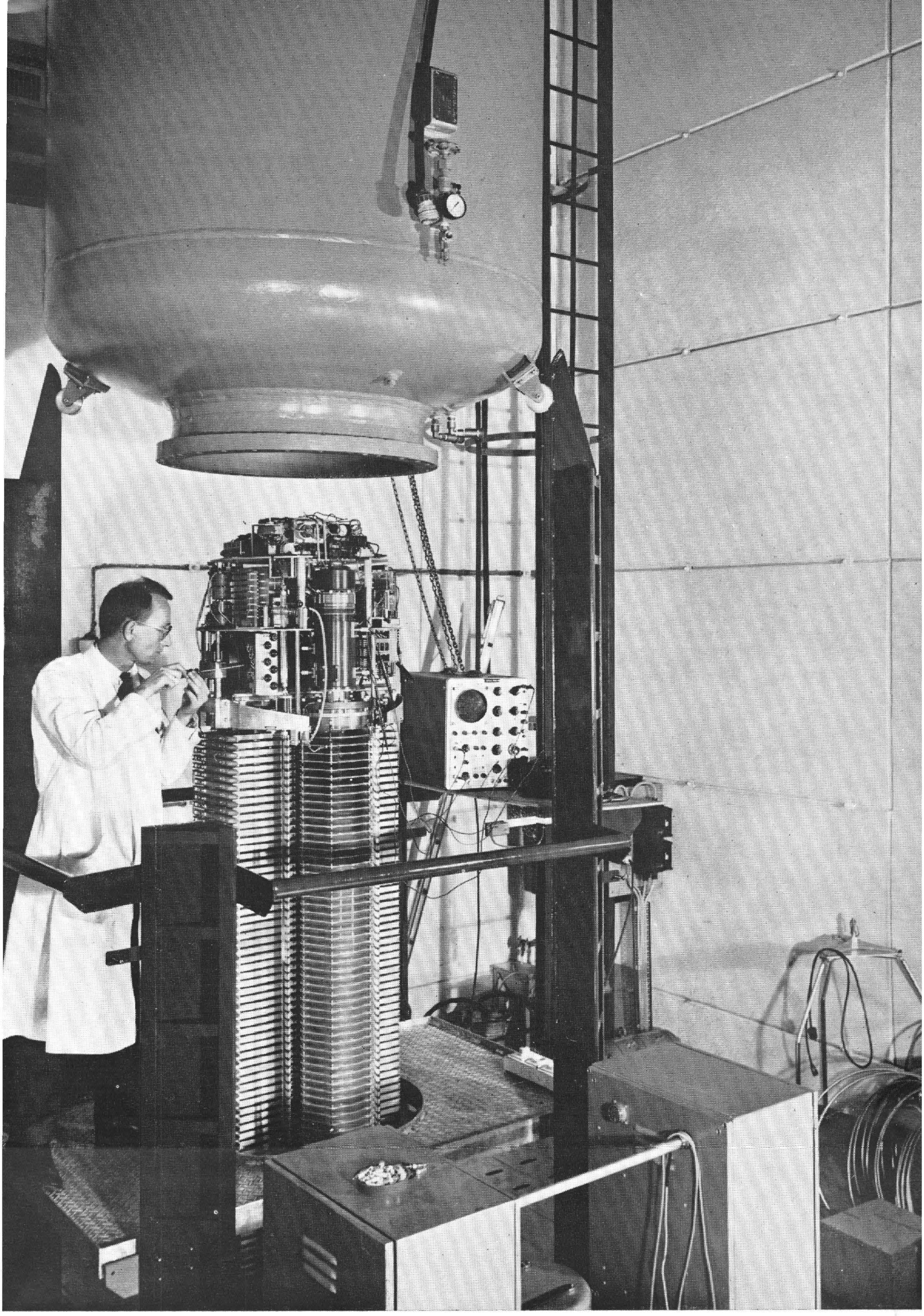
Seven angular distributions of elastically scattered neutrons on natural silicon have been measured at primary neutron energies between 0.57 and 2.28 MeV. Differential elastic neutron scattering cross sections are being evaluated from the experimental results and will be published. Similar measurements on ^{7}Li have been started.

The results of the differential elastic and inelastic neutron scattering cross section measurements on natural Fe have been submitted for publication.

II. Absolute measurements on radionuclides

A great number of calibrated sources of various radionuclides have been prepared for measurements at CNMB as well as for outside laboratories. Many sources are especially precise or difficult to calibrate. ^{60}Co standards in particular have been calibrated and distributed in line with the Euratom recommendation with regard to the standardization of in-pile thermal neutron flux measurements. Several standard solutions with activities known to better than a few tenths of a percent have been prepared.

Investigations aimed at the improvement of existing methods and the development of new techniques for absolute counting of radionuclides resulted in the following publications :



CENTRAL NUCLEAR MEASUREMENTS BUREAU, GEEL (Belgium)
VAN DE GRAAFF ACCELERATOR EXPERIMENTAL HALL

(See other side of page for caption)

The accelerator is an essential piece of equipment used in the study of neutron data, knowledge of which constitutes a basic essential, especially in the development of fast reactors.

a 1 % accurate method of measuring low-energy X-rays ;

precise calibration of radionuclides with liquid scintillators ;

thin-layer absorption in 4π-geometry measurements ;

possibilities afforded by measurements with calibrated spectrometers.

Further studies concerned the improvement of source preparation techniques. The different methods — from simple precipitation to vacuum evaporation of electrodeposited metals — have been compared. The results demonstrate that source preparation can introduce large errors.

Precise measurements of various nuclear and atomic data of interest to nuclear energy, such as the fluorescence yield of Cr, the thermal-neutron absorption cross section of ^{59}Co, the intensities of some conversion electron lines and the decay scheme of ^{241}Am, as well as the γ-branching ratios in the decay schemes of ^{65}Zn and ^{85}Kr, have been completed. The results of these investigations have either been published or have gone to press. Furthermore, measurements are in progress on several decay schemes, on fluorescence yields, on conversion coefficients, and on half lives (in particular of uranium isotopes).

III. Determination of isotope ratios of stable and fissile nuclides

The Mass Spectrometry Group has three well-defined tasks :

— the establishment of standards of known isotopic composition,

— to check the isotopic composition of samples,

— the routine chemical and isotopic analysis of samples.

The Mass Spectrometry Group is now entirely housed in the new building and the facilities for isotopic analysis of α-active material, including transplutonium elements, are in use.

As a result of instrument development, accuracy was increased by a factor of four on boron isotope ratio measurements. $^{10}B/^{11}B$ ratios are now measured with a precision of 0.1 % or better. The CNMB boron standard has been recalibrated, using the new tandem mass spectrometer. Measurements were also performed at the National Bureau of Standards (Washington) and New Brunswick Laboratory (USA). All figures agree and corroborate the earlier measurements of CNMB.

A lithium standard programme was set on foot and is expected to be completed by the end of 1967. Different European and American laboratories with experience in this field have been contacted ; a request has been received for cooperation and exchange of lithium samples.

Under the heavy water standard programme, normalization of ^{18}O in D_2O, investigation of the decomposition of D_2O in connection with D/H analysis, and density measurements of D_2O with the float method have been performed.

Eight laboratories are participating in a programme on the absolute determination of isotopic concentration in heavy water, a sample of 200 ml D_2O being sent to each. The agreement of the results obtained to date is highly encouraging.

Furthermore, the isotopic composition of 197 solids and the chemical composition of 622 gas mixtures were measured in connection with other projects, in and outside CNME.

IV. Sample preparation and assaying

The aim of the service is to provide well-defined samples for use in neutron measurements. Experiments financed by the European American Nuclear Data Committee (EANDC) have priority. A total of 129 different applications (covering 2506 samples) was dealt with in 1965, which represents an increase of 46.5 % with respect to the 1964 orders.

The majority of these requests stemmed from Euratom institutes (51.2 %) and national laboratories within the Community (24 %), but substantial help was also provided to universities in Belgium, Germany, Italy, and the Netherlands (19.4 %). A limited degree of support (5.4 %) was given to laboratories outside the Community.

Two thousand two hundred and fifty one samples of 34 different metals and alloys were prepared by metallurgical methods such as melting (by induction, levitation, resistance, electron bombardment heating), rolling, punching, machining, powder metallurgy, and electrolysis.

A hundred and twenty nine samples were prepared by chemical methods, mostly by electrospraying techniques, while 126 were prepared by evaporation techniques, each requiring a special study for adherence, layer thickness, uniformity, etc.

Most of the samples were precisely defined with respect to their isotopic and chemical composition and their physical properties such as mass, homogeneity, thickness and size. In this connection, several existing techniques could be considerably improved and new methods have been developed, e.g. a capacitive layer thickness probe working to an accuracy of $\pm$ 0.1 μm, and an α-absorption and an X-ray absorption device.

V. Relations with national and international organizations

The Joint Euratom Nuclear Data and Reactor Physics Committee, the secretariat of which was taken over by the CNMB, carried on with the coordination of measurement programmes in the Community as well as continuing to cooperate with the European-American Nuclear Data Committee (EANDC) and the European-American Committee on Reactor Physics (EACRP). The CNMB organized two EANDC-sponsored round table conferences, one on high-precision chemical analysis of substances of interest to nuclear energy and the other on mass spectrometry and counting techniques. The EANDC Standing Subcommittee on Standards required for neutron measurements of interest to nuclear energy (chairman provided by the CNMB) has launched activities calculated to improve the nuclear standards situation, especially with respect to neutron data measurements in the 1-100 keV region.

A member of the CNMB attended the meeting of the International Nuclear Data Scientific Working Group, organized by the International Atomic Energy Agency (IAEA). One CNMB member and three members of the Euratom Working Group on Reactor Dosimetry (secretariat assumed by CNMB are on the editorial board for an IAEA Handbook on In-Pile Dosimetry.

For the Committee on Atomic Weights of the International Union of Pure and Applied Chemistry, a report was drawn up on atomic weights obtained by mass spectrometry measurements : the report constitutes a critical study of the degree of accuracy which can be attributed to these weights. Furthermore, the CNMB participates in the work of the Consultative Committee for Ionizing Radiations and the Working Group on Radionuclide Measurement of the International Bureau of Weights and Measures, as well as collaborating closely with national standards laboratories inside and outside the Community.

DOCUMENT No. 17 REACTOR AND NEUTRON PHYSICS

I. Design study for a pulsed source reactor

The bulk of the work connected with the preliminary design study for the pulsed reactor SORA, launched at the beginning of 1962, was completed at the end of 1965, by which time the Euratom departments concerned had drawn up the specifications for all the reactor components.

With regard to the solution of the thermomechanical problems and the detailed mockup construction, the contract concluded between Euratom and the industrial group formed by Belgo-nucléaire and Siemens-Schuckert-Werke has expired, but the results already obtained under this contract, coupled with the findings of studies carried out at Ispra, have made it possible to draw up the complete specifications so that firms can be invited to submit tenders.

A contract was concluded between the USAEC and Euratom covering the SORA critical experiment, which is now in progress at Oak Ridge, where the life-size mockup was dispatched in May 1965 after being designed and built at Ispra. The zero power experiment went critical on 28 September 1965 ; the initial experimental results coincide with the theoretical calculations. The reactivity value measured for the mobile reflector is in good agreement with the calculated value, a result which bears out the validity of the "reflector pulsation" principle.

To optimize the cold source, a life-size mockup was built and the relevant tests are now being carried out on the Van de Graaff accelerator. A model was set up to check safety rod operation, as a result of which it was concluded that they can be withdrawn at a rate of 40 m/sec.

II. Neutron physics

The activities of the cold neutron installation centred on problems of scatter by impurities on the transition metals as well as on inelastic scatter measurements on gases absorbed in carbon. The findings were reported at the last Brookhaven Conference.

The rotary crystal spectrometer rig was installed in 1965 and a number of test series were performed. Some of the missing components were fabricated and checked and are now being mounted.

The polarized neutron measurements bore mainly on the investigation of a general physical phenomenon, namely the non-conservation of parity in the particular instance of polarized neutron capture reactions. The findings were presented at the Antwerp Conference on nuclear structure and the Karlsruhe Conference on polarized nucleons. A further activity pursued using the same installation pertained to the scatter of high-energy capture gamma rays. Different types of process were identified and studied.

The theory of neutron spectrum measurements in fast reactors using activation techniques has been further developed. Experiments aimed at demonstrating its validity are in preparation at the EURACOS installation (Enriched URAnium COnverter Source) of the Ispra-1 reactor.

The complete equipment of the cold source at Ispra is ready for installation during the next maintenance shutdown.

The Van de Graaff accelerator has been operated reproducibly at its rated performance. The beam deflection electromagnet was installed and put into operation, thus making available a second target position for other experiments. The SORA assembly mockup, the flight path and the accessory instrumentation were installed in line with this target position. Preliminary measurements are being performed on time-of-flight spectra and decay time data. The equipment for pure geometry thermalization experiments was installed in line with the position of the straight target, while the components required for safety reasons are in the process of fabrication. Furthermore, preparations have been completed for the preliminary measurements of decay constants and ambient temperature spectra.

III. Shielding and reactor safety

Studies performed in connection with shielding physics were continued from both the theoretical and the experimental angle. The first results have been published on the development of an analytical method for the solution of the Boltzmann equation in shielding.

A series of measurements is being carried out at Padua University on the removal cross sections of various materials, and an initial set of results has already been published.

In connection with the work carried out on ESSOR safety and the development of reactor dynamics calculation methods, the two-dimensional version of the COSTANZA code, aimed at the solution of time-dependent diffusion equations, has been elaborated and compared with an original version of the nodal method and the various approximate techniques of kinetic calculation. Finally, a new code for the study of xenon-induced spatial instabilities has been written in cylindrical geometry.

IV. Theoretical and experimental reactor physics studies

A theoretical neutron thermalization model was set up to describe liquid state effects on the slow neutron scatter by moderators. This model, which takes account of the influence of the condensed state on the translational degree of freedom of the molecule, has been applied in particular to light water. The TERMIDOR programme for the calculation of the thermal neutron spectrum in D_2O lattices was successfully extended to plutonium-bearing lattices.

An initial study was published in connection with the elaboration of a variational method for investigating the space-energy distribution of thermal neutrons in the reactor cell.

The stationary and the time-dependent neutron transport equation have been applied successively to a certain number of problems, use being made of a number of independent techniques, one of them being based on the neutronic wave concept while another employs the Carleman-Kupradse method.

There are other methods having a wide field of application, i.e. the multiple collision method and the statistical technique represented by the numerical code TIMOC, which has been substantially improved by a new sampling system. The first collision probabilities in annular systems were programmed for use in a numerical method of the THERMOS type. Furthermore, the programme PROCOPE, for the rigorous calculation of collision probabilities in clusters and lattices, was developed in collaboration with the CEA.

A detailed study of noise analysis in a neutron field was completed and a number of new measurement techniques were put forward.

In the studies conducted on Pu-240 resonance absorption, particular attention was paid to the fuel and moderator temperature effect as well as to the range within which the various calculation methods used are valid.

The characteristics were defined of a source reactor of some tens of kW intended for use in detector calibration and the performance of fine structure experiments in heavy water lattices. It could be constructed in the Ispra I storage pool with used fuel elements extracted from this reactor.

DOCUMENT No. 18 THE "CETIS" COMPUTER CENTRE

I. Equipment

As regards the equipment at the "CETIS" computer centre the year 1965 was marked by two events : the Commission's decision to renew the digital computers and the taking into use of a remote-control processing connection between Ispra, the joint data-processing installation in Brussels and the establishment at Geel.

These events were the logical outcome of the evolution of Community needs in the field of machine computation. As early as the beginning of 1964 it was evident that the demand for the use of the digital computers was constantly rising, and in June 1965 this led to the virtual saturation of the available facilities. At the same time new requirements were becoming apparent at the Euratom Head Office and at other, more recent, establishments of the Joint Nuclear Research Centre.

At the Commission's behest technical studies were consequently carried out with a view to renewing the digital machines. These studies led to the choice of IBM 360/65 (512K) and IBM 360/30 computers as replacements for the existing equipment. The relevant contracts have been signed and installation of the new machines is scheduled for July 1966.

In addition, the elaboration of optimized procedures for the transmission of data and test programmes has enabled better use to be made of remote-control data processing.

Finally, relations were intensified with those departments which have problems concerning the acquisition, digitalization and transmission of data to be processed by computer, and improved means of solving such problems were studied. In an initial experiment, relating to the nuclear chemistry laboratory, an on-line internal remote-control processing link will be rigged between the digital outputs of the laboratory spectrometers and the IBM 360/65 computer.

II. Activities

Besides the activities pursued in collaboration with its customers the "CETIS" computer centre continued its work on numerical analysis, the programming system, nuclear codes, etc.

In the field of numerical analysis, and independently of the work on function approximation, valuable results were obtained in the application of variational methods to the multidimensional equations of reactor kinetics. For the solving of these equations, a comparative study was carried out on several methods involving finite differences. Also conducted were a number of studies on the Markov chains, linear programming, a special computer design for a period meter, a report relating to previous work on a learning machine, and inferential statistics.

The theory of optimum reactor control was mathematically examined from the point of view of penal functions. In addition, certain applications of computer techniques to optimum control were studied and tried out.

As regards system programming, the studies undertaken aimed primarily at the development of programmes intended to facilitate the use of analog and digital computers. Version IV of the APACHE system (digital automation of analog programming) was definitively tested and distributed to 36 major computer centres in Europe and America. The initial reactions from the users provided evidence that this system can be successfully applied. At the same time, two APACHE programmes were compiled for the simulation of fixed or variable delays. The general structure of the CARONTE system for the automatic execution of a predetermined sequence of nuclear codes was elaborated in such a way that the user can choose between codes for the calculation of multigroup constants, diffusion codes and transport codes ; he will be able to determine any sequence of these codes, including the possibility of loops.

Development work on the LYRA system was continued. This system is designed for automatically converting tables of multigroup nuclear data into tables with formats which, by being passed through a standard model (DSN), are suitable for codes other than the original. At present it is possible to convert formats CRAM, AIM, SIZZLE, ULCER and THERMOS into format DSN.

The SAHYB programme was likewise studied and finalized. This permits the treatment of problems under initial and limit conditions which are usually handled on analog or hybrid computers ; auxiliary operations here are the generation of functions and of fixed or variable delays. The FIOT system proved very useful for improving the applicational possibilities of the IBM 7090 ; it allows superimposition of the calculation and input/output operations in the case of programmes written in FORTRAN II. In order to facilitate the testing of documentation programmes to be written in 1401 language, CETIS developed a system whereby IBM 1401 programmes can be compiled and simulated on the IBM 7090.

With regard to the nuclear codes, CETIS continued its work on the testing thereof, in collaboration with ENEA, and on the translation of the existing FORTRAN II codes into FORTRAN IV (12 codes are at present ready for use). Further work was also done on the design of new codes, among which mention can be made of :

— PINETO, for the solving of non-linear differential equation systems in neutron dynamics. Extensive use was made of this code in the calculations relating to the SORA and ESSOR reactors.
— THERFAST, a modification of the THERMOS code for the solving of the space/energy transport equation in the thermal zone, as a result of which it can also be used for the fast zones (extension of the energy range to 100 KeV).

Theoretical and practical studies were carried out on combined analog/digital computation techniques. In particular, a comparative mathematical study of digital, analog and hybrid computers shed further light on approximation and simulation by means of the theory of automatic machines. In addition, the possibility of a hybrid extension of the CETIS computers was studied and a suitable system devised. This is the SIOUX system, in which the analog computer is broken down into independent sub-units controlled via digital instructions.

In the realm of automatic documentation special efforts were devoted to the concept of semantic distance between two words, with the aid of statistical functions (association factors), and to the overall improvement of information retrieval systems.

In automatic translation, the favourable reception accorded to the Russian/English translation system has resulted in a steadily increasing demand. Various improvements were made and others are being studied with a view to their incorporation in the new machine.

Table I gives a breakdown of computer utilization according to user category for the period January - November 1965. Table II shows the utilization of the analog computers in the same period, broken down according to the type of work.

Table I

COMPUTER UTILIZATION ACCORDING TO USER CATEGORY

(in per cent)

Period January-November 1965

A. "Closed-shop" work (*)	IBM 7090 %	IBM 1401/1 %	IBM 1401/2 %
1. *Computer operation and maintenance* (Input-output, training, start-up, demonstrations, engineering changes, servicing etc.)	10.40	78.29	17.67
2. *Operation of programme library and testing of programming systems*	5.55	2.75	2.15
3. *Computation services*			
(a) for Euratom scientific departments (including CID) and Euratom contracts	4.50	0.44	7.77
(b) for the European Communities' Statistics Office and EEC	10.49	3.83	18.52
(c) for general departments of the Ispra Centre	2.44	0.57	26.25
(d) for general departments of Euratom Head Office, Brussels	0.28	0.17	2.08
4. *CETIS research proper*			
(a) automatic documentation	1.42	0.39	10.37
(b) other research : system programming (1) numerical analysis elaboration of nuclear codes, etc.	11.35	2.29	1.94
B. "Open-shop" work (**)			
1. *Work for Euratom account*			
(a) Reactor Physics Department (use of library codes)	14.09	2.17	0.16
Reactor Physics Department (other questions)	23.44	5.17	2.36
(b) other departments of the Ispra Establishment	4.69	0.55	3.56
(c) ORGEL project	2.06	0.17	0.04
(d) Head Office and other establishments of JRC	1.91	0.32	0.83
2. *Work for outside account* (universities, nuclear research centres, scientific institutes, private firms etc)			
(a) service-rendering contracts	1.15	0.16	0.91
(b) research contracts, contracts of association or special agreements	6.20	2.72	5.39
	100 %	100 %	100 %

(1) APACHE system, CARN monitor, automatic flow-charting, documentation compiler.

Table I (continued)

(*) By "closed-shop" is meant 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 point 4.

(**) By "open-shop" is meant computer work carried out by outside customers themselves, only the computer time and operation being provided by CETIS. About half of this work involves solely the use of standard library codes.

Table II

UTILIZATION OF ANALOG COMPUTERS ACCORDING TO TYPE OF WORK

Period January-November 1965

"Closed-shop" work	PACE 231R 1 %	PACE 231R 2 %	PACE 231R 3 %
Computer operation and maintenance	23.24	23.59	19.94
Computation services :			
for Euratom scientific departments (including CID) and Euratom contracts	24.75	70.47	72.41
CETIS research proper :			
system programming (APACHE system, CARN monitor, automatic flow-charting, documentation compiler, numerical analysis, full testing, elaboration of nuclear codes, etc.	52.01	5.94	7.65
	100 %	100 %	100 %

Finally, as part of its training activities in 1965 CETIS organized the following courses, which are open to the entire scientific staff of the Centre :

— digital programming course,

— analog programming course,

— introductory course on topology.

DOCUMENT No. 19 **BIOLOGY**

Owing to the considerable curtailment sustained by the "Biology" budget appropriations under the revised second five-year plan, the Commission's research activities in this field during the period under review had to be confined to the following items :

As regards the diagnosis and treatment of conditions caused by irradiation, contacts between the various research groups were greatly intensified. Working sessions were held, joint programmes were drawn up and it is hoped that it will be possible within a reasonable time to overcome the immunological barriers which still militate against grafts. This problem of grafting, moreover, is assuming an importance which extends far beyond the field of radiobiology. The day may not be so far off when therapeutics as a whole will be revolutionized by the possibility of replacing almost any diseased or injured organ by a healthy one taken from another live subject or from a corpse.

Special attention continued to be devoted to the study of radiation effects on embryos, whose particular sensitivity to very small radiation doses has long been known. It is important to find out exactly which phases of development are the most critical, to study the genesis mechanism of malformations and to do everything possible to reduce their frequency. In this sector, too, a Community working group was set up consisting of a large number of experts who between them can muster all the necessary techniques and skills.

The genetic effects of radiations are being studied at all levels and in the most widely differing organisms, from fish to man. Our knowledge of this subject can in fact only progress through observation of control animals which are prolific and rapid breeders, and which at the same time possess characteristics which are easily identified and measured.

Much of the fundamental research on the action mechanism of radiations unfortunately had to be abandoned for the reason given above.

The toxic effects of radioisotopes are being very closely studied. The physico-chemical characteristics of these isotopes at the time of their entry into the organism are of considerable importance as regards their subsequent effect. Furthermore, each element shows a characteristic behaviour, so that these studies call for a wide variety of investigative techniques coupled with an extensive range of disciplines. A whole network of specialists is engaged on this question. Already, for example, it has been established that all the notions serving as a basis for the surveillance of workers exposed to plutonium will have to be reviewed.

The development of techniques for the sampling of marine populations and for their culture in the laboratory was actively continued at Fiascherino (Contract of Association with CNEN). It is already possible to establish in an aquarium biocoenoses which are sufficiently close to the natural environment to allow laboratory studies on the transfer of radionuclides between the various trophic levels.

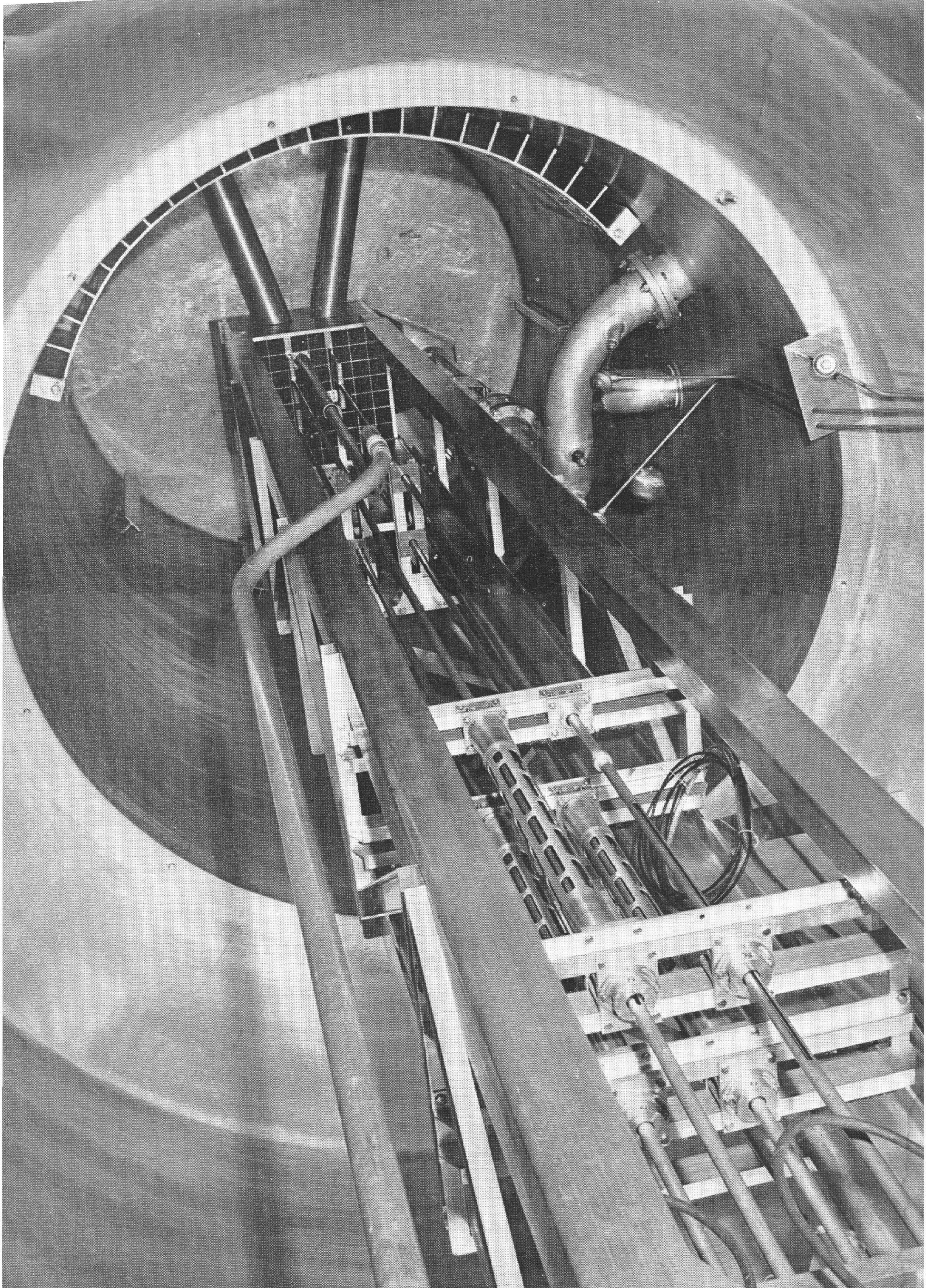
The work in hand under the nuclear medicine research programme is progressing extremely favourably despite the fact that, here again, certain projects had to be abandoned owing to the budget restrictions. Indeed, the complementary activities of the Pisa and Brussels research teams have yielded a number of findings of immediate consequence for the diagnosis and treatment of cancer, arteriosclerosis, cardiac conditions and diabetes. A section of this group which is working in Africa has made a contribution of paramount importance relating to endemic goitre and kwashiorkor.

The study of mutagenesis in plants was continued under the Euratom/ITAL Association, and local and international sub-contracts were integrated into this programme. Results of practical value were obtained on various crops such as peas (increased yield and better positioning of the pods to facilitate mechanical harvesting) and potatoes (resistance to mildew demonstrated in the course of initial tests carried out on mutated clones).

A new approach was made to the problem of improving agricultural crops ; this consists on the one hand in the use of radiations in an attempt to reduce the obstacles to the crossing of species that normally cannot be hybridized, and on the other hand in taking advantage of the heterosis that can result from the crossing of non-irradiated plants of a given variety.

The effects of radiations on seeds and the relations between the embryo and the endosperm were studied at the University of Cagliari by means of the embryo-transplantation technique. In the course of this work the existence was revealed of a cell-multiplication inhibitor which appears in the wheat seed after a dormancy period of 30 weeks.

The subjects for research by the Biology Department at Ispra are chosen primarily on the basis of the Centre's overall research programme and the attendant risks.



INSTITUTE FOR ATOMIC SCIENCES IN AGRICULTURE (ITAL), WAGENINGEN, (Netherlands) — REACTOR ; INTERIOR OF THE ALUMINIUM VESSEL CONTAINING THE CORE STRUCTURE AND THE TWO IRRADIATION CHANNELS

(See other side of page for caption)

This 100 kW swimming-pool reactor is specially designed for the irradiation of biological specimens with slow or fast neutrons. The EURATOM-ITAL Association also has two Ca-137 sources (5000 and 300 curies), a 250 keV X-ray machine and a 2 MeV Van de Graaff accelerator.

They currently comprise studies on :

a. radioactive contamination hazards in the vicinity of the Centre, including the area irrigated by the waters of Lake Maggiore ; particularly with regard to the local food chains ;

b. the noxious or other effects of radioisotopes and substances used in nuclear technology (e.g. organic coolants) ;

c. the immediate effects of ionizing radiations on mammalian cells, with a view to applications in dosimetry or prognosis.

In addition to these experimental studies, mention must be made of the supplementary physical and chemical determinations.

A noteworthy activity is the "Eurosols" programme (contamination levels in the food chain), which is being carried out jointly by the Ispra group, the Euratom/ITAL Association and the Euratom/CEA Association. The aim of this programme is to study in the laboratory (at ITAL), in vegetable muds and in lysimeters (at Ispra) the physico-chemical characteristics and the interactions with radioactive effluents of eight main European soils taken from the Netherlands, Germany, France and Italy.

The conclusions of a report by Mr. Alain Savary on the possible uses of nuclear energy in the overseas territories associated with the European Community underlined the potential value to the developing countries of biological, medical and agricultural applications of nuclear techniques. On the basis of such criteria as the direct influence on the welfare of the population and the chances of obtaining practical results quickly, the Biology Departments consequently made an initial study of projects which could be undertaken in Africa and in which use could be made of Euratom's experience in the relevant fields. Several of these projects were intensively studied in collaboration with the services of the European Development Fund. The projects in question relate to the improvement of millet (a small-seeded cereal grass grown for food in the impoverished, arid regions of the southern Sahara) in Senegal, tsetse-fly control in the Central African Republic, the canning of salt-water fish in the Ivory Coast and the eradication of tapeworm larvae in meat in the Chad Republic.

A convention on the interdisciplinary training of young biological research workers was concluded between the European Atomic Energy Community and the Free University of Brussels, the University of Leiden, the Max Planck Institute, the Centre National de la Recherche Scientifique, the Commissariat à l'Energie Atomique, the Comitato Nazionale per le Ricerche Nucleari and the Comitato Nazionale per l'Energia Nucleare. A number of researchers are already benefiting from this unique opportunity of an initiation into modern biology.

The dosimetry programme, which is of the utmost importance since in the final analysis any radiobiological observation must be based on correct measurement of the dose, is now being expanded. A group of experts recently met for discussions on this subject.

The activities carried out under the entire programme gave rise to 329 scientific publications, of which 102 were compiled with the direct participation of Euratom researchers.

DOCUMENT No. 20

IMPLEMENTATION OF CONTRACTS UNDER POWER-REACTOR PARTICIPATION PROGRAMME

I. ENEL power plant on Garigliano

1. *Operation*

Industrial operation of the plant proceeded normally during the first nine months of 1965. In accordance with the programme, the plant has been shut down since 24 September 1965.

During the period from January to September, the installation operated more or less non-stop at full power and proved able not only to cope with the base load for long periods but also to meet fluctuations in grid demand without any difficulty. The load factor for the period from January 1965 up to shutdown was 93.5 %.

The output and burn-up figures for 1965 were as follows :

— net electric power produced . . . . 902,320,000 kWh

— average burn-up . . . . 4,781 MWd/t

The aforementioned shutdown was necessary in order to carry out annual maintenance on the installation, to replace 108 stainless steel channels with Zircaloy channels, and to perform the operations laid down in the research and development contract with Euratom.

In the last few months preceding shutdown, there was seen to be an increased pressure drop in the core, due to the accumulation of corrosion products in the fuel elements, at the lower support plate. All the fuel elements were unloaded, transferred to the storage pond and mechanically cleaned.

In the core reloading, the 108 channels were duly replaced, as well as 6 fuel elements. Under the research and development programme, four of the latter were exchanged for instrumental elements and two for fresh standard elements in order to check the influence exerted on their behaviour during the coming year by the accumulation of corrosion products.

Chemical analysis of these corrosion products showed them to consist mainly of copper, iron and nickel oxides. Copper alloys are in fact used in the 4 feed-water preheaters and in the 2 secondary-steam generators ; all these items were found to be affected by corrosion, a subject upon which more is said below.

The fact that activation of the corrosion products was relatively slight points to the conclusion that they had been in a low-neutron-flux region for quite a long period and that they had not been recirculated through the core for any length of time.

The main features of the maintenance programme are set out below.

The turbo-generator set was inspected in detail.

Contamination inside the turbine proved very slight and the erosion situation was on the whole satisfactory.

A "Magnaflux" examination revealed cracks in some of the fins and in the peripheral zone of the disc in the 20th medium-pressure stage. Since the other stages are intact, this defect is believed to be due to fatigue caused by resonance vibrations. The stage in question was brought out of service and the disc diameter reduced to eliminate the cracked part. During the next shutdown period, the 20th stage will be replaced by an assembly with a different resonance frequency.

No defects were observed in the generator.

Inspection of the steam generators and the feed-water preheaters revealed leakages.

A leak was found in only one generator tube, and final repair has been postponed to a future shutdown. On the other hand, the losses detected in two preheaters are quite substantial and require adjustment during the present shutdown.

Towards the end of the year, minor leakages were observed near the pressure-vessel penetrations of two drainage tubes in the clean-up system and two in-core instrumentation tubes.

2. *Performance of the contract*

a. Secondment of personnel

During 1965, the following personnel were assigned to the Garigliano power plant :

	Total	Man/months
EURATOM STAFF — permanently seconded (*) — temporarily seconded	 1 2	 12 0.3
Engineers seconded by organizations or enterprises in the Community	8	8.5
Total	11	20.8

(*) For half the year, an engineer was seconded to GENERAL ELECTRIC (S.JOSE) for work in connection with special activities concerning the Garigliano power plant.

The breakdown by country of the engineers seconded by organizations and enterprises was as follows :

Belgium	1
Germany	3
France	3
Italy	1

b. Acquisition of information

Thirty-three reports and papers were drawn up during the year. This figure includes reports by engineers seconded from Euratom and organizations and firms in the Community countries, and also papers presented by these engineers and representatives of the contractors at the last information meeting, held on 31 May and 1 June 1965.

II. ENEL power plant at Latina

1. *Operation*

No noteworthy incident occurred to disorganize operation of the power plant in 1965. There was a 34-day shutdown (between mid-May and mid-June) for annual maintenance.

The following are a few operating data for the year :

— net electric power generated . . . . . . 1,440,600,000 kWh

— load factor for whole year . . . . 82 %

— average burn-up at 31 December 1965 . . . . 1422 MWd/t

The work programme for the shutdown period had been prepared three months beforehand by the PERT method. Inspection of the circuits and physical plant showed that, generally speaking, the equipment was in satisfactory condition,and thus the bulk of the work performed during the shutdown was of the type carried out in a normal servicing period.

Apart from this overall picture, mention should be made of the main turbines and condensers. Inspection of the former revealed that a large number of the stellite covers on the backs of blades in the low-pressure stages were damaged and had to be replaced.

Work was also performed on two main turbines to supplement a modification programme carried out in 1964.

All the condensers were inspected, cleaned and subjected to various repairs. This brings us to the matter of plant operation, as on several occasions during the year the power of the installation had to be reduced (usually for brief periods) in order to repair leaks in one or other of the main condensers.

These leaks were traced to perforation of Cu-, Zn- and Al-alloy tubes as the result of erosion caused by particles of sand, a phenomenon which has also been observed in other power plants with sea-water circulation.

To prevent this, it is planned to use a ferrous-sulphate solution which settles on the tube wall to form hard erosion resistant film.

Other short but frequent power reductions were occasioned by the need to repair leaks in the steam-generator steam/water circuits, more particularly at the manifold inspection-doors.

All in all, interruptions of normal plant operation during 1965 were attributable mainly to conventional and paranuclear components. As regards the specifically nuclear equipment, one noteworthy incident which occurred repeatedly throughout the year, and affecting the loading-unloading machines, consisted in defects in the fuel-element grab and its cable. The frequency of these failures caused the re-fuelling cycle to fall behind schedule. Nine hundred and forty-two fuel channels have been reloaded since the start of the cycle (September 1964) accounting for around 83 tons of contained uranium.

The fuel behaviour was satisfactory, only two canning failures being detected during the year. In October and December 1965, nearly 80 tonnes of fresh fuel elements were delivered by the UKAEA.

Towards the end of the year, the first consignment of irradiated fuel to the Windscale reprocessing plant was sent by sea.

A research programme is being carried out on the reactor under a contract awarded by the Commission.

2. *Performance of the contract*

a. Secondments

The following personnel were assigned to the plant during 1965 :

	Total	Man/months
Euratom employees permanently assigned	2	24
Engineers seconded by enterprises or organizations in the Community	5	2.2
Student trainees	2	4
Total	9	30.2

The breakdown by country of these engineers and trainees is as follows :

Engineers : France 5
Trainees : France 2

b. Acquisition of information

Twenty-nine reports and papers were drawn up during the year. This figure includes reports by engineers seconded by Euratom and organizations and firms in the Community, and also papers presented by these engineers and representatives of the contractors at the information meeting held on 31 May and 1 June 1965. In addition, two reports were produced by student trainees.

III. SENA power plant at Chooz

1. *Status of the work*

The end of 1965 was marked by the final phases of plant-construction work. The civil engineering has been virtually completed, and the only remaining tasks in this field are generally speaking those which depend upon progress in assembling and cabling.

The fabrication at works of the major items of equipment was completed. Most of the materials have been delivered on site, albeit some time behind schedule, which has slightly disorganized the assembly and first test programmes.

All the key components covered by the assembly programme — reactor vessel, steam generators, pressurizer, main and auxiliary condensers — have been installed.

Assembly of the primary circuit has been completed. Among the current assembly activities may be mentioned all those relating to the turbo-generator group, a number of circuits and auxiliary systems and the reactor internals.

In the case of the internals, it was decided to carry out modifications to the SENA thermal shield consisting mainly in the welding of the joints at the top and bottom of the three parts of the shielding and in the reduction of certain assembly clearances.

The majority of the water and steam lines have been assembled.

The main transformer was installed in the course of February 1966.

The various items of equipment were tested individually as and when assembled.

The first overall test, i.e. the hydrostatic test on the primary circuit, was carried out in December, two months later than originally planned. This delay was due to the supply problems already described and to certain difficulties which cropped up during test preparations .The results were satisfactory, only one fairly sizeable leak being detected, namely in the vessel-flange O-ring.

Two batches of fuel assemblies, active followers and control rods arrived on the site during November and December. Each batch was flown from New York to Brussels in 20 containers and then transported by truck from Brussels to Chooz.

Thus at the end of 1965, the stock at the power plant was made up of 48 fuel elements, 23 active followers and 9 control rods.

Core loading is scheduled for the spring of 1966 and industrial commissioning for the end of the same year.

2. *Performance of the contract*

a. Secondments

The following personnel were assigned to the plant during 1965 :

	Total	Man/months
Euratom employees permanently assigned	3	36
Student trainees	4	12.6
Total	7	48.6

The breakdown by country or origin of these trainees is as follows :

Belgium	2
Germany	1
France	1

b. Acquisition of information

A total of 35 reports 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 representatives of the contractors at the information meeting held on 31 May and 1 June 1965.

In addition, two reports were produced by student trainees.

IV. KRB power plant at Gundremmingen

1. *Progress of work*

By the end of 1965, plant construction was sufficiently advanced for some pre-operational circuit tests to be carried out.

The civil engineering has more or less been completed ; most of the activities in this field relate to internal finishing of the buildings. The delay in the construction of the leaktight containment resulting from the re-examination of the plates was partially made good by very accurate timing of the work. Through a local subsidence, this building has a slight tilt, but this was allowed for in the calculations.

The fabrication at works, delivery and installation of the equipment are virtually completed. Failure to meet the vessel delivery deadline, due to difficulties with the nozzle welds, has had only a minor influence on the overall schedule.

Among the most important activities during the final quarter were the instrumentation and laying of the cables.

Acceptance-testing of the circuits will be undertaken as soon as all these connections have been completed. One of the last activities of the year was the assembling of the reactor internals, a task which was performed with the greatest care. The internals are aligned with the axis of the vessel, which itself is at an angle to the vertical determined by the inclination in the reactor building caused by the subsidence.

To conclude this survey of the status of plant construction, the turbo-generator set operated during November and December on the steam produced in the standby boilers. The aim of these tests is to enable a number of adjustments to be made to and tests to be carried out on the turbine with the generator connected up.

The plant is due to come on full stream at the end of 1966.

2. *Performance of the contract*

a. Secondment of personnel

The following personnel were assigned to the plant during 1965 :

	Total	Man/months
Euratom employees permanently assigned	2	24
Engineers seconded by enterprises or organizations in the Community countries	1	0.9
Student trainees	4	6.7
Total	7	31.6

The breakdown by country of these engineers and trainees was as follows :

Engineers : France 1
Trainees : France 4

b. Acquisition of information

The total of 34 reports and papers drawn up during the year includes reports by engineers seconded by Euratom and organizations and firms in the Community countries, and also papers presented by these engineers and representatives of contractors during the information meetings held from 31 May to 1 June and from 18 to 19 November 1965.
In addition, 5 reports were produced by the four trainees.

V. The GKN power plant at Dodewaard

1. *Status of the work*

During 1965, the N.V. Samenwerkende Electriciteits-Productiebedrijven (SEP) requested the Commission for approval of the transfer to the N.V. Gemeenschappelijke Kernenergiecentrale Nederland (GKN) of the rights and obligations arising out of the Euratom/SEP contract of participation. On the Commission's approval of this transfer, the GKN became a party to the contract.

The detailed design studies on the equipment, together with the research and development activities laid down in the construction programme, are now in progress.

The chief modifications to the project relate to the following points :

— Mounting of the start-up monitors in the core instead of in the biological shield. The purpose of this is to reduce the sources used and to secure various operational advantages.
— Replacement of the core-spraying system by a core-flooding system for improved core cooling in the event of a primary circuit failure.

Fabrication at works of certain components has started or will commence in the very near future. These parts include the reactor vessel and internals, the control-rod hydraulic-drive system, the generator and the turbine.

The on-site activities, which started in October 1964, were concentrated entirely on the civil engineering in 1965. Among the units now under construction are the reactor building, the workshop, the turbine building and the administration building.

According to the construction schedule, the reactor vessel should be installed towards the end of 1966 and assembly of the turbo-generator set should be completed in the second half of 1967. The reactor should go critical around the end of 1967.

2. *Performance of the contract*

a. Secondment of personnel

The following personnel were assigned to the plant during 1965 :

	Total	Man/months
Euratom employees permanently assigned	2	24
Engineers seconded by enterprises or organizations in the Community countries	1	6
Total	3	30

Country of origin of the engineer : Germany *b.* Acquisition of information

A total of 18 reports and papers 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 representatives of the contractors at the information meeting held on 31 May and 1 June 1965.

VI. Condensed statement of statistical data

The two tables below summarize the statistical data given in paragraphs 1.2(a) and (b) to V.2(a) and (b) concerning the secondment of personnel and the acquisition of information in 1965.

Secondment of personnel in 1965										
Contractors	Euratom employees		Engineers from organizations and firms in the Community countries		Student trainees		All personnel seconded		Reports and Papers**
	Total	Man/months	Total	Man/months	Total	Man/months	Total	Man/months	
ENEL (SENN)	3*	12.3	8	8.5	—	—	11	20.8	33
ENEL (SIMEA)	2	24	5	2.2	2	4	9	30.2	31
SENA	3	36	—	—	4	12.6	7	48.6	37
KRB	2	24	1	0.9	4	6.7	7	31.6	39
GKN (SEP)	2	24	1	6	—	—	3	30	18
Gen. Tot.	12	120.3	15	17.6	10	23.3	37	161.2	158

*) Two employees temporarily seconded.

**) Reports drawn up by engineers seconded by Euratom and organizations and firms in the Community countries, and also by student trainees.
Papers presented by engineers seconded by Euratom and organizations and firms in the Community countries, and also by representatives of the contractors at the information meetings held from 31 May to 1 June and from 18 to 19 November 1965.

Secondment of personnel in 1965 : breakdown by country of origin					
	Germany	Belgium	France	Italy	Total
Engineers seconded by organizations or firms in Community countries	4	1	9	1	15
Student trainees	1	2	7	—	10

VII. Information supplied by the contractors

In return for its backing, 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 information includes :

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

— diagrams, specifications, schemes, main technical characteristics and data, and construction and testing 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, steps taken to overcome them ;

— information of a financial, technical and economic character.

The breakdown by power plant and by type of document of the information received during the year as follows :

INFORMATION RECEIVED	ENEL (SENN)	ENEL (SIMEA)	SENA	KRB	GKN (SEP)	Total
Initial reports	—	—	—	—	1	1
Annual reports	1	1	1	1	1	5
Quarterly reports	11	2	5	4	2	24
Special reports	11	1	—	—	1	13
Safety reports	—	—	—	10	3	13
Plans, specifications, etc.	33	—	21	158	117	329
Total	56	4	27	173	125	385

VIII. Dissemination of information

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

1. *Dissemination of documents*

The following documents are distributed via the six national correspondents :
— reports by engineers seconded by the Commission ;
— periodical lists relating to the reports by engineers seconded by enterprises or firms in the Community and to documents supplied by the contractors.

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

2. *Information meetings*

Two information meetings were held in 1965 — the fifth at Brussels on 31 May and 1 June and the sixth at Munich and Gundremmingen on 18 and 19 November.

The fifth meeting, which like its predecessors was devoted to experience acquired in the fields of design, construction, testing and operation of the five power plants in which the Commission is participating, was attended by 275 representatives from 135 organizations and firms in the Community countries.

The sixth meeting differed from the others, as it was given up entirely to a single project (KRB) and because the special technical problems affecting the conventional and paranuclear equipment of the Gundremmingen plant were examined. This meeting was attended by 153 persons representing 88 Community organizations and firms.

DOCUMENT No. 21

THIRD-PARTY LIABILITY

I. Entry into force of European Conventions on third-party liability

As was stated in the Eight General Report, the additional protocols to the Paris Convention on third-party liability in the field of nuclear energy of 29 July 1960 and the Brussels Supplementary Convention of 31 January 1963 were signed on 28 January 1964. These permit simultaneous accession to the European Conventions of Paris and Brussels and the Vienna World Convention, the text of which was drawn up shortly after the signature of the Brussels Supplementary Convention. The obstacles which delayed the ratification of the Paris and Brussels Conventions are thus now removed, and these Conventions have been signed by the majority of West European countries and by all the Member States of the Community. The text of the conventions is now final, but the conventions have not yet come into force, since the number of instruments of ratification deposited is still insufficient. Only one of the Community Member States — France — has as yet deposited its instruments of ratification. The Commission has urged Member States to speed up the ratification procedure.

II. The present legal situation in the Member States

The legal situation on nuclear third-party liability in the Member States of the Community is marked by the existence of temporary laws the provisions of which, while broadly fitting in with the regulations of the conventions on third-party liability, nonetheless do not reflect them completely. Except for Luxembourg, all the Member States of the Community have so far had a special system of third-party liability for nuclear damage.

In *Belgium,* the special provisions for nuclear hazards laid down in the law of 7 July 1962 applies only to the National Nuclear Research Centre at Mol. In 1965 the Belgian Government submitted to Parliament draft laws for the ratification of the Conventions on third-party liability, together with an implementing law. Voting on the implementing law will probably take place in 1966. This document stipulates that once these laws have been voted those provisions of the Conventions which have not yet come into force will become national law in Belgium.

In the *German Federal Republic* it is the provisions of the 1959 law on atomic energy which are applicable. They broadly correspond to the regulations of the conventions on third-party liability, but must be considerably amended for technical reasons of a legal nature. It was intended to submit to Parliament at the end of 1965 or the beginning of 1966 draft laws concerning ratification and the draft law adapting the law on atomic energy to the terms of the Conventions. However, they have not yet been put before the Bundestag.

In *France* a short provisional law on nuclear insurance and third-party liability, which is to be replaced by the law implementing the Conventions, was promulgated on 26 October 1965. Parliament simultaneously voted a law authorizing the ratification of the Conventions. It is not known how long it will take to overcome the obstacles which have hitherto prevented the Government from submitting a draft implementary law to Parliament.

In *Italy* the law of 31 December 1962 embodied regulations which agree with the Conventions, only a few points requiring to be adapted. The preparatory legal work for the ratification and amendment of the law of 31 December 1962 has not yet begun.

In *Luxembourg* the actual ratification of the Conventions has not yet begun.

In the *Netherlands* a provisional law relating to nuclear third-party liability was voted on 26 October 1965 and came into force on 1 January 1966. Certain provisions of this law will have to be amended when the third-party liability Conventions are ratified. The schedule for the ratification of the Conventions in the Netherlands is not yet known.

III. Coordination of implementing legislation

Work on the coordination of the national legislations implementing the Paris Convention and the Brussels Supplementary Convention was continued by the Member States and the Commission. This harmonization is of the utmost importance, because both the Conventions leave Member States a fairly large amount of latitude in the matter of implementary legislation, so that without it a situation very prejudicial to the development of nuclear industry and nuclear insurance would arise.

The above-mentioned work has led to a recommendation by the Commission dated 28 October 1965 (See Journal Officiel No. 196 of 18 November 1965), in which Member States are invited to embody the following points uniformly in the implementing provisions for the two Conventions :

1. A nuclear installation, in the sense of Article 1 a) ii) of the Paris Convention, can be composed of different installations, insofar as the operator is the same and they constitute an organic entity, i.e. a spatial unit ;
2. The operator of a nuclear installation is designated at the moment of the grant of an authorization to construct (Article 3 c of the Paris Convention) ;
3. The operator's responsibility extends to all damage caused by ionizing radiations emitted by any source situated within the nuclear installation (Article 3 c of the Paris Convention) ;
4. The national provisions must stipulate that the operator's liability can be transferred to the conveyor of nuclear substances (Article 3 c of the Paris Convention) ;
5. Litigation for damages envisaged by the Paris Convention is subject to a time-limitation of three years, to be reckoned either from the moment when the injured party had knowledge of the damage and of the operator responsible or from the moment when he reasonably should have had such knowledge (Article 8 c of the Paris Convention) ;
6. National regulations do not avail themselves of the possibility afforded under Article 8 e of the Paris Convention of excluding claims for compensation in respect of the aggravation of damage ;
7. The obligation embodied in the financial guarantee contained in Article 10 a of the Paris Convention and intended to meet a liability as defined in Articles 3 and 4 of the said convention is not affected by the fact that the damage is already covered by another insurance scheme or financial guarantee ;
8. In the exercice of the right of appeal provided for in Article 5 a of the Brussels Supplementary Convention, the State has priority over the insurers or any other guarantor.

EUROPEAN INSTITUTE FOR TRANSPLUTONIUM ELEMENTS
KARLSRUHE (Germany)

(See other side of page for caption)

The Institute for Transplutonium Elements plays a major role in research work relating to the development of fast reactors. In particular, it is responsible for the fabrication of fuel elements for « MASURCA ».

DOCUMENT No. 22

INSURANCE OF THE JOINT NUCLEAR RESEARCH CENTRE'S INSTALLATIONS

I. Nuclear Risk Insurance

The problem of insuring the Commission's own nuclear installations is twofold — insurance against material damage and coverage of third-party liability.

As regards the insurance of material damage, the Commission, in full agreement with the Council considered it unnecessary in 1966 to change the previous system, under which this kind of risk is not covered through the insurance market but from the Commission's own budget.

The question of coverage of the third-party liability involved in the operation of the JRC Establishments had already been discussed in the Council in previous years ; owing to the complexity of the problem and the variety of practice in the different Member States, it was impossible to apply a standard solution to all Euratom's installations. The system applied in the preceding years was continued provisionally, namely, coverage by insurance of the Community's liability for the Ispra Centre and the Central Nuclear Measurements Bureau, and by the budget for the risks connected with the Transuranium Institute at Karlsruhe. Discussions are in progress as to the possibility of obtaining unsurance coverage for the last-named risks.

II. Practical problems of nuclear insurance

The exceptional nature of the nuclear hazard, our still very imperfect knowledge of the probability and nature of this risk, and the small number of nuclear installations in existence so far, are all reasons which have hitherto prevented the coverage of nuclear risks by the insurance market in the same way as other industrial risks.

In each Community country, a pool has been formed of all the insurance companies concerned with nuclear insurance. Nuclear insurance can only be taken out through those pools who, for their part, have mutually agreed not to undertake insurance contracts in any but their own country.

The insurers state that they are not in a position to insure nuclear risks except by the pool system. The basic reason for this is that, for lack of precedents, nuclear risk probabilities cannot be calculated statistically, and therefore the balance between premiums received and compensation paid out cannot be worked out in advance. Because this equilibrium principle, on which companies handling normal insurance base their operations, cannot be applied, coverage of the nuclear risk always involves the insurer in a hazardous venture.

The numerous difficulties besetting nuclear insurance stem from the fact that insurers are only prepared to accept relatively minor risks for their own account. Thus, as regards insurance against material damage, it is often impossible to obtain single coverage for large installations ; for even if all Community and non-Community insurers willing to reinsure Community nuclear risks were to share in their coverage, the total coverage capacity offered would not amount to the desired insurable value of the installation. In the field of third-party liability, the States for the same reason have undertaken to guarantee all damage exceeding a sum which, in the Member States, varies between five and fifteen million EMA u.a.

The nuclear insurance market will not emerge from its predicament until far more nuclear installations are insured ; when that day comes, it will run on its own power, giving satisfaction to insurers and insured alike.

To encourage insurers and insured to work out a joint solution now to the practical difficulties of nuclear insurance, the Commission held a conference on Nuclear Insurance Problems, on 8 and 9 July 1965, in Berlin ; it was attended by the nuclear insurance firms of the Community, the industrial firms belonging to UNICE (Union of Industries of the European Community) and the electricity producers of the European Community Committee of UNIPEDE (International Union of Electric Power Producers and Distributors), together with representatives of the Member States. The conference produced some satisfactory results, e.g. cooperation on the determination and assessment of nuclear risks. Furthermore, the participants approved in principle a framework policy covering the third-party liability of nuclear installations — a policy prepared jointly by the Commission, the insurers and the insured parties. This framework policy was worked out at meetings of experts. The policy, which will form the basis of nuclear third-party insurance, will be published in the Spring of 1966. A framework third-party insurance policy for nuclear transport will be similarly prepared by the Commission and the parties concerned in nuclear insurance.

The new Paris Convention on third-party liability in the field of nuclear energy and the supplementary Brussels Convention will give Europe a uniform legal groundwork for nuclear liability. The new provisions in the conventions, regarding liability and risk coverage, call for a departure from the traditional principles of insurance and the development of a new policy tailored to European nuclear liability.

The growth of the nuclear industry in the Community has shown the need for an alignment of policies, for in the first place, the disparity of insurance charges in the various countries means that the industries are competing in a common market under unequal conditions, and secondly, the opportunities for reinsurance must be improved so as to lower cost of nuclear insurance.

The policy is a framework only, because at present it would be impossible and, indeed, useless, to draw up a detailed, uniform policy, owing to the difference in the various countries' legal requirements ; similarly, insurance customs, which should not be discarded without good reason, vary from one Community country to another. But, in so far as the clauses of the framework policy do not conflict with imperative national arrangements, they should as far as possible be incorporated in this form in insurance policies.

DOCUMENT No. 23

MANAGEMENT OF INDUSTRIAL PROPERTY

The portfolio of patents protecting inventions stemming from work under the Community research programme maintained its rate of growth in 1965. No change has been made in the Commission's policy on patents, which was defined in four statements by the Commission to the Council — 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). The aptness of this policy has been confirmed by the absence of difficulties in its practice.

1. *Communication of patent applications (article 16)*

Notification of patent applications as required by Article 16 of the Treaty went forward without a hitch and within the time-limits laid down. By 31 December 1965 the Commission had received details of 12,570 patent applications, 1,248 of them notified in 1965. The number of inventions covered by patent applications communicated to the Commission in the form of either accounts of contents or simple notifications totalled 9,169.

2. *Filing of patents by the Community and holders of its contracts*

At the end of 1965, the Commission's Patents Office had examined 874 proposals for inventions stemming from the research programme. These inventions, between the entry into force of the Treaty and the end of 1965, had been the subject of 714 first patent applications filed in one country on behalf of either the Community or the holders of Commission contracts, 182 of them being filed in 1965. The total number of requests for extension of patent rights to other countries had reached 2,167 by the end of 1965.

Of the applications lodged in countries where a preliminary examination is required, 89 were granted ; very few were rejected.

The following table is a breakdown of inventions for which patents had been filed up to the end of 1965 :

	1965	Total 1958-1965
Orgel	10	97
Fast reactors	28	94
Thermonuclear	19	72
BR 2	3	29
Dragon	18	111
Miscellaneous	104	311
	182	714

The breakdown by origin is as follows :

	1965	Total 1958-1965
Euratom	64	216
Association contracts	57	237
Other contracts	37	137
Dragon	18	109
Miscellaneous	6	15
	182	714

A list of the patent applications filed between 1 January and 31 December 1965 is given in Document No. 34 attached to the present General Report.

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

3. *Exploiting the portfolio patents*

Although the JRC establishments, associates and contractholders use on a laboratory or semi-industrial scale a large proportion of the patented inventions stemming from the Community programme, the number of inventions worked under licence remains small.

The granting of licences in respect of patents for reactors or reactor parts must wait until the construction of prototypes is decided upon. As to the other patents, of more limited scope (small apparatus, measuring instruments, etc.) the principle of non-exclusivity, laid down by the Treaty, discourages the potential licence seekers, mainly small or medium enterprises.

Even so, whereas only one new licence was granted in 1964, seven licence contracts, entailing the payment of royalties, were negotiated in 1965 and signed by the date of this report. These contracts relate to a rig for purifying an inert enclosed atmosphere, a movement-transforming mechanism, an electrostatic pulverizer, an electrical connecting device with automatic plug, a remote handling grab, a blocking device for the rotational movement of remote-handling gear, an electromagnetic device generating frequency-modulated pulse series, a ceramic crucible compound for melting uranium and its alloys, safety fuses for high-tension condensers, and a remote-controlled gas-sampling machine.

Negotiations have been started on two other licences.

We should also mention that the Commission has received the first royalties due from the licencees.

4. *Standardization of industrial property rights within the Community*

The preliminary draft European Patent Convention, in the preparation of which the EEC and Euratom Commissions participated, was submitted to the Council for their consideration ; their conclusions are still pending.

DOCUMENT No. 24 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				
	1.1.62	1.1.63	1.1.64	1.1.65	1.1.66
Regulation No. 7	83	97	117	135	165
Regulation No. 8	127	134	155	168	192

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 at 1 January 1966 are set out in the following table according to industry :

	Bel-gium	Ger-many	France	Italy	Nether-lands	Commu-nity
Concentrate fabrication	1 (1)	1	4	1 (2)	—	7
Fuel fabrication	1	1	8	—	—	10
Fuel element fabrication	3 (3)	5 (6)	5	2	—	15
Reactors	8 (5)	27	32 (4)	20	8	95
Irradiated fuel reprocessing	1	—	1	1	—	3
Laboratories	5	10	8	11 (6)	—	34
Materials depot	—	—	—	1	—	1
	19	44	58	36	8	165

(1) Outside the Community (Congo Democratic Republic)
(2) Installation halted
(3) Including two installations halted
(4) Including one installation halted
(5) Including one reactor outside the Community
(6) Including two laboratories no longer reprocessing nuclear material

III. Materials, stocks and movements (Regulation No. 8)

The figures hereunder show the position regarding the implementation of Regulation No. 8 at 1 January 1966.

a) The enterprises, establishments and installations to which Regulation No. 8 applies are distributed as follows :

	Belgium	Ger-many	France	Italy	Nether-lands	Commu-nity
Enterprises	7	31	17	17	8	80
Establishments	8	33	47	20	8	116
Installations	16	48	78	35	15	192
— Mines	—	2	20	1	—	23
— Concentrate fabrication	—	1	4	—	—	5
— Fuel fabrication	1	1	5	—	—	7
— Fuel element fabrication	1	3	8	2	—	14
— Reactors	7	26	28	20	8	89
— Irradiated fuel processing	1	—	1	1	—	3
— Laboratories	6	15	11	10	7	49
— Depot	—	—	1	1	—	2

b) *Stocks held and stock movements within the Community :*

— ores : 9 enterprises send the Commission quarterly statements of output and stocks at 23 mines ;

— source materials and special fissile materials : 71 enterprises send the Commission the balance-sheets and inventories of 169 installations.

c) *Export and import transactions with non-member countries :*

27 enterprises sent the Commission 387 import or export declarations relating to the transfer to or from non-member countries of the following :

	Imports	*Exports*
— natural uranium	35	26
— depleted uranium	21	6
— thorium	24	63
— special fissile materials	174	38
Total :	254	133

One hundred and twenty one of these imports and 21 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 countries.

STOCKS OF IMPORTED SPECIAL FISSILE MATERIALS

	31.12.62 Bilateral agreements concluded by		31.12.63 Bilateral agreements concluded by		31.12.64 Bilateral agreements concluded by		31.12.65* Bilateral agreements concluded by	
	Community	Member States	Community	Member States	Community	Member States	Community	Member States
Enriched uranium (U-235 kg)								
Research centres	2	98	4	151	2	545	13	315
Fuel production	1	138	130	473	212	588	1.134	1.266
Reactors	106	680	1.145	836	2.661	1.074	3.826	830
	109	916	1.279	1.460	2.875	2.207	4.973	2.411
Total for Community	1.025		2.739		5.082		7.384	

* Provisional figures

	31.12.62 Bilateral agreements concluded by		31.12.63 Bilateral agreements concluded by		31.12.64 Bilateral agreements concluded by		31.12.65* Bilateral agreements concluded by	
	Community	Member States	Community	Member States	Community	Member States	Community	Member States
Plutonium (kg)								
Research centres	1.0	1.0	8.0	4.0	51.0	4.4	122.0	7.9
Industrial installations	—	—	—	—	—	—	133.6	5.1
Reactors	0.2	0.1	0.4	0.2	2	0.2	80.4	—
	1.2	1.1	8.4	4.2	53	4.6	336	13
Total for Community	2.3		12.6		57.6		349	

* Provisional figures

STOCKS OF NATURAL URANIUM (tons)
IN REACTORS IN THE COMMUNITY AT:

	31.12.1962	31.12.1963	31.12.1964	31.12.1965*
Reactors	669	884	1.230	1.725

* Provisional figure

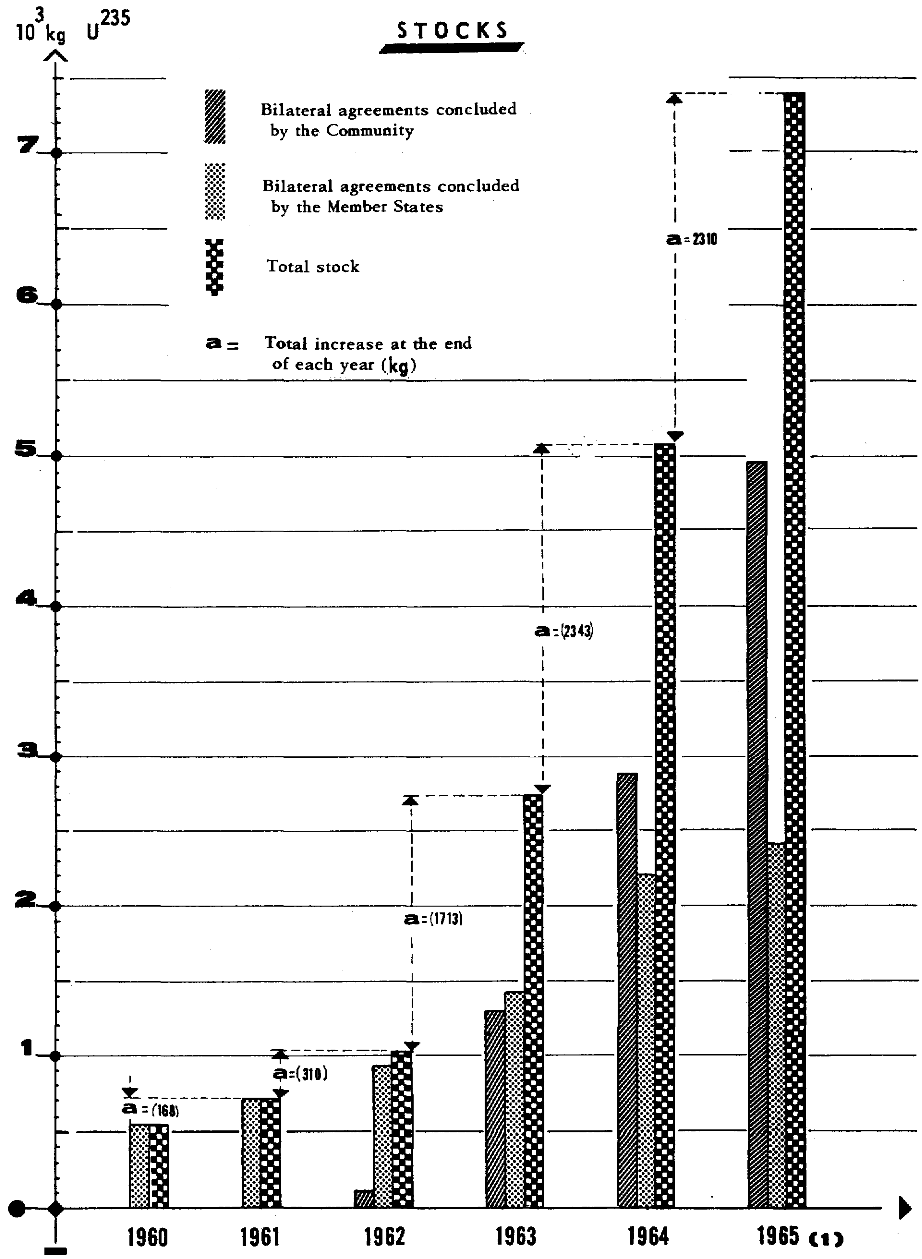
e) The following graphs illustrate the trend in stocks and imports of enriched uranium and plutonium within the Community in recent years.

IV. Inspections

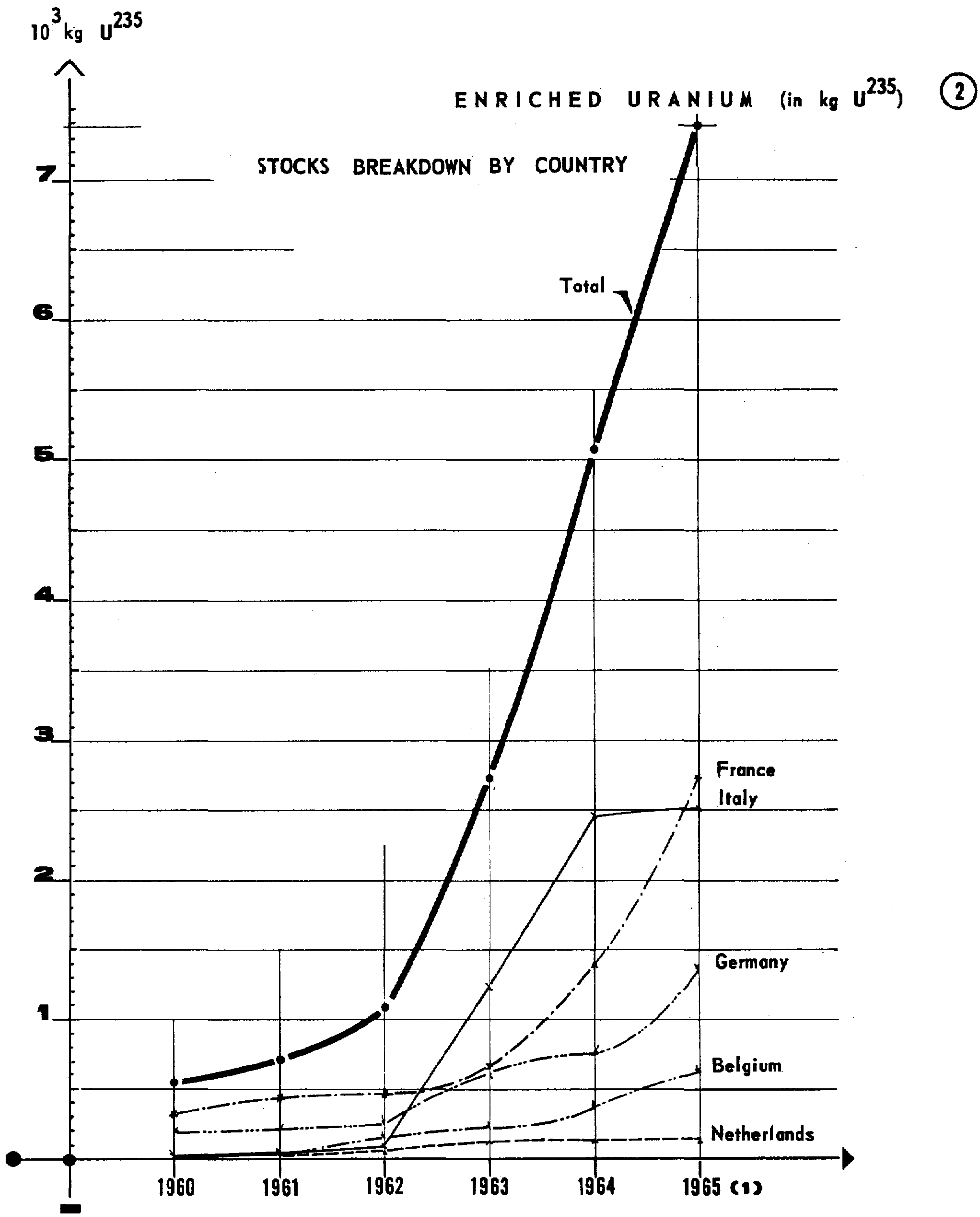
During 1965, inspectors visited 74 installations. The total number of inspections effected in 1965 was 184.

	Number of inspections
— Ore concentration plants	3
— Fuel preparation plants	12
— Fuel element fabrication plants	23
— Power reactors	22
— Research reactors	88
— Research laboratories	34
— Irradiated fuel reprocessing plants	2
	184

ENRICHED URANIUM (in kg U^{235}) ①

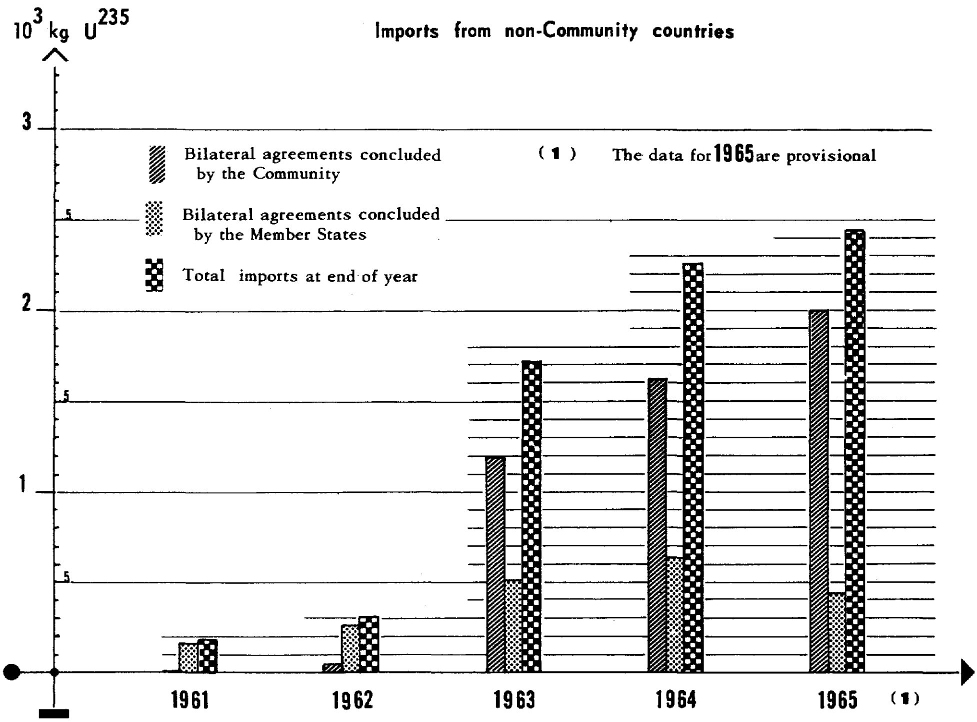


(1) The data for 1965 are provisional



(1) The data for 1965 are provisional

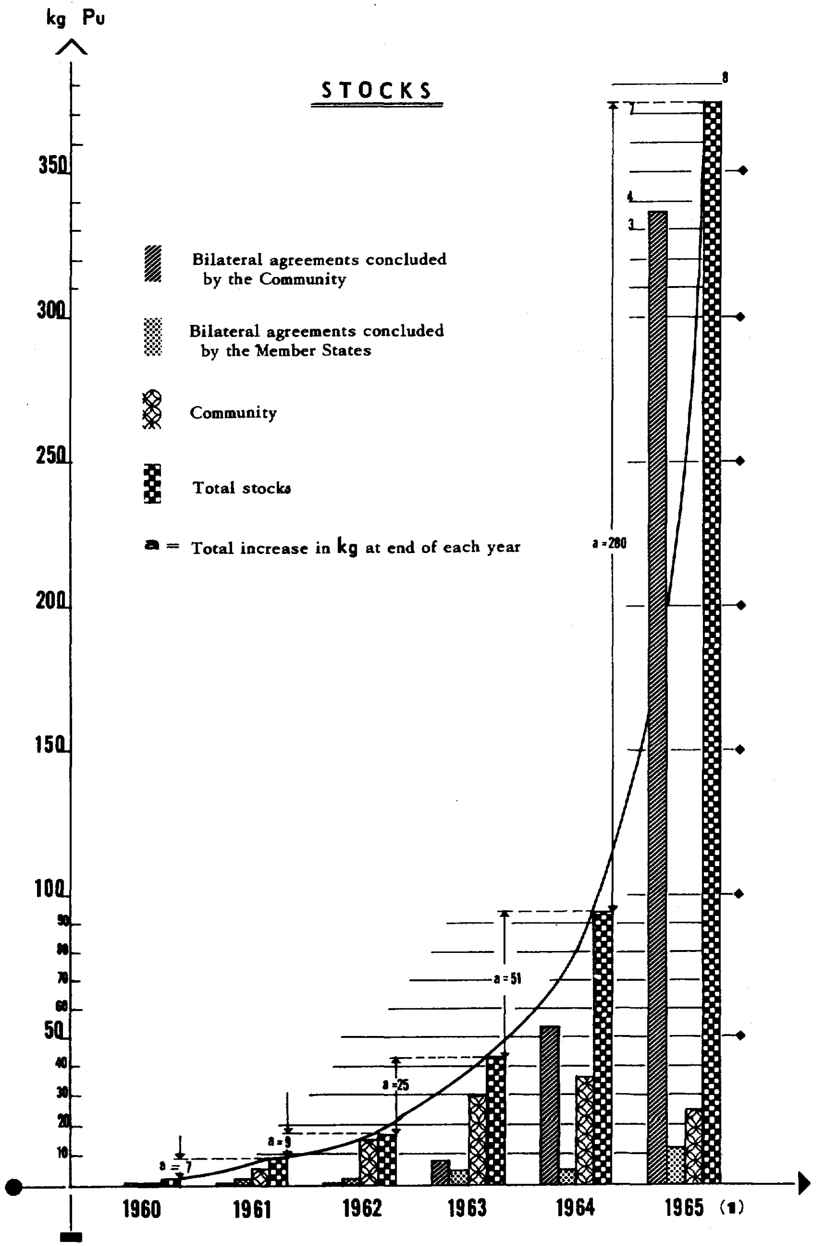
ENRICHED URANIUM (in kg U^{235}) 3



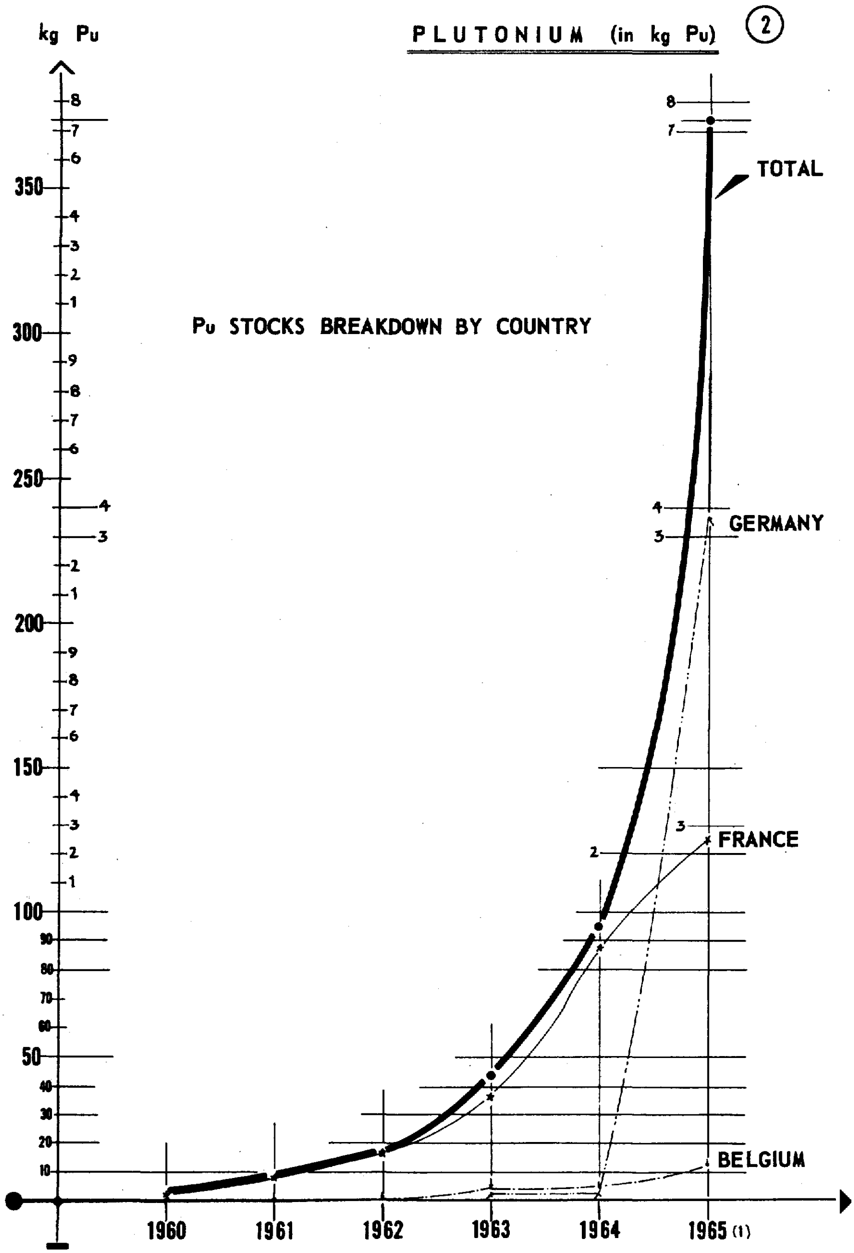
(2) NB. The aggregate imports over this 5-year period amount to 6,920 kg.

NB. The corresponding figure for exports over the same period is 170 kg.

PLUTONIUM (in kg Pu) ①



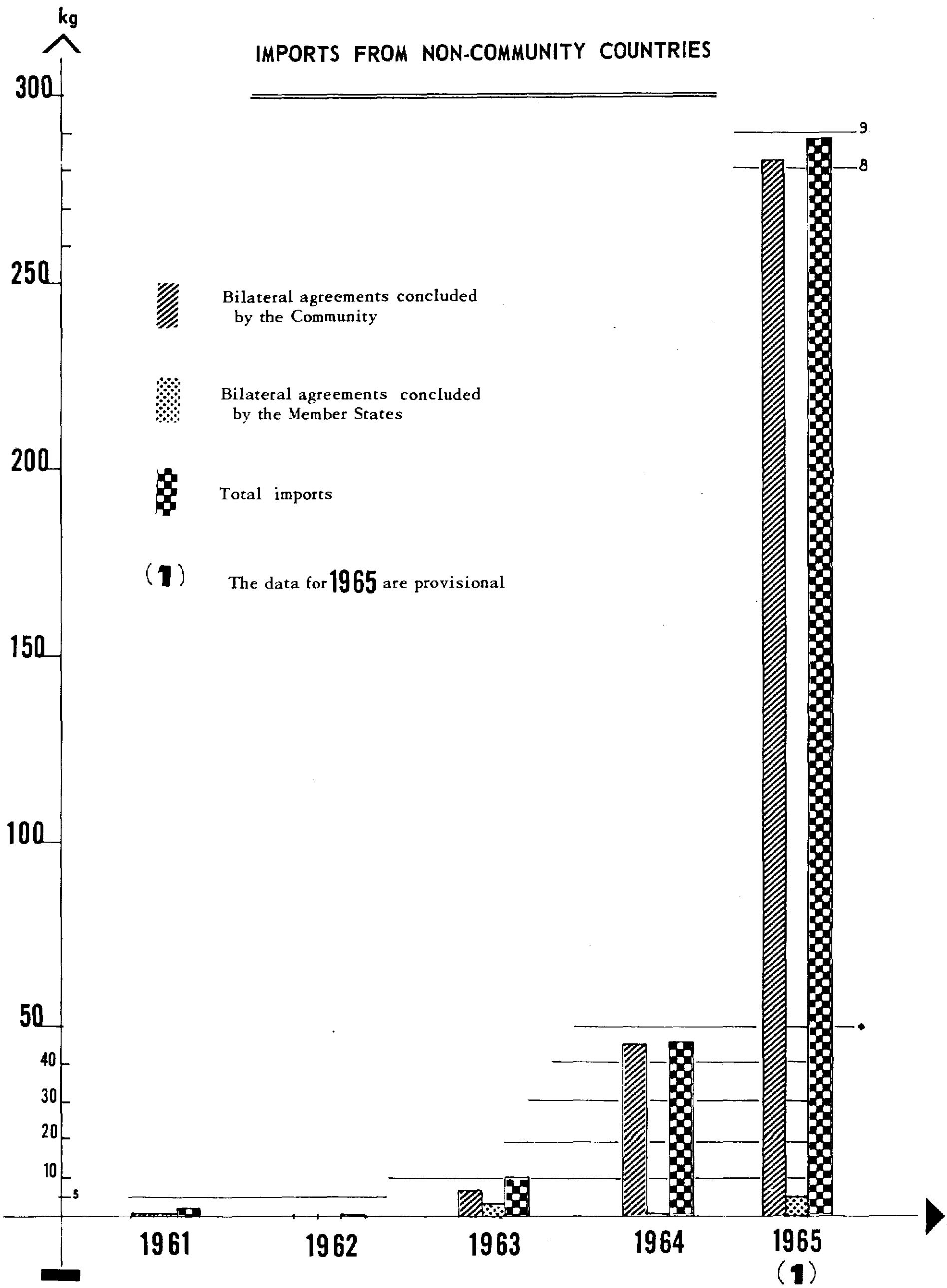
(1) The data for 1965 are provisional



(1) The data for 1965 are provisional

(2) The Italian and Dutch stocks do not exceed 1 kg

PLUTONIUM (in kg Pu) ③



DOCUMENT No. 25

ACTIVITIES OF THE SUPPLY AGENCY

I. Problems relating to resources and long-term uranium supplies

During the past year a group of geologists from Member States drew up a report on the Community's uranium resources. This report embodied various observations made in the course of the national geological research work carried out within the Community concerning the methods of uranium prospecting employed as well as its organization and economics. By critical examination of all the facts thus amassed, a certain number of major points emerged.

It is now recognized that the bulk of the economically feasible concentrations of uranium in the Community countries, including both deposits of industrial interest or indices are located in areas whose formation was considerably affected and even determined by Hercynian orogenesis, namely, Brittany, the Massif Central and the Vosges Mountains in France, the Black Forest, the Bohemian Forest, the Fichtelgebirge and the Frankenwald in West Germany and the Alpine area in Italy.

The research carried out in the Community countries up to 1964 revealed the presence of resources which could be worked at a cost of 8 EMA u.a./lb of U_3O_8, giving a total of about 31,000 tons of uranium metal.

It was estimated that the uranium resources obtainable at a comparable price could be increased by launching an exploration programme in three of the Community countries, namely, West Germany, France and Italy and that the additional resources thus obtained would be of the order of 10,000 tons uranium in West Germany, 20,000 in France and 10,000 in Italy.

It was felt that there was no great likelihood of major uranium deposits being found in the Benelux countries.

Acting in line with a time-tested policy of systematic prospecting based on the gradual narrowing down of areas likely to contain uranium deposits, the experts stated that a certain number of conditions must be fulfilled in order to ensure optimum economy and efficiency in any prospecting programme. In particular, they stressed the need to use specialist geological teams working either for national bodies or for private undertakings. Moreover, exploration should be carried out continuously on a wide scale, and with a high degree of flexibility.

With regard to the cost of prospecting and the evidencing of deposits which could be worked at a cost of 8-10 EMA u.a./lb of U_3O_8 of commercial uranium concentrate, experience tends to bear out the view that, under the conditions obtaining in the countries of Europe and owing to the nature of the deposits liable to be found there, the first stage of any prospecting operation, i.e., that aimed at assessing the potential of any given area, should not cost an average of more than 0.5 EMA u.a./lb of U_3O_8, while, after this initial phase, the cost of more precise survey work and the determination of the volume of the deposits should not exceed 1.5 EMA u.a./lb of U_3O_8.

The promoting and coordinating role generally played by the national bodies which carried out, in particular, the necessary preliminary studies, the dissemination of information on uranium metallogenesis and methods of prospecting, and also the centralization of all data concerning the work carried out, would thus be consolidated under such a scheme.

In a more general sphere, it was estimated that direct cooperation is eminently desirable at Community level. This should aim at the exchange of information concerning prospecting programmes, the techniques employed and the results obtained. In addition, collaboration between the six Community countries with a view to a more frequent exchange of technicians in the field of prospecting was advocated in particular.

Nonetheless, even if additional uranium sources are in fact discovered, as it would seem reasonable to hope, they will not be sufficient to meet the requirements of all the Community countries during the next few decades as estimated in the report on long-term uranium supply problems drawn up in 1963 by the Consultative Committee of the Euratom Supply Agency.

Working along these lines, the Commission and the Agency studied the possibility of obtaining uranium supplies from non-Member Countries in Europe and overseas, such as Spain, Portugal, Sweden and Argentina.

As a result of the work carried out in the Iberian Peninsula by national bodies in Spain and Portugal it would appear that, geologically speaking, these two countries are very similar to those of the Community with regard to the characteristics of their uranium-bearing formations. The work carried out by the Spanish and Portugese national organizations has shown that potential resources are available in the form of several tens of thousands of tons of U_3O_8, which could be worked at a cost of 5-10 EMA u.a./lb.

The Commission is watching the development of these resources with great interest.

The exchange of views which took place in Sweden in December 1965 led to more detailed studies of Swedish activities with regard to the exploitation of the low-content uranium deposits in the Billingen-Falbyden district in Väster Götland province (reserves estimated at a million tons of uranium at 300 g of uranium per ton). A processing plant with an annual capacity of 120 tons of uranium concentrate has been built at Ranstad. Because of the processing costs, which amount to 11.50-17.50 EMA u.a./lb of U_3O_8, including plant amortization, this reserve, about 350 thousand tons of which are regarded as recoverable, does not seem to offer any particular interest to the present or medium-term uranium market as the state of technology stands at the moment. Nonetheless, the low recovery rate (around 50 % of the ore) suggests that these costs could be improved on, and consequently lowered.

In April/May 1965, under the Euratom/Argentina Agreement for Cooperation, the Commission sent a group of three geologists from the Bundesanstalt für Bodenforschung, the French Atomic Energy Commission (CEA) and the Supply Agency on a visit to Argentina.

The purpose of the trip was to study geological and technical aspects of the uranium mining industry in Argentina and the potential of this country with regard to uranium deposits and also to assess the possibilities offered by Argentina with regard to the long-term supply of uranium to the European Community. At the same time the group was asked to examine the extent to which European industry might take part in the development and exploitation of this potential.

The experts pointed out that, as a result of a relatively modest effort, the prospecting work carried out by the Comisión Nacional de la Energia Atómica (CNEA) revealed the existence of fairly large uranium reserves amounting to about 10,000 tons of U_3O_8 which could be worked at a cost of less than 8 EMA u.a./lb of U_3O_8, as well as 15,000 tons of U_3O_8 which could be worked at a cost of between 8-12 EMA u.a./lb of U_3O_8.

The report states that only 20-25 % of a total area of 400,000 km^2 which the CNEA geologists consider of interest as a possible source of uranium has so far been surveyed, in many cases very perfunctorily. It stresses that if some promotion effort could be put behind the prospecting and exploitation of this potential, Argentina might well be in a position one day to export substantial quantities of concentrates or uranium-bearing material.

However, the exploitation of these reserves with a view to exports runs a risk of being hampered by certain factors of an economic and legal nature in particular.

Nonetheless, the representatives of the CNEA, showing that they were alive to future possibilities and to the present difficulties, demonstrated their attempts to find a solution compatible with the national interest as well as their awareness of the economic importance of exporting concentrates or uraniferous substances. Studies are now under way with a view to modifying the more restrictive provisions of the uranium law, with a view partly to promote foreign investment in Argentina's uranium mining industry.

The CNEA appears to be favourably inclined towards developing the Argentinian uranium potential on a cooperative basis and would doubtless be prepared to undertake negotiations to this effect, provided that the national uranium requirements are adequately covered and the country's interests safeguarded.

II. Activities of the Supply Agency in the Commercial Field

During 1965 the Supply Agency continued its commercial activities designed to help the users of nuclear fuel in the Community.

With regard to meeting the requirements of nuclear research, the policy of batching orders, many of which are for small quantities, was pursued to the satisfaction of the users, who have learned to appreciate the time thereby saved in negotiations.

Under the framework contract with the USAEC for the leasing of enriched uranium it was possible to meet all the enriched uranium requirements of those responsible for the research programme carried out in the Community.

Thus the Agency was able to lease fuel for the first core of the marine propulsion reactor to be used to drive the experimental ship "Otto Hahn" at Hamburg. This consists of 130 kg of U-235 with an average enrichment of 4 %.

During 1965 supplies were obtained on the same terms for the test reactors PEGASE at Cadarache (148 kg of U-235) BR2 at Mol (63 kg of U-235), OSIRIS at Saclay (10.5 kg of U-235) and other research reactors in the Community. New orders have already been placed for 1966 and they will be filled within the next few months.

Furthermore, under the framework contract for short-term leasing of enriched uranium drawn up with the USAEC at the end of 1964 under the Agreements for Cooperation linking Euratom and the American body in the fast reactor field, it was possible to import a total of 658 kg of U-235 with enrichments of from 20 % to 93 % during the eight months following the signing of the contract.

In addition to these deliveries, new firm orders were placed at the beginning of the present year, bringing to over 9,000,000 EMA u.a. the total value of special fissile materials received or due to be received in the near future under this second major contract, under which no quantitative ceiling is set.

Finally, with regard to plutonium supplies for the Community's fast reactor research programme, for which 90 kg of plutonium were already bought from the UKAEA in 1964 and 1965, the Agency signed a contract with the USAEC on behalf of three of its associates, the French Atomic Energy Commission (CEA), Gesellschaft für Kernforschung, Karlsruhe, and the Italian Atomic Energy Commission (CNEN) in June 1965 for the sale of a series of batches of plutonium in oxide and metal form and of different isotopic composition. The bulk of the deliveries stipulated under the contract, which total about 415 kg and represent a value of over 18 million EMA u.a., were effected during the period covered by this report.

All the plutonium requirements of the present fast reactor research programme are therefore met.

The Agency is also studying the trend of demand over the longer term and the means of ensuring that they are covered. At the beginning of 1965 it approached the bodies liable to satisfy the stated requirements of the Community users.

Other consignments of special fissile materials (uranium and plutonium) were delivered or ordered for research purposes in 1965 under sales contracts drawn up with the USAEC. They concern quantities which are in some cases substantial, although generally smaller than those referred to specifically above. The main deliveries under these contracts are for the high-temperature reactor of the Arbeitsgemeinschaft Versuchsreaktor GmbH (AVR) at Jülich (58.5 kg of U-235), the fast reactor programme of the Gesellschaft für Kernforschung (GfK) at Karlsruhe (15 kg of U-235 for irradiation tests) and the OSIRIS reactor of the CEA (24 kg of U-235).

Leaving aside the deliveries carried out in 1965 under contracts concluded in 1964 and also those received under the GKSS contract and the large plutonium sales contract, the total deliveries under sale or lease contracts signed by the Supply Agency during 1965 could be estimated at about 5,350,000 EMA u.a., representing about 370 kg of U-235 leased or sold and about 5 kg of plutonium sold.

Finally, it should be emphasized that on the expiry of the Belgian/US Agreement for Cooperation the special fissile materials supplied to Belgian enterprises under this Agreement were transferred to the Euratom/US Agreement for Cooperation in 1965. The total amount of materials affected, mainly for the BR2 and BRO2 reactors, is about 145 kg of U-235 leased or sold to the Community.

The requirements of nuclear power plant operators were met by special contracts of varying duration as required. Deliveries under the SENA contract (Société d'Energie nucléaire franco-belge des Ardennes) started in 1965 and are being continued in 1966. This has so far resulted in the importation of a large number of the fuel elements for the first core for the Chooz reactor, which, with an average enrichment of about 3 %, contain some 1,330 kg of U-235, representing a value of about 12 million EMA u.a. Furthermore, more than 123 kg of U-235, of a value of about 1,111,000 EMA u.a., had to be delivered during the first half of 1965 for fabrication in the Community of the reserve elements for this reactor.

With regard to the KRB plant (Kernkraftwerk RWE - Bayernwerk GmbH) a barter agreement has just been drawn up for supplying the Gundremmingen reactor up to 1 January 1969. This contract, which provides for the delivery of 2 tons of U-235 contained in uranium with an average enrichment of 2.5 %, representing a value of roughly 15 million EMA u.a., stipulates that all the power plant's fuel is in principle to be supplied by the USAEC and makes explicit mention of the possibility of concluding a toll enrichment contract after 1969. The first consignments of enriched materials delivered under the first contract have already been received and the others are due to follow at a faster rate.

It was only after lengthy negotiations, dealing simultaneously with the sale of enriched uranium on a deferred payment basis and a sale linked with a barter agreement, that the KRB finally adopted this latter solution, as a result of which it is able to obtain on the market natural uranium at more favourable conditions and in addition to take advantage of a supplementary loan granted by the Exim-bank and tied up, as is the main capital investment, with this reactor's participation in the Euratom/USAEC joint power reactor programme.

It should be added that the USAEC has also agreed in principle to conclude a barter agreement for the fuelling of the Lingen nuclear power plant, which is operated by the KWL company (Kernkraftwerk Lingen GmbH).

Finally, other negotiations are under way with regard to supplies for the Obrigheim and Dodewaard power plants, which are the property of the KWO (Kernkraftwerk Obrigheim GmbH) and GKN (N.V. Gemeenschappelijke Kernenergiecentrale Nederland) respectively.

DOCUMENT No. 26 HEALTH AND SAFETY LEGISLATION ENACTED AND DRAFT TEXTS SUBMITTED TO THE COMMISSION UNDER ARTICLE 33 OF THE EURATOM TREATY DURING 1965

Belgium

The following were communicated by Belgium to the Commission, under Article 33 of the Treaty :

- draft Royal decree modifying the Royal decree of 28 February 1963 relating to the general regulation of the protection of the population and workers against ionizing radiations (this draft referred mainly to the regulation of sealed radioactive sources) ;
- a draft circular relating to the implementation of the regulation concerning the medical supervision of workers (irradiation tables) ;
- a draft circular relating to the implementation of the Royal decree of 28 February 1963 (interpretation of the definition of the controlled area).

The following documents, upon which the Commission had already given an opinion, came into force in 1965 :

- the "Royal decree of 10 February 1965 modifying point II, chapter II, sections I and II of the General Regulation for industrial safeguards" ;
- various prescriptions of the "Royal decree of 16 April 1965 establishing industrial medical services, and reorganizing emergency and first-aid treatment in places of work and modifying points II and III of the General Regulation for the industrial safeguards".

Germany

Germany has communicated the following draft to the Commission :

- "Second Regulation modifying and supplementing the First Regulation on protection against ionizing radiations".

This regulation, which envisaged procedures designed to facilitate certain activities, especially the import and export trade, came into force in October 1965.

France

France communicated the following to the Commission under Article 33 of the Treaty :

— a draft decree relating to the general principles of protection against ionizing radiations ;
— a draft decree relating to the protection of workers against ionizing radiations ;
— a draft decree laying down the conditions and procedures of approval by bodies authorized to carry out certain inspections of ionizing-radiation sources ;
— a draft decree amending the regulation for the transport by rail, road and internal waterways of dangerous materials.

Italy

Italy has communicated the following to the Commission under Article 33 of the Treaty :

— a draft decree laying down the quantities of radioactivity subject to the application of the D.P.R. of 13 February 1964, No. 185 ;
— a draft decree concerning the procedure for the delivery of a favourable opinion on commercial undertakings of category B ;
— a draft decree to modify and supplement the law of 31 December 1962 on the peaceful uses of nuclear energy ;
— a draft decree concerning the classification of commercial undertakings.

DOCUMENT No. 27 BACKGROUND RADIOACTIVITY

In the Community countries numerous measurements are carried out relating to the radioactive contamination of the air and fall-out, water and foodstuffs. The results are transmitted to the Euratom Commission, which publishes quarterly and annual figures.

In the case of the air and fall-out the measurements carried out as part of the general programme of surveillance are for the most part confined to the total beta-activity, whereas in the case of foodstuffs it is mainly the concentration of strontium-90 and caesium-137 that is determined.

As regards radioactive fall-out, in most of the Community countries the principal vector for the radioactive contamination of humans is milk. The measurements of the radioactivity in other foodstuffs, which are published in annual reports, give a survey of the radioactive contamination of food and provide an estimate of the average annual strontium-90 uptake in man. The determination of strontium-90 calls for a lengthy chemical analysis, so that a considerable time elapses before the relevant data can be passed on. Consequently, the Community averages for 1965 are not yet to hand.

I. Radioactive contamination of the air and fall-out in 1965

The data are supplied by a network of about 120 stations. To give an accurate picture of the trend during 1965, graphs are attached which show, by way of example, the daily values for radioactive contamination of the air recorded by the stations at Brussels, Bari and Ispra (Euratom Joint Research Centre). Also given are the monthly average values observed at these stations since 1958.

It can be seen from the graphs that radioactive contamination of the air was highest in 1963. This contamination was due mainly to the various series of nuclear tests conducted in 1962.

The last few months of 1963 were marked by a considerable drop which led to very low average contamination levels in 1964 (0.5 - 2 pCi/m^3). The year 1965 showed a drop by a factor of approximately 5 with respect to 1964.

As in 1964, however, a relative increase is observed in the radioactive contamination of the air at the end of the spring. This is a normal phenomenon caused by seasonal fluctuations in the intensity of air exchanges between the troposphere and the stratosphere. The contamination levels for 1965 are comparable to those recorded before the resumption of nuclear tests in 1961.

As far as radioactive fall-out is concerned, the average decrease from year to year can be put at a factor of 3.5. In fact in 1964 the average value recorded was 229 mCi/km^2, whereas for the first nine months of 1965 it was 57 mCi/km^2.

From the health point of view the level of radioactive contamination in the air in 1965 does not present any danger.

II. Radioactive contamination of milk in 1964

The surveillance programmes on the contamination of milk in the Community countries were fully maintained during 1964 and in some cases even extended.

The average strontium-90 and caesium-137 concentrations recorded for the Community as a whole are plotted in the attached graphs in order to show the trend of radioactive contamination in milk during the years 1962, 1963 and 1964. For the sake of comparison the values observed in the United States and Canada are also given.

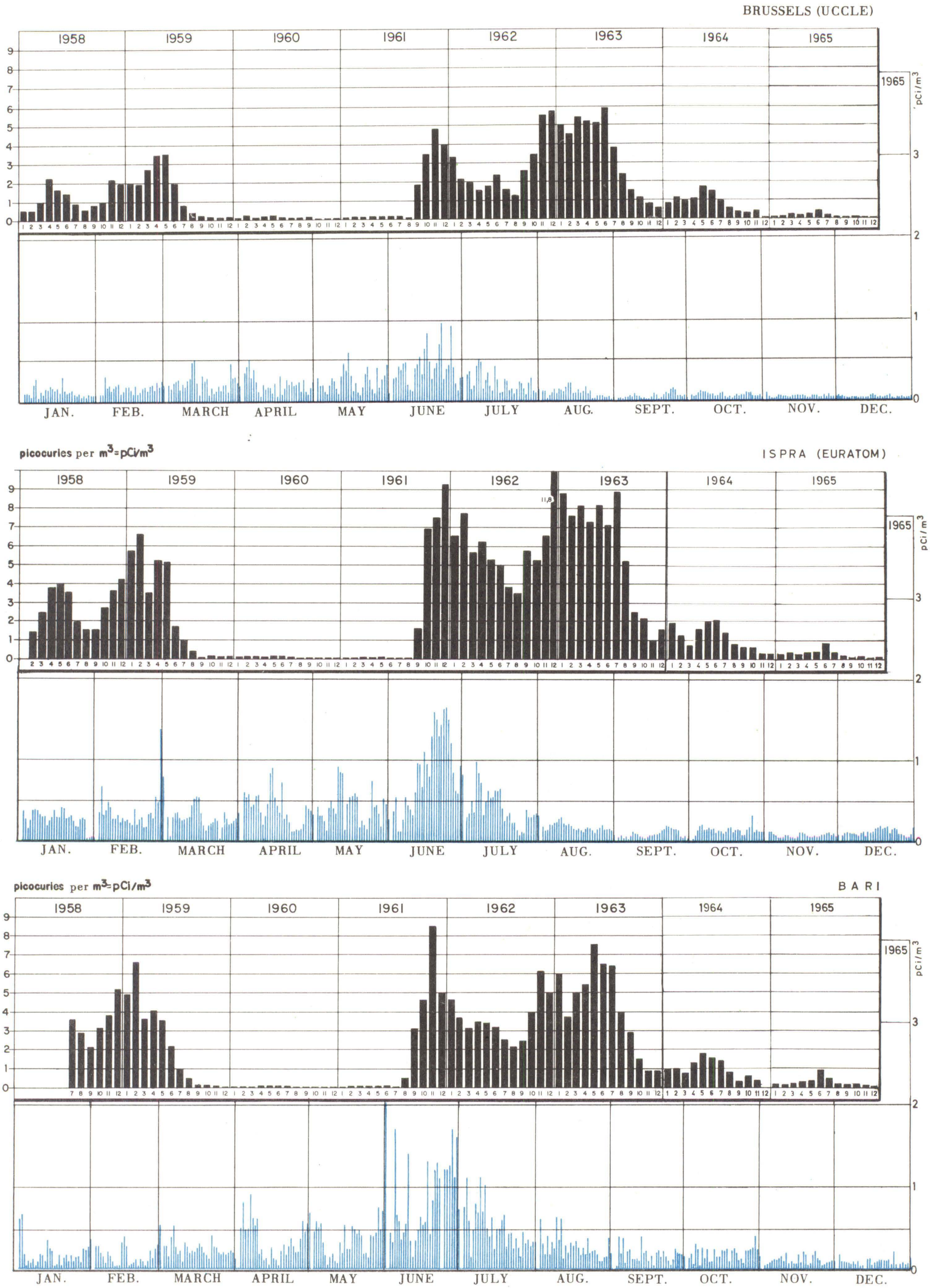
It will be seen that after mid-1963 the milk contamination level rose during the second half of the year to around 30 pCi per gram of calcium in the case of strontium-90 and to around 200 pCi per litre in that of caesium-137. This increase was due to the considerable radioactive fall-out that coincided with the growth period of the grass in 1963.

After the beginning of 1964 there was a decrease in milk contamination ; this was very slight at first but became more pronounced when the cows were fed mainly on fodder grown in 1964. By the end of 1964, in fact, the strontium-90 concentration was only two-thirds of that observed at the beginning of the year. The drop in the caesium-137 concentration during the same period was even greater.

The Community average for strontium-90 from January to December 1964 was 27.2 pCi per gram of calcium, i.e. slightly higher than the corresponding average in 1963 (23.4 pCi/g Ca). The highest average so far is 31.7 pCi/g Ca, which was attained over the twelve-month period from June 1963 to June 1964.

For caesium-137 the values were 156 pCi per litre in 1964, 167 pCi per litre in 1963 and 205 pCi per litre in the period June 1963 - June 1964.

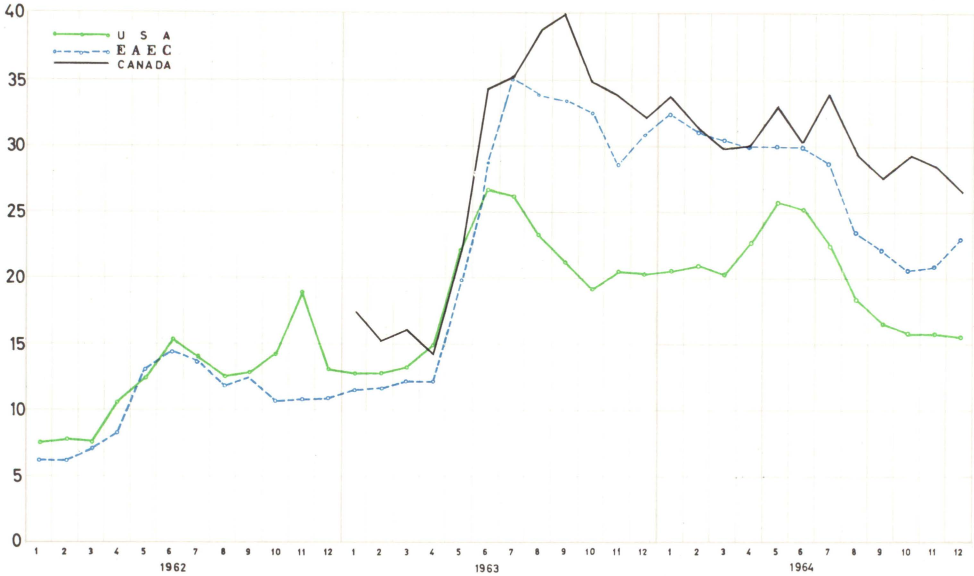
ARTIFICIAL BETA ACTIVITY IN AIR



Example of artificial atmospheric beta radioactivity measurement in 1965 and from 1958 to 1965 at Brussels, Ispra and Bari.

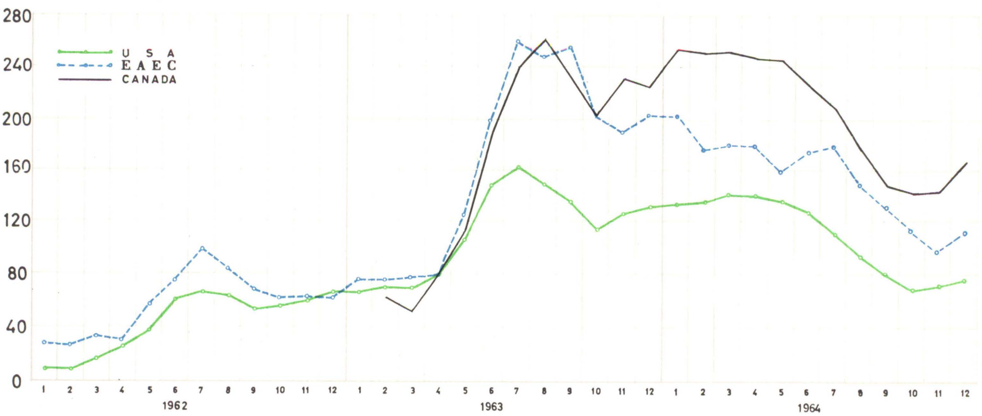
^{90}Sr IN MILK

pCi/gCa = picocurie per gram of calcium



^{137}Cs IN MILK

pCi/l = picocurie per litre



Radioactive contamination in milk by Sr^{90} and Cs^{137} in 1962,1963 and 1964 in the Community countries and in the USA and Canada.

DECONTAMINATION OF THE ISPRA-I REACTOR

(See other side of page for caption)

Health protection (and hence decontamination) is one of the fundamental factors in the safety of the technicians who have to work on and in nuclear reactors.

The average strontium-90 and caesium-137 concentrations observed in 1964 were equivalent to 10 % and 4 % respectively of the maximum permissible concentration for the population.

Comparison of the values recorded in the Community, the United States and Canada reveals that the trends are parallel although the actual concentrations differ. These discrepancies are due mainly to geographical location and to differences in the amount of precipitation.

DOCUMENT No. 28 NUCLEAR PLANT SAFETY

For several years past the Commission has been engaged in a programme of activities in the safety field which have resulted in the first place from clauses laid down in the basic contracts concluded with companies operating nuclear power plants accepted under the US/Euratom Cooperation Agreement, i.e. SENN in Italy, KRB in the German Federal Republic and SENA on the Franco-Belgian frontier.

The Commission also carried out other safety assessments on requests from governments or from private firms. This applies to the SEP project in the Netherlands and AKB in Germany, to the nuclear ship NS Savannah and the Eurochemic plant in Belgium.

In addition to the above investigations the Commission has begun to lay down practical procedures for carrying out safety studies on other projects or in prolongation of previous investigations. These new studies result from agreements made between the governments of certain Member States and Euratom, under which the Commission, assisted by national experts, will keep track regularly of the safety features of certain installations in collaboration with the competent technical departments of the Member State concerned. This applies to the joint enterprise Kernkraftwerk Lingen GmbH, and also to the nuclear ship Otto Hahn in Germany and the GKN enterprise at Dodewaard in the Netherlands.

Furthermore, in view of the terms governing the implementation of the Council's decision to accord joint enterprise facilities to the Kernkraftwerk Obrigheim, the Commission will be called upon to perform a similar function to that envisaged for the Lingen plant.

To avoid overlapping, all these technical investigations are carried out in close cooperation with the competent national authorities and technical bodies.

With a particular view to the harmonization and standardization of the techniques of safety assessment procedures for nuclear installations, the Commission has extensively furthered the pooling of available technical skill by meetings between experts of Member States, and where appropriate of experts from outside the Community.

1. *SENN*

During the period in question, the studies effected in consultation with the competent departments of the Italian Atomic Energy Commission (CNEN) and with the cooperation of German experts and technical advisers from the USAEC, have been devoted principally to assessing the effect which the development programme envisaged for the SENN plant will have on operational safety. A report has been made and forwarded to the US/EURATOM Joint Reactor Board.

2. *SENA*

Study of the progress made in the design and construction of the Givet-Chooz plant (SENA project) continued in close technical collaboration with the competent departments of the French Atomic Energy Commission (CEA).

Work has entered a critical phase, particularly in view of the Commission's obligation to decide as to the increase of the initially-proposed rated power of 210 MWe to 286 MWe before the scheduled commissioning of the plant in mid-1966.

The Commission has therefore availed itself of the technical advice of outside experts by concluding a study contract with the Italian CNEN, the Institut für Mess- und Regelungstechnik of the University of Munich and the Belgian CEN.

3. *KRB*

The studies begun in 1964 have also entered a decisive phase in view of the imminent start-up of the plant, which like that of SENA is scheduled for mid-1966.

The Commission has enlisted under a study contract the services of the safety experts of the Institut für Mess- und Regelungstechnik and the Italian CNEN.

4. *GKN (previously SEP)*

Following the preliminary opinion on the safety of the Dodewaard plant project provided by the Commission on the basis of the report drawn up by an ad hoc group of experts from Member States, the Dutch Government has granted a construction licence. It has expressed the wish that the Commission in collaboration with the same group of experts, should keep abreast in a regular manner of the safety aspects of the GKN plant during its construction, start-up and initial operation, as has been done for the SENN, KRB and SENA plants.

The practical forms of the cooperation with the competent Dutch authorities have been arranged.

5. *Nuclear vessel "Otto Hahn" and Joint Enterprise KWL*

On the Commission's proposal, the German Government has signified its agreement to the establishment of collaboration between the competent German technical departments in safety matters (Reaktorsicherheitsinstitut and the TUV (Technical inspection Authorities) of the Länder, Germanischer Lloyd) and the Euratom Commission assisted by experts of the Member States and, where appropriate, experts from outside the Community.

The German governmental departments have in particular shown their desire to see established, on a Community and wider international scale, the practical conditions for the operation of the German nuclear vessel in port waters.

For these projects also, practical arrangements for the implementation of the studies are being made.

6. *Marine propulsion - NS "Savannah"*

The study of the trial operation of the ship NS "SAVANNAH" was continued under contract in collaboration with the shipping classification offices in the Community, Germanischer Lloyd (Germany) and the Bureau Veritas (France).

The structural modifications introduced in certain parts of the nuclear installation following the first period of operation have been studied with a particular view to safety. The results of these studies will shortly be published in a 5th evaluation report at present in preparation.

7. *EUROCHEMIC*

Following a request from the Belgian Government, the Commission has given a favourable opinion from the safety angle on the question of the adaption of the Eurochemic installations to the reprocessing of fuels with a high U-235 enrichment.

This opinion was given on the basis of an evaluation report submitted by a committee of experts from the Community and the US.

The Commission has continued to participate in the work of the Eurochemic/Belgian Public Health liaison committee on the safety of the Mol reprocessing plant.

DOCUMENT No. 29 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 1-1-1963	Personnel employed on 31-12-1967
	in millions of EMA units of account								
I INRC - Ispra	6.6	80	64.8	10.9	—	4.3	—	1,270	1,700
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	—	—	—
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 reprocessing	—	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	1,910	3,150(1)

(1) Maximum number of personnel laid down in article 3 of the Council's decision adopting the second programme.

DOCUMENT No. 30 CONTRACTS AWARDED BY THE COMMISSION IN 1965 UNDER ITS RESEARCH PROGRAMME

RESEARCH AND SUPPLEMENTARY CONTRACTS (1)

Object	Number	Total sum payable by the Commission during the overall period of the contracts (in EMA u.a.) (2)
Contracts relating to Joint Research Centre establishments :		
a. ISPRA		
— Scientific Data Processing (CETIS)	1	51,000
— Direct conversion	7	172,000
— Other research	1	30,000
b. KARLSRUHE		
— Transplutonium elements	1	96,000
— Transuranium elements	1	1,418,000
c. PETTEN		10,000
ORGEL Project	8	566,000
Proven-type reactors	25	3,095,000
Technical and economic studies	5	283,000
Power reactors	1	50,000
Irradiated fuel reprocessing	4	1,449,000
Processing of radioactive wastes and residues	7	1,375,000
Radioisotopes		
— Research	10	176,000
— Industrial applications	10	121,000
Biology and Health and Safety	8	785,000
	89	9,677,000

Contracts : 11,000,000 EMA u.a.

(1) This list takes account only of those supplementary contracts which raise the financial ceiling of the previous contracts.

(2) Amounts quoted in round figures.

CONTRACTS OF ASSOCIATION AND SUPPLEMENTARY CONTRACTS

Object	Number	Total sum payable by the Commission during the overall period of the contracts (in EMA u.a.) [2]
Fast reactors	2	2,499,999
New reactor types	1	3,579,231
Fusion and plasma physics	5	21,372,980
Biology and Health and Safety	1	472,000
	9	27,924,210

LIST OF NEW CONTRACTS AWARDED IN 1965
(not including supplementary contracts)

I. *Contracts relating to JRC establishments*

a. ISPRA

— Scientific data processing (CETIS)

No. of contract	Contractor	Title
038-65-3 CETI	PRAXIS-Milan	Participation in a project for the integrated use of nuclear computer codes - improvement of the APA-CHE system

— Direct conversion

No. of contract	Contractor	Title
013-64-8 CODD	TECHNISCHE HOCH-SCHULE STUTTGART Prof. Kluge Stuttgart	Research programme on reduced extraction potential anodes
016-65-06 CODD	FELDMUHLE AG Plochingen	Research programme to develop a metal-ceramic bond having good mechanical characteristics for use at temperatures of over 1,000 °C in a thermionic converter

No. of contract	Contractor	Title
020-65-08 CODD	Prof. Dr. Ing. W. KLUGE	Research programme on reduced extraction potential anodes (Extension of contract number 013-CODD)
015-65-04 CODD	Interatom - Cologne	Theoretical calculations for the design of a zirconium-hydride-moderated low-power space reactor
018-65-10 CODD	BROWN-BOVERI - Mannheim	Research programme on the development of automatic measuring devices required for long-term testing of thermionic converters

— Other research

No. of contract	Contractor	Title
019-65-10 CODD	BROWN BOVERI - Mannheim	Research programme on barium vapour addition in thermionic converters
021-65-10 CODD	CEN - Brussels	Research programme on fabrication of canned fuel elements for thermionic conversion
149-64-1 ISPD	AEG - Frankfurt	Research programme on reactor shielding

b. KARLSRUHE

— Transplutonium elements

No. of contract	Contractor	Title
008-65-10 TPUN	REACTOR CENTRUM NEDERLAND - The Hague	Research programme on techniques for the separation of americium and curium from solutions with high neutral salt concentrations, the development of analysis techniques for transplutonium elements and study of their nuclear properties
002-64-09 TRUF	CEA - Paris	Research programme on plutonium recycling

c. PETTEN

No. of contract	Contractor	Title
041-64-12 PETN	NIJVERHEIDS-ORGANISATIE - TNO - The Hague	Studies connected with the equipment of the HFR reactor vessel inlet device to permit open tank operation

II. *ORGEL project*

No. of contract	Contractor	Title
173-64-3 ORGF	UGINE - Paris	Research programme on means of preventing the hydrogenation of large-diameter Zircaloy-2 tubes in contact with terphenyl
203-65-03 ORGC	BAYER - PROGIL	Research programme on: a) standardization of methods for the analysis of polyphenyls and some of their mineral or organic impurities; b) development of special analysis techniques to improve the interpretation of polyphenyl research data
231-65-04 ORGC	BATTELLE - Frankfurt SERAI - Brussels TNO - The Hague	Research programme for the synthesis of three distinct families of aromatic hydrocarbons
232-65-9 ORGN	TNO - The Hague	Research programme for the development of ceramic layers for thermal insulation
243-65-08 ORGI	SNAM - Milan	Research programme on a high-temperature-resistant metallurgical bonding for joining stainless steel and SAP tubes
244-65-08 ORGI	CISE - Milan	Research programme on Zircaloy-2 or zirconium-niobium

No. of contract	Contractor	Title
245-65-04 ORGF	UGINE - Paris	Research programme on means of preventing the hydrogenation of large-diameter Zircaloy-2 tubes in contact with terphenyl
246-66-01 ORGD	NUKEM - Wolfgang-Hanau	Improvement of the technology for the production of cast uranium carbide rods

III. *Fast reactors*

No. of contract	Contractor	Title
013-65-01 RAAN	TNO - The Hague	Carrying out of a fast reactor programme
014-65-01 RAAB	BELGIAN GOVERNMENT	Study project jointly financed by the Euratom Commission and the Belgian government, to be carried out by Belgo Nucléaire and the CEN, on : — sodium-cooled fast power reactors — steam-cooled reactors — development of mixed UO_2-PuO_2 fuels for fast reactors — adaptation of the volatilization-fluorination process to fast reactor fuels
015-65-01 RAPB	BELGIAN GOVERNMENT-BELGONUCLEAIRE	Stipulation of terms and conditions for the execution by the contractor of the studies described below, financed jointly by the Euratom Commission and the Belgian Government : — sodium-cooled fast power reactors — steam-cooled reactors — development of mixed UO_2-PuO_2 fuels for fast reactors

No. of contract	Contractor	Title
016-65-01 RAPB	BELGIAN GOVERNMENT-CEN	Stipulation of terms and conditions for the execution by the contractor of studies on the adaptation of the volatilization-fluorination process to fast reactor fuels to be financed jointly by the Euratom Commission and the Belgian Government

IV. *Proven-type reactors*

No. of contract	Contractor	Title
021-64- TEEB	MMN - Brussels	Research programme on the development of fabrication and inspection techniques for high-quality stainless steel tubes for use as clads in pressurized-water reactors
027-64 TEEF	FRAMATONE/CERCA - Paris	Research programme on the development of fabrication and inspection techniques for high-quality stainless steel tubes for use as clads in pressurized-water reactors
030-64-1 TEEN	T.H. EINDHOVEN	Study of hydraulic stability in boiling water reactors
036-64-01 TEEF (RD)	CEA - Paris	Irradiation of UCI samples
037-64 TEED	FRIED KRUPP	Experimental programme for the development of large steel reactor vessels
040-64 TEED	REISHOLZ	Inner lining with austenitic steel of target pressure vessels for pressurized-water reactors
041-64 TEED	REISHOLZ	Development of large-diameter seamless thick-walled tubes with pressure-fitted austenitic steel lining for pressurized-water reactors
042-64 TEED	MAN	Technological development of pressure vessel manufacture

No. of contract	Contractor	Title
043-65-11 TEEI (RD)	FIAT - Turin SORIN - Saluggia	Study of fission gas release mechanism in uranium oxide
044-65-2 TEGF	SUD-AVIATION Paris	Research programme on the experimental and theoretical investigation of possibilities for the use of stainless steel NIOA structures for thermal insulation and even hermetic sealing of prestressed concrete reactor vessels
048-64-4 TEGD	FRIED KRUPP Essen	Development of prestressed concrete vessels for gas-graphite reactors
049-65 TEED	OERLIKON Eizenberg	Study of the fracture-resistance capacity of high-yield-strength steel heavy-gauge welded joints in the light of new theories and on the basis of deformation rate
053-64-12 TEEF	CEA - Paris	Study of light-water reactor parameters
054-64-4 TEEB (RD)	CEN - Brussels	Study of the part played by crystal defects in metals in the oxidation mechanism and internal precipitations of gas-metal compounds
055-65-3 TEEB	CEN - Brussels	Research on the influence of neutron and gamma irradiation on the corrosion of materials of nuclear interest
057-64-7 TEES	BATTELLE-INST. — Geneva	Study of the creep mechanism in ferrous materials
059-65 TEEF	Centre National de la Recherche Scientifique (CNRS - Paris)	Study of the properties of high-purity stainless steels
060-65 TEEN	TNO	Development of a new technique for determining the embrittlement temperature of steels
062-65-08 TEGD	KFA - Jülich	Study of gas-cooled tubular fuel elements with internal and external finning

No. of contract	Contractor	Title
066-65-1 TEES	BATTELLE-INST. Geneva	Preparation of irradiations of a number of steel alloys carried out by the Oak Ridge National Laboratory, Naval Research Laboratory, as well as the preparation, in conjunction with the JRC establishment at Petten, of the possible irradiation of steel samples from the Battelle Institute, Geneva, in the HFR reactor
067-65-06 TEED	AEG - Berlin	Development of advanced-type fuel assemblies for boiling water reactors
070-65-7 TEEC (RD)	AEG - Berlin SNECMA - Paris	Development of a BWR with VORTEX fuel
069-65-07 TEEN (RD)	TECHNISCHE RIJKSHOGESCHOOL - Eindhoven	Continuation of research on heat transfer and flow conditions in vertical channels
079-64-10 TEEB (RD)	BRUSSELS UNIVERSITY	Study of certain metal oxidation problems and application of impedance measurement methods to the investigation of corrosion resistance in aqueous medium
083-66-01 TEED (RD)	AEG - Berlin	Development of a steam-water separator

V. *Technical and economic studies*

No. of contract	Contractor	Title
024-65-06 ECIC	BELGONUCLEAIRE - CEA - NUKEM - PHILIPS-DUPHAR - TRANSNUCLEAIRE	Studies on packaging and transport conditions for radioactive materials
025-65-7 ECID	Deutsche Versicherungs-Schutzverband Frankfurt	Study on insurance of nuclear damage to fixed nuclear plants

No. of contract	Contractor	Title
026-66-02 ECIF	EUREQUIP - Neuilly	Study of selection criteria and training procedures for operating personnel of nuclear plants in the Community
028-65-02 ECIF	METRA INTERNATIONAL Paris	Study of the incidence of direct and indirect taxation systems in force in the Member States on the capital costs of nuclear and conventional power plants as well as on the generation cost and sale of current. Assessment of the advantages stemming from tax exemptions linked with the granting of joint enterprise status under the Euratom Treaty
033-66-01 ECID	KIENBAUM - Gummersbach/ Rheinland	Investigation of the effects of nuclear techniques on conventional industry

VI. *Power reactors*

No. of contract	Contractor	Title
008-65-10 REPC	Prof. Ing. L. MERZ CNEN	The safety aspects of the GUNDREMMINGEN nuclear power plant

VII. *Irradiated fuel reprocessing*

No. of contract	Contractor	Title
002-65-05 RCII	CNEN - Rome	Verification of decontamination factors in amine extraction process (TCA)
003-65-6 RCIS	BATTELLE - Geneva	Development of a ceramic crucible material for uranium melting

No. of contract	Contractor	Title
005-65-04 RCII	SNAM - Milan	Research on uranium carbide formation in low-melting amalgams and alloys and densification by melting
006-65-07 RCIB	CEN - Brussels	Assembly of data required for the establishment of the specifications of a pilot industrial reprocessing plant using the hexafluoride volatilization method

VIII. *Processing of radioactive wastes and residues*

No. of contract	Contractor	Title
004-65-3 WASI	CNEN - Rome	Construction of an experimental station in Italy for the final storage of solid radioactive wastes at ground level
005-65-5 WASI	CNEN - Rome	Study of the possibilities for the use of cheap and abundant detrital material for the processing of liquid wastes of varying degrees of activity
006-64-12 WASD	GESELLSCHAFT FÜR STRAHLEN-FORSCHUNG	Research aimed at the construction of an experimental station in the German Federal Republic for the final storage of solid radioactive wastes in a salt dome
007-65-3 WASF	COTREL - Paris	Study and determination of sites particularly suitable for radioactive waste storage
008-65-5 WASF	BUREAU DE RECHERCHES GEOLOGIQUES ET MINIERES Paris	Investigation of the properties of various radioactive tracers for ground-water flow studies
010-65-01 WASB	CEN - Brussels	Research on storage of radioactive wastes and the migration of radioelements in the soil
011-65-08 WASB	CEN - Brussels	Research on the fixation of fission products by absorption on mineral exchangers

IX. *New reactor types*

No. of contract	Contractor	Title
007-65-01 NTRI	CISE - Milan	Execution in the CISE laboratories of research aimed at the development of a fog-cooled reactor
008-65-01 NTAL	CNEN - Rome	Research on the development of fog-cooled reactors

X. *Radioisotopes*

a. Research

No. of contract	Contractor	Title
059-64-12 RISF	Science Faculty, Paris University, Mlle CAUCHOIS	Experimental study of photo-activation by means of x-rays emitted during the bombardment of a solid target by accelerated electrons
065-64- RISD	TECHNISCHE HOCHSCHULE - Munich	Preparation of optically active amino-acids and peptides with specific tritium labelling as well as of deuterium-labelled amino-acids
070-64-6 RISD	TECHNISCHE HOCHSCHULE - Munich	Formation mechanism of labelled molecules during uranium fission
072-64-4 RISD	UNIV. BERLIN - Berlin	Preparation of organic compounds tritiated by enzymatic reactions
074-64-9 RISI	PAVIA UNIVERSITY	Study and production of C14-labelled actinomycin
076-64 RISF	CENTRE DE RECH. NUCLÉAIRES - Strasbourg	Preparation of organic compounds labelled by radio-chemical methods and storage studies
080-64-11 RISF	INST. GUSTAVE ROUSSY Villejuif	Study of the preparation, storage and use of H3- and P32-labelled deoxyribonucleic acids
081-64-11 RISF	UNIV. OF STRASBOURG Strasbourg	Research on the storage and use of P32-, C14- and H3-labelled ribonucleic acids

No. of contract	Contractor	Title
083-64-11 RISI	MILAN UNIVERSITY Milan	Synthesis of C14-labelled glucoses by intermediate enyzmatic metabolism
085-64-11 RISB	CEN - Brussels	Study of the preparation of labelled molecules by gamma-irradiation

b. Industrial applications

No. of contract	Contractor	Title
026-65-07 IRAI	SORIN - Saluggia	Research aimed at the development of a series of dosimetric films as direct visual monitors of the dose received in the 0.5 - 5 Mrad range during the irradiation of industrial products
034-65-4 IRAI	SORIN - Saluggia	Research on the development of a radioactive method for automation of phosphate and sulphate analysis in aqueous solutions
038-65- IRAI	FIAT - Turin	Research on the development and construction of a device for the continuous and discontinuous measurement of liquid-induced cavitation in solids
089-64-12 IRAF	SEDAD - Paris	Research programme consisting, in the first stage, of a study of the conditions governing the adaptation of neutron irradiations to the continuous measurement of the C/H ratio and hydrocarbon density, in conjunction with a gamma monitor, as well as the development of an experimental rig designed for such measurements, and, possibly in a second stage, of the elaboration of an apparatus for operation in industrial conditions

No. of contract	Contractor	Title
090-65-10 IRAF	Centre d'Etude et de Recherches Océanographiques C.R.E.O. - Paris	Drafting of a critical summary of the research already carried out on the isolation of radioactive and activable tracers in sedimentology
092-65-10 IRAI	SORIN - Saluggia	Study of a system for fixing methyl bromide occuring in the gas used to pin-point leaks in gas mains by means of radioactive tracers
094-65-10 IRAI	SORIN - Saluggia	Construction and finalization of a prototype rig for the continuous analysis of gas mixture by the absorption of soft X-rays by emitted radioactive sources
095-65-10 IRAI	SORIN - Saluggia	Study of the use of radioisotopes to detect obstruction in hot-water pipes
097-65-06 IRAB	Faculté des sciences agronomiques de l'Etat Gent	Improvement of the neutron probe technique for measurement of the moisture content of materials and soil ; development and construction of a prototype apparatus

Expert's contracts

No. of contract	Contractor	Title
080 IRAB	PAUWELS Brussels	Application in textile industry

IX. *Fusion and plasma physics*

No. of contract	Contractor	Title
010-65-1 FUAD	INST. FUR PLASMA-PHYSIK Munich - Garching	Research on controlled nuclear fusion

No. of contract	Contractor	Title
011-65-1 FUAD	KFA - Jülich	As above
012-65-1 FUAD	CEA	As above
013-65-1 FUAI	CNEN - Rome	As above
014-65-1 FUAN	FOM - Utrecht	As above

XII. *Biology and Health and Safety*

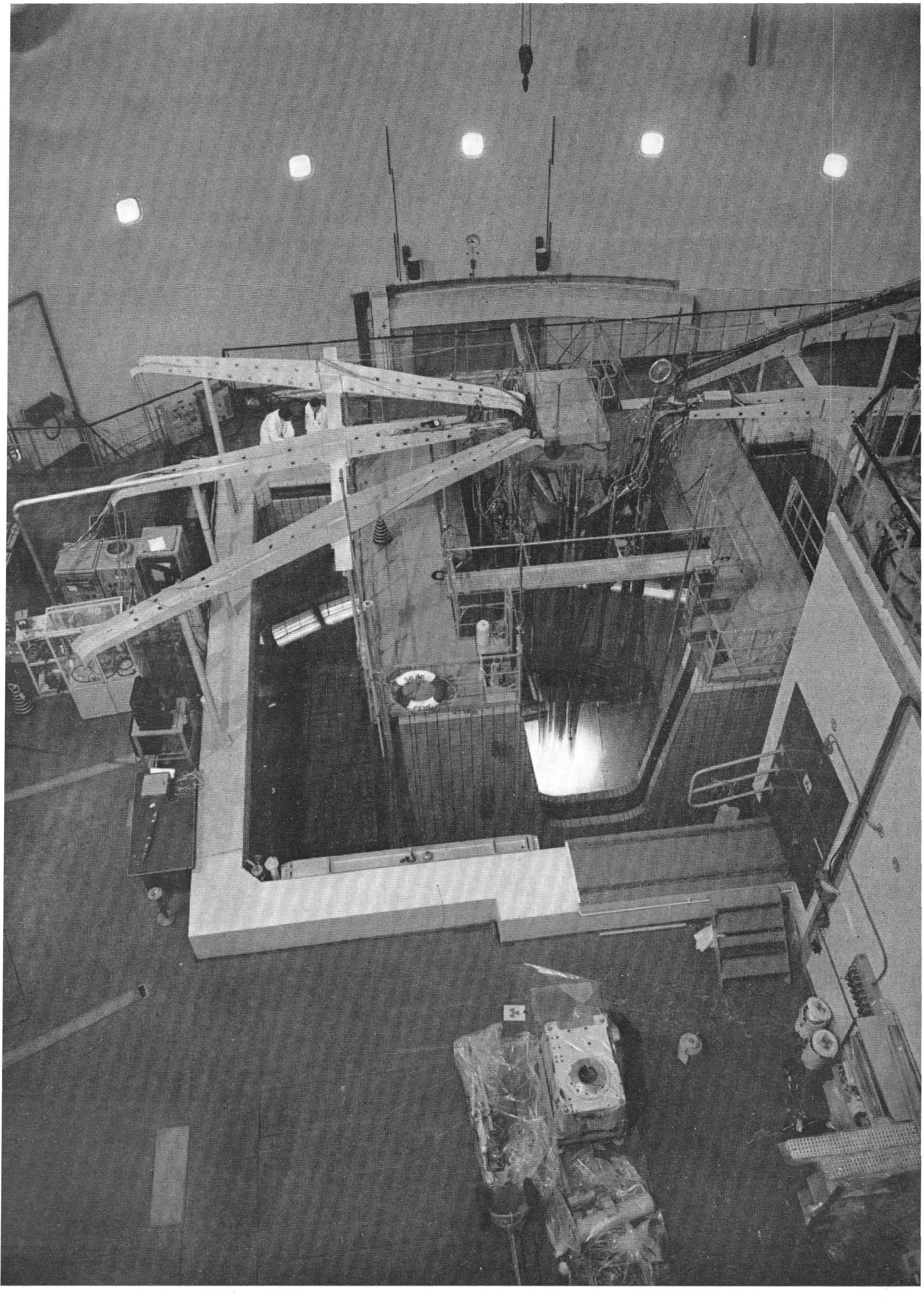
a. Biology

No. of contract	Contractor	Title
033-64-10 BIOI	UNIV. OF TURIN Turin	Research in man on the improvement of donor-donee combinations in tissue grafts
040-65 BIOI	MARIO NEGRI PHARMACOLOGICAL RESEARCH INSTITUTE	Research into chemical therapy of leukemia
043-65 BIOI	NAPLES UNIVERSITY Topographical Anatomy Inst.	Study of the effect of ionizing radiations on embryo development in mammals
041-65-10 BIOD	HEILIGENBERG INST. Heiligenberg	Experimental biology
045-65-01 BIAD	GESELLSCHAFT FUR STRAHLEN-FORSCHUNG mbH Munich	Study of the frequency and photogenesis of long-term genetic and somatic radiation effects in animals
048-65 BIOI	SORIN-PISA UNIVERSITY TURIN UNIVERSITY	Study of the chemical, physico-chemical and biological characteristics of certain radioiodine-labelled proteins

No. of contract	Contractor	Title
051-65-1 BION	GRONINGEN UNIVERSITY Groningen	Research on the detection of and chemical protection against early biological reactions after various types of irradiation
058-65-07 BIOF	INSTITUT PASTEUR Paris	Research on the use of nuclear techniques to study mechanisms involved in the transcription and reading of genetic materials

b. Health and Safety

No. of contract	Contractor	Title
023-66-01 PSTD	GESELLSCHAFT FUR STRAHLEN-FORSCHUNG Munich	Analytical study of radiation fields in proximity to ionizing radiation sources and nuclear reactors



GRENOBLE (France) — SILOE REACTOR

(See other side of page for caption)

This 15 MW high-flux swimming-pool reactor is an important aid in the irradiation of fuels and materials. Under the ORGEL programme, Euratom has used this facility for the irradiation of terphenyls in a loop built specially for this purpose.

DOCUMENT No. 31 ACTIVITIES OF THE INFORMATION AND DOCUMENTATION CENTRE (CID)

The Information and Documentation Centre (CID) was set up in order to enable the Commission to meet its obligations in two major fields concerning the dissemination of information. These are, firstly, scientific and technical documentation, by means of which the knowledge already acquired in the fields in which they are working can be made available to scientists rapidly and in as much detail as possible, and, secondly, scientific and technical information, which involves collecting and disseminating the results of the Community's research programme. In 1965 the CID continued its activities in both these sectors.

The CID's working programme is regularly discussed and fixed by the Consultative Committee on Information and Documentation (CCID), consisting of experts from the Six Member Countries. Permanent exchanges of views on the subject also take place with the working group made up of heads of documentation services of the national nuclear research centres.

At the same time, the CID continues to take part in the work of the International Documentation Federation (FID), the European Translation Centre, International Cooperation in Information Retrieval among Examining Patent Offices, etc.

In December 1965 the Commission signed a contract with the Kernforschungsanlage at Jülich for the joint creation of EASTATOM, a centre for the selection, the acquisition and, if required, the translation of Eastern nuclear literature not yet translated into a Western language. Details of the most important documents handled by EASTATOM will be given in the "Transatom-Bulletin" from 1966 onwards.

I. Scientific and technical documentation

1. *Conventional documentary research*

Pending the launching of its semi-automatic documentation system, the CID continues to meet the needs of the Joint Research Centre, the Patent Office and the Commission's contractors and associates by conventional methods. In 1965 a total of 222 bibliographical research operations were carried out, to which should be added 62 "periodical" retrievals in the course of which the available documentation in certain fields was regularly kept up-to-date. The particular value of two of these research operations, relating to labelled molecules and transplutonium elements respectively, was sufficient to warrant their publication.

2. *Semi-automatic documentation*

It is a well-known fact that the number of information units (reports, articles, books, patents, etc.) of interest to nuclear science and technology runs to several hundred thousand, new units being added each year at an ever-increasing rate. It will also be recalled that the Commission, realizing that owing to its very abundance thorough utilization of this material was impossible by conventional documentary research methods, decided to devise a system of semi-automatic documentation based on the use of an electronic computer. The Commission's aim was to be able to meet not only its own documentary requirements but also those of persons, industrial enterprises and national centres in the Community Member Countries.

Work was continued on the development of this system during 1965 and preliminary operating tests carried out.

All the information units dating back to before 1965 which the CID was able to collect have now been analyzed, coded and stored in the computer's memory. Units relating to 1965 were processed and stored as they were collected by the CID.

A considerable percentage of this information was taken from the USAEC reference periodical "Nuclear Science Abstracts".

This information is coded directly by USAEC specialists on the staff of "Nuclear Science Abstracts", in line with the system devised by the CID. Other information units are connected to Euratom under two contracts drawn up with the "Excerpta Medica Foundation" of Amsterdam (nuclear medicine) and the Société Brevatone of Paris (patents of nuclear interest).

The CID has also started sifting 40 reference periodicals other than "Nuclear Science Abstracts" in order to extract information of nuclear interest from them. On completion of an automatic sorting operation aimed at preventing duplication, it was found that the number of relevant information units referred to in these sources and not covered by "Nuclear Science Abstracts" was much higher than had at first been thought. The work involved in setting up a complete nuclear scientific memory will thus be considerably greater than originally anticipated.

It will also be recalled that the CID computer installation is being used, with the aid of a CETIS programme, to set up a five-language Euratom glossary embodying the provisional results of the work carried out by the Terminology Bureau of the Linguistic Service with a view to setting up a standard nuclear terminology as laid down in Article 8 of the Treaty.

In previous years the CID's main effort was devoted to the analysis and storage of information. In 1965 the stress was placed more and more on preparations for the productive stage, involving logging in documentation requests, translating them into the "language" of the computer and "interrogating" this latter, and then forwarding the "replies" to the customer. A test programme was therefore carried out the aim of which was to devise more suitable methods for obtaining relevant and complete results.

During 1966 the semi-automatic documentation system is to be put into operation in three stages. It will first be used by the Joint Research Centre, after which it will gradually be made available to holders of Euratom Contracts and finally to any interested persons in the Community.

3. *Bibliographical sources*

The exploitation of nuclear energy does not depend solely on techniques bearing a nuclear stamp. For this reason the CID collects precise information concerning the documentation centres, libraries and periodicals specializing in the various fields on which nuclear technology must be able to call for the solution of certain problems. By the end of 1965 the CID had set up contacts with 268 Community centres specializing in these marginal fields.

4. *Libraries*

The CID supervises the activities of the five libraries run by the Euratom Commission at Brussels and the different Joint Research Centre establishments : Ispra, Geel, Petten and Karlsruhe. The Brussels library centralizes the acquisitions made by all these libraries, with the exception of that at Ispra. Necessary steps have also been taken in order to enable the Karlsruhe library to become independent. In 1965 the checking of subscriptions to periodicals and of the libraries' expenditure and budgetary commitments was carried out by automation by way of an experiment.

II. Scientific and technical information

The dissemination of knowhow obtained during the completion of the Community's research programme was continued along the lines laid down by the Commission before the Council on 1 April 1963. It will be recalled in particular that the Commission drew up different procedures for the dissemination of two main categories of documents called "publications" and "communications" respectively. Whereas the former are widely disseminated, distribution of the latter is limited, since the data contained in them are of immediate industrial value and top priority is thus given to persons and enterprises in the Community whose legitimate interest in them can be duly substantiated.

1. *Non-periodical publications, reports, "communications" (article 13 of the Treaty) and conference proceedings*

The Commission made public a total of 673 scientific and technical reports during 1965. In the same period it forwarded 332 "communications" to persons, enterprises and Community Member States via national correspondents appointed in each of the Member Countries.

Furthermore the CID published the proceedings of two conferences during 1965, namely, the Conference on the Preparation and Biomedical Applications of Labelled Molecules held in Venice and the Conference on the Radioactive Contamination of Workers, which took place in Munich. Work was commenced on the publication of the proceedings of two other conferences during the course of the year.

2. *Periodicals*

The three periodicals, Euratom Information, Transatom Bulletin and Euratom Bulletin, appeared regularly in 1965. As well as listing the patents filed, information contains abstracts, bibliographical data and accounts of Euratom's scientific and technical publications dealing with research carried out under its own programme as well as under the research and association contracts concluded with outside bodies.

An index published for the entire year 1965 is designed to provide access to information in a variety of ways by different subject-headings. Owing to the increase in the number of reference documents, it was found necessary to go over to monthly publication of Euratom Information in 1965.

In 1965, Transatom Bulletin, which also appears monthly, listed 11,379 translations, completed or in hand, of scientific or technical documents on nuclear questions in the lesser known languages. In addition to the usual bibliographical references Transatom Bulletin gives detailed information on how to obtain these translations.

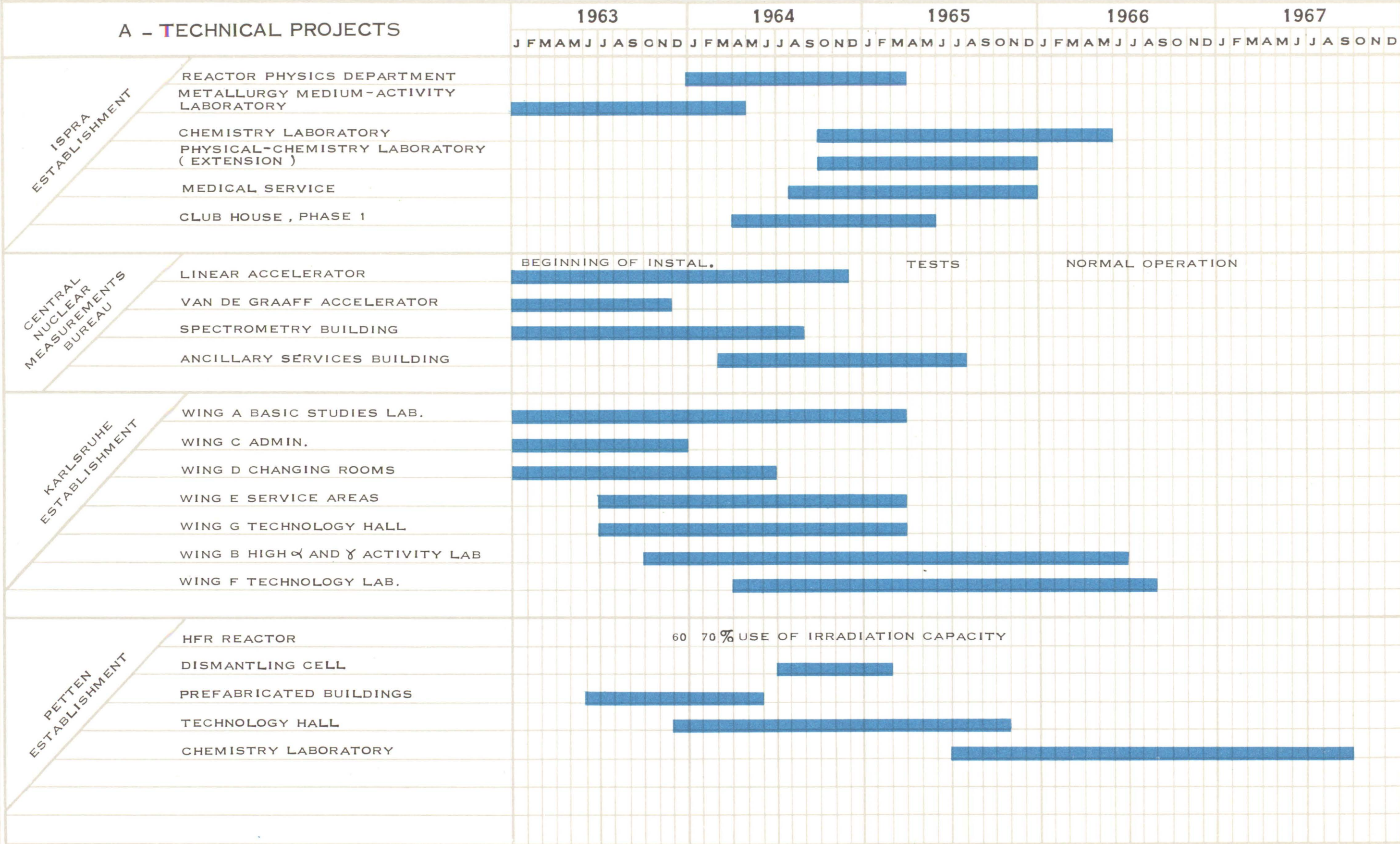
The Euratom Bulletin is a quarterly review published in separate Dutch, French, German, Italian and English editions. It deals with matters connected with the peaceful uses of nuclear energy and the Commission's activities in a form aimed at a very wide public. Numerous items of information published by this review have been quoted by the press and several articles reproduced in their entirety, so that the Euratom Bulletin may claim to have become a highly effective information vehicle.

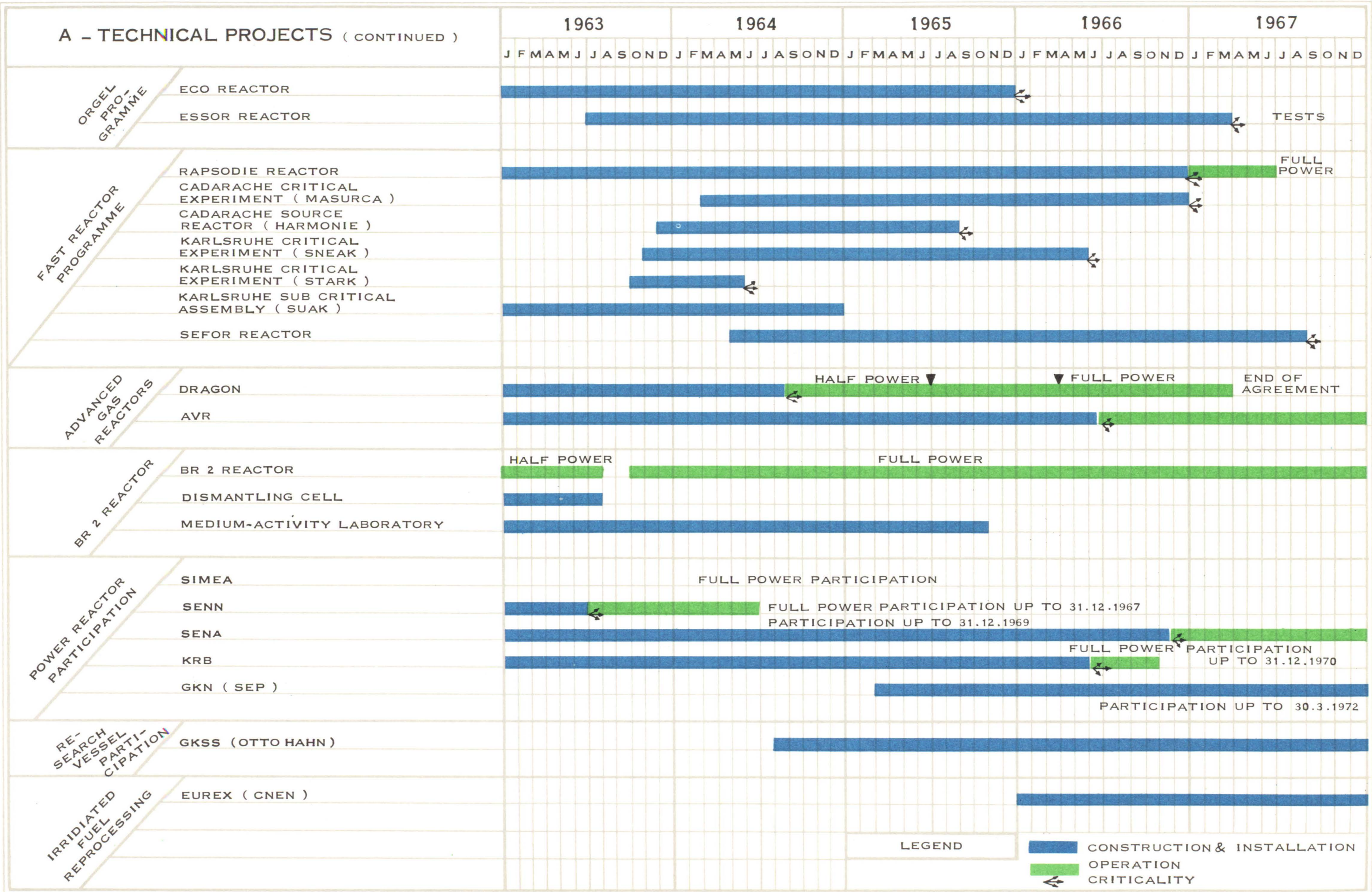
DOCUMENT No. 32

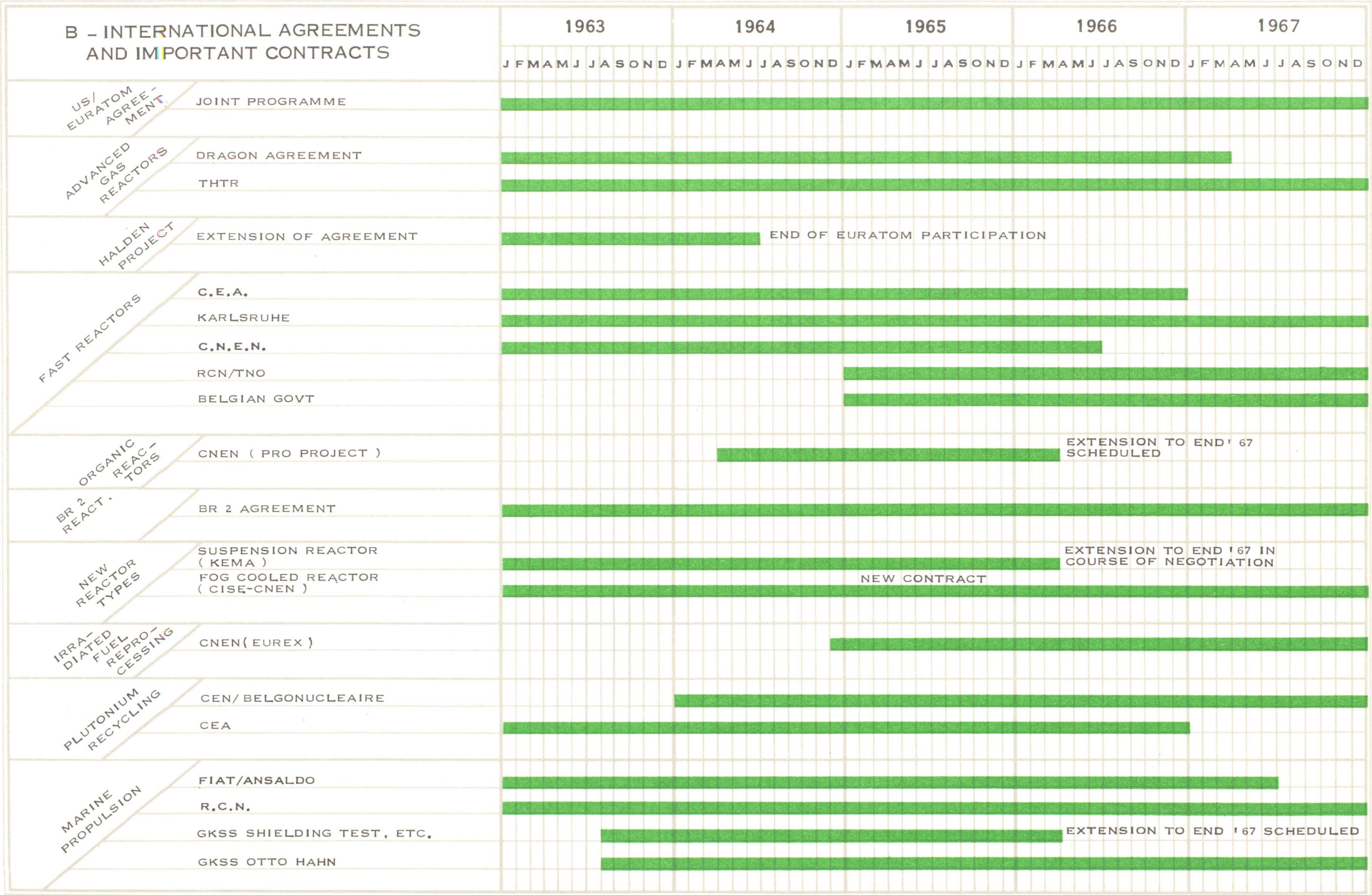
SCHEDULE FOR EXECUTION OF LARGE-SCALE PROJECTS PROVIDED FOR UNDER THE SECOND FIVE-YEAR PLAN

SCHEDULE FOR EXECUTION OF LARGE-SCALE PROJECTS PROVIDED FOR UNDER THE SECOND FIVE-YEAR PLAN

STATUS AS ON 1 APRIL 1966




A – TECHNICAL PROJECTS (CONTINUED)
1963
1964
1965
1966
1967
J F M A M J J A S O N D
ORGEL PROGRAMME
ECO REACTOR
ESSOR REACTOR
TESTS
FAST REACTOR PROGRAMME
RAPSODIE REACTOR
FULL POWER
CADARACHE CRITICAL EXPERIMENT (MASURCA)
CADARACHE SOURCE REACTOR (HARMONIE)
KARLSRUHE CRITICAL EXPERIMENT (SNEAK)
KARLSRUHE CRITICAL EXPERIMENT (STARK)
KARLSRUHE SUB CRITICAL ASSEMBLY (SUAK)
SEFOR REACTOR
ADVANCED GAS REACTORS
DRAGON
HALF POWER
FULL POWER
END OF AGREEMENT
AVR
BR 2 REACTOR
BR 2 REACTOR
HALF POWER
FULL POWER
DISMANTLING CELL
MEDIUM-ACTIVITY LABORATORY
POWER REACTOR PARTICIPATION
SIMEA
FULL POWER PARTICIPATION
SENN
FULL POWER PARTICIPATION UP TO 31.12.1967
SENA
PARTICIPATION UP TO 31.12.1969
KRB
FULL POWER
PARTICIPATION UP TO 31.12.1970
GKN (SEP)
PARTICIPATION UP TO 30.3.1972
RESEARCH VESSEL PARTICIPATION
GKSS (OTTO HAHN)
IRRIDIATED FUEL REPROCESSING
EUREX (CNEN)
LEGEND
CONSTRUCTION & INSTALLATION
OPERATION
CRITICALITY


B – INTERNATIONAL AGREEMENTS AND IMPORTANT CONTRACTS
1963
1964
1965
1966
1967
J F M A M J J A S O N D
US/EURATOM AGREEMENT
JOINT PROGRAMME
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DRAGON AGREEMENT
THTR
HALDEN PROJECT
EXTENSION OF AGREEMENT
END OF EURATOM PARTICIPATION
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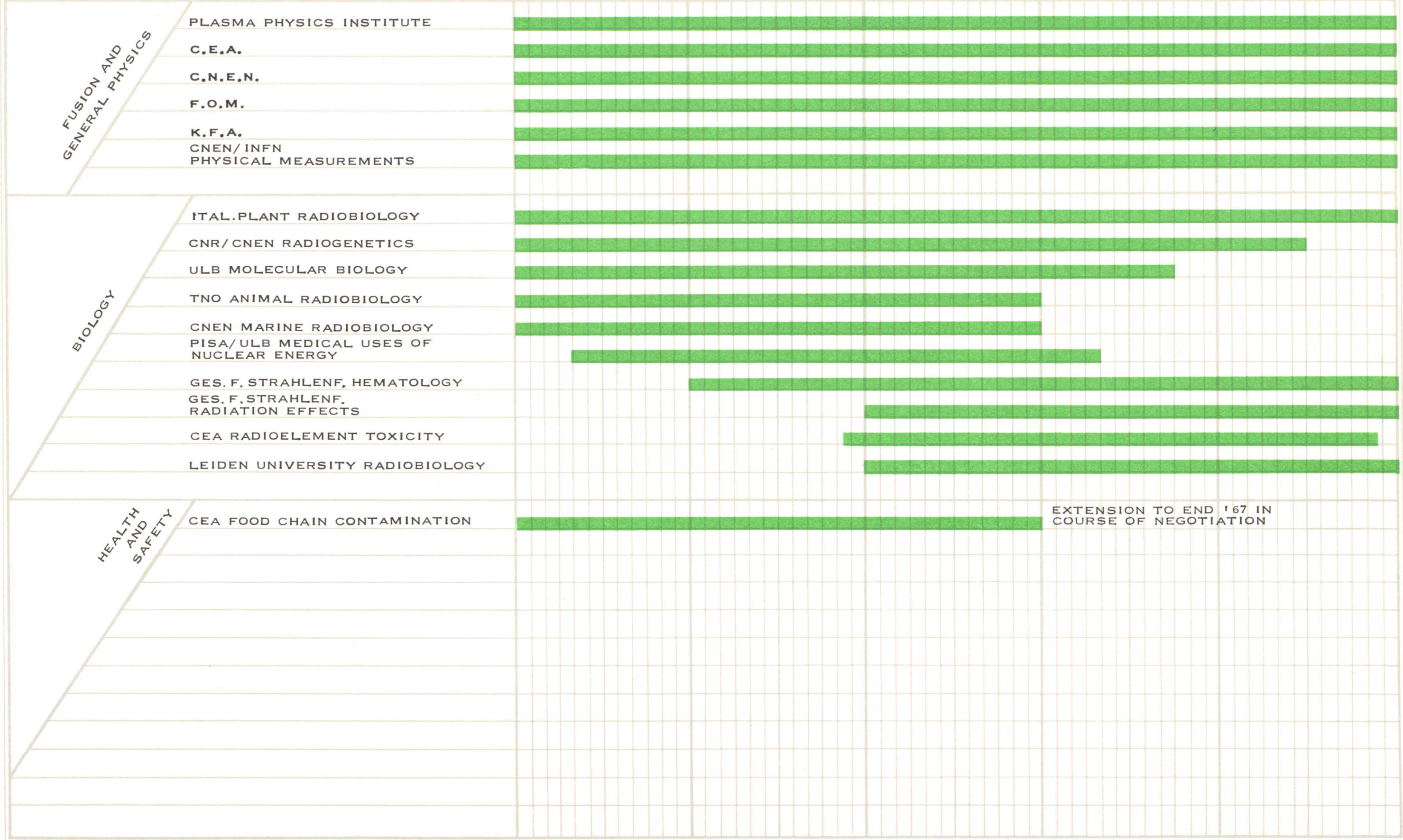
C.E.A.
KARLSRUHE
C.N.E.N.
RCN/TNO
BELGIAN GOVT
ORGANIC REACTORS
CNEN (PRO PROJECT)
EXTENSION TO END '67 SCHEDULED
BR 2 REACT.
BR 2 AGREEMENT
NEW REACTOR TYPES
SUSPENSION REACTOR (KEMA)
EXTENSION TO END '67 IN COURSE OF NEGOTIATION
FOG COOLED REACTOR (CISE-CNEN)
NEW CONTRACT
IRRADIATED FUEL REPROCESSING
CNEN(EUREX)
PLUTONIUM RECYCLING
CEN/BELGONUCLEAIRE
CEA
MARINE PROPULSION
FIAT/ANSALDO
R.C.N.
GKSS SHIELDING TEST, ETC.
EXTENSION TO END '67 SCHEDULED
GKSS OTTO HAHN

B – INTERNATIONAL AGREEMENTS AND IMPORTANT CONTRATCS (CONTINUED)



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XXX	An Investigation of the Stability of a Two-Phase-Flow System with a Change of Phase Report EURAEC 1459 e (MF)
XXX	Burnout Phenomena in Boiling Water Reactors Report EUR 2085 d, e (MF) Report EUR 2329 d (MF) Report EUR 2382 e (MF) Report EUR 2650 e (MF)
XXX	Development and Testing of a Temperature Transient Method for Performing In-Pile Thermal Conductance Testing Report EURAEC 1437 e (MF)
XXX	Development of Steam Separation Technology Report EURAEC 1376 e (MF)
XXX	Development Program for the Garigliano Nuclear Reactor Report EUR 2308 e (MF) Report EUR 2344 e, i (MF) Report EUR 2381 e, i (MF) Report EUR 2668 e, i (MF)

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XXX — Subcritical PU Fuel Lattice Experiment
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PATENT APPLICATIONS FILED BY THE COMMISSION AND ITS CONTRACTORS TO SAFEGUARD INVENTIONS DEVELOPED UNDER THE EURATOM RESEARCH PROGRAMMES

(from 1 January to 31 December 1965)

File No.	Title of Patent	Inventor	Holder	Origin
I/453	Caisson de protection pour réservoirs de transport de matières radioactives	Bonnet (EUR) Mollica (EUR) Bottani (EUR)	Euratom	Ispra
I/520	Electrisch verwarmingselement	Lijbrink (RCN) Heiers (EUR) Beijer (RCN)	RCN	Petten
I/525	Générateur d'hyperfréquence créant des champs intenses	Consoli (CEA) Le Gardeur (CEA) Mourier (CEA)	CEA	CEA 007 FUAF
I/540	Pompe volumétrique	Bonnaure (EUR)	Euratom	Ispra
I/541	Système d'entraînement pour barre de contrôle et de sécurité de réacteur nucléaire	Bonnaure (EUR)	Euratom	Ispra
I/542	Commande assistée de pont roulant (see add. patent I/858 Be)	Bonnaure (EUR)	Euratom	Ispra
I/547	Perfectionnement aux ponts roulants télécommandés, particulièrement pour l'emploi en cellules étanches	Riey (TPLM) Caillebault (TPLM) Pesenti (EUR) Sayag (EUR) Babule (EUR)	Euratom and TPLM	Contract
I/549	Machine-outil à commande manuelle de dessertissage sous eau, notamment destinée à être utilisée dans des piscines d'installations d'énergie nucléaire	Sayag (EUR) Pesenti (EUR) Perot (UMG)	Euratom and UMG Automation	Contract
I/550	Machine-outil télécommandée de tronçonnage en immersion, notamment destinée à être utilisée dans des piscines d'installations d'énergie nucléaire	Sayag (EUR) Pesenti (EUR) Perot (UMG)	Euratom and UMG Automation	Contract

File No.	Title of Patent	Inventor	Holder	Origin
I/551	Appareil de radiographie sous eau, notamment pour radiographier des objets ou éléments radioactifs	Sayag (EUR) Nauche (EUR) Menetrier (SIAR) Perot (UMG)	Euratom	Petten
I/556	Verfahren und Anordnung zum gleichzeitigen Bestrahlen einer Vielzahl gleichförmiger Probekörper in einem Kernreaktor	Bodnarescu (EUR)	Euratom	CEN Mol GEX BR2
I/568	Multiplexmeszsystem	Becker (EUR)	Euratom	Ispra
I/571	Kapillarstruktureinsatz für Wärmeröhren und Verfahren zur Herstellung eines solchen Einsatzes	Caron (EUR) Busse (EUR) Grover (Los Alamos Scient. Lab)	Euratom	Ispra
I/572	Sicherheitsverbindung für Pulsationsräder zum Pulsen der Reaktivität eines Versuchs-Kernreaktors	Hanke (EUR)	Euratom	Ispra
I/587	Schaltungsanordnung zur amplitudengerechten Umwandlung einer Gleichspannung in eine Rechteck-Wechselspannung	Pegels (EUR)	Euratom	Petten
I/599	Enceinte de travail, notamment boîte à gants	Gandolfo (EUR) Rouillard (Ets la Calhène Bezons)	Euratom	Euratom Mol
I/600	Antriebsvorrichtung für drehbare und gleichzeitig hin- und herbewegbare Meszsonde	Naumann (CEN)	Euratom	Petten
I/604	Auswechselbarer Kolonnenkörper für den Aufbau eines Geräts für die fraktionierte Destillation hochsiedender, insbesondere fester Substanzen	Hodapp (EUR) Luhleich (EUR)	Euratom	Ispra
I/606	Inrichting voor het ontwikkelen van dunnelaag-chromatografieplaten	Geiss (EUR) Schlitt (EUR)	Euratom	Ispra
I/609-612	Apparat für die Neutronenselektion mittels umlaufendem Schaltrotor	Will (EUR) Geist (EUR) Krebs (EUR)	Euratom	Ispra
I/610	Dampfdruckmessgerät und Kalorimeter für höhere Temperaturen	Bodansky (EUR) Busse (EUR) Grover (Los Alamos Scient. Lab)	Euratom	Ispra

File No.	Title of Patent	Inventor	Holder	Origin
I/611	Feststehender Neutronenkollimator mit veränderlichem Durchtrittsquerschnitt	Krebs (EUR) Rochez (EUR)	Euratom	Ispra
I/614	Leghe a base di uranio aventi proprietà migliorate, impiegate come elementi combustibili nei reattori nucleari e relativo metodo di preparazione	Wilson (SNAM) Bastelli (SNAM) Squadrelli-Saraceno (SNAM) Dalmastri (CNEN)	SNAM	SNAM-CNEN 001 TEGI
I/616	Microsaldatore per termocoppie irradiate	Bellezza (EUR)	Euratom	Petten
I/638	Utilizzazione in reattori nucleari di leghe ternarie di uranio contenente molibdeno con niobio o zirconio	Fizzotti (CNEN) Colabianchi (CNEN) Masperoni (CNEN)	CNEN	CNEN-SNAM 001 TEGI
I/641	Verfahren und Vorrichtung zum Schmelzen von Urandioxyd bzw. Plutonium-dioxyd	Schikarski (NUKEM) Teiwes (NUKEM)	Euratom	NUKEM 013 TEED R & D
I/655	Vorrichtung und Verfahren zur Wärmeisolierung von Reaktorkanälen (add. patent to I/318 GF)	Ohlmer (EUR) Dufresne (EUR) Finzi (EUR)	Euratom	Orgel
I/656	Werkwijze voor het bepalen van een stroming en toestel voor het uitvoeren van deze werkwijze	Souffriau (CEN) Baetsle (CEN)	CEN	CEN 002 WASB
I/657	Vorrichtung zur Sicherung gegen Lösen eines gekuppelten Verbindungskanals von einem « heissen » Behälter	Werner (EUR)	Euratom	CCR Karlsruhe
I/661	Generatore di correnti dell'ordine dei Megaampere mediante l'uso di esplosivi	Knoepfel (CNEN) Herlach (CNEN)	Euratom	CNEN fusion
I/662	Halte- und Zentriervorrichtung für der Wärmeausdehnung unterworfene Körper	Berg (EUR)	Euratom	Petten
I/664	Contatore corporeo totale universale	Donato (Univ. Pisa) Gennaro (Univ. Pisa) Giordani (Univ. Pisa)	Euratom and University of Pisa	ULB 026 BIAC (PISA)

File No.	Title of Patent	Inventor	Holder	Origin
I/665	Collimatore	Gennaro (Univ. Pisa)	Euratom and University of Pisa	ULB 026 BIAC (PISA)
I/666	Dispositivo pertracciare scintigrammi	Salvadori (Univ. Pisa) Donato (Univ. Pisa) Giordani (Univ. Pisa) Gennaro (Univ. Pisa)	Euratom and University of Pisa	ULB 026 BIAC (PISA)
I/668	Dispositif de contrôle (add. patent to I/667 Fr)	Aubert (CEA) Fortin (CEA) Gugenberger (CEA) Martin (CEA) Rouge (CEA)	CEA	CEA 002 TEGF (Grenier)
I/680	Verfahren zum Vermeiden von Kohlenstoffablagerungen im Primärkreislauf von Hochtemperatur-Reaktoren	Schulten (KFA) Valette (EUR)	KFA	BBK/KFA 003 RGAD
I/681	Improvements in or relating to nuclear reactors — Concrete pressure vessel having wall embedded heat exchangers (see I/833 UK)	Coast (UKAEA) Lockett(UKAEA) Iver (UKAEA)	UKAEA	Dragon case 102
I/682	Vertelsmechanisme	Bonsel (RCN) Weevers (RCN)	RCN	RCN 007 PNIN
I/683	Werkwijze voor het impregneren van grafiet met metalen of metaallegering	Burg (EUR) Lanza (EUR) Marengo (EUR)	Euratom	Ispra
I/684	Improvements relating to the control behaviour of fast nuclear reactors	Rinaldini (EUR)	Euratom	Ispra
I/685	Procédé de préparation d'éléments combustibles nucléaires à base de carbures mixtes	Wurm (EUR) Beucherie (EUR)	Euratom	Ispra
I/687	Anordnung zur Funktionsüberwachung von thermischen Isolierschichten in Kernreaktorkanälen	Finzi (EUR) Jorzig (EUR) Ohlmer (EUR) Becker (EUR)	Euratom	Ispra

File No.	Title of Patent	Inventor	Holder	Origin
I/688	Isolement thermique (see I/738)	Finzi (EUR) Faure (EUR) Lebrun (EUR)	Euratom	Ispra
I/689	Wärmeröhre	Fiebelmann (EUR)	Euratom	Ispra
I/691	Magasin pour l'entreposage d'éléments combustibles en forme de barres pour réacteurs nucléaires	Bouchet(PEROT) Charles (EUR)	Euratom	Ispra
I/692	Process and plant for the purification of terphenyl and/or analogous organic materials	Imarisio (EUR)	Euratom	Ispra
I/693	Abschirmung für Kernreaktoren oder dergleichen	Enginol (GKSS)	GKSS	GKSS 002 PNID
I/694	Halbleiter-Laser	Hora (IfP)	IfP	IfP 003 FUAD
I/695	Leiteranordnung zum Anschluss mehrerer Stromquellen an einen Verbraucher	Knobloch (IfP)	IfP	IfP 003 FUAD
I/696	Perfectionnements apportés aux échangeurs d'ions et à leurs procédés de fabrication (add. patent to I/594 Fr)	Lefevre (CEA) Prospert (CEA) Raggenbass (CEA)	CEA	CEA 025 RISF
I/697	Fabbricati in materiale composito Al-AL_2O_3 per applicazioni nucleari, e procedimento per l'ottenimento degli stessi	Gualandi (ISML) Jehenson (EUR)	Euratom et ISML	ISML 065 TEO I
I/698	Procédé de retraitement des combustibles irradiés par fluoruration	Camozzo (EUR) Francesconi (CEN) Pierini (EUR) Schmets (CEN)	CEN	CEN 004 RICB R & D
I/699	Sas de transfert complémentaire	Gandolfo (EUR)	Euratom	Mol
I/700	Improvements in or relating to the operation of nuclear reactors — Proposals for fuel element shuffling leading to a core loading with horizontal layers of equal age	Marien (UKAEA)	UKAEA	Dragon case 100
I/707	Improvements in or relating to electric power generation - MHD - GT Thermodynamic Cycle	Bonsdorff (UKAEA)	UKAEA	Dragon case 113

File No.	Title of Patent	Inventor	Holder	Origin
I/708	Verfahren und Anordnung zur Feststellung von durch Kernstrahlung entstandenen Inhomogenitäten in Metalldrähten	Meier (EUR)	Euratom	CEN Mol GEX BR2
I/709	Procedimento per la chiusura ermetica di elementi di combustibile	Perona (CISE) Volta (EUR)	CISE/ Euratom	Ispra (CISE 180 ORGI)
I/710	Processo di saldatura per martellatura (add. patent to I/493 It)	Perona (CISE) Volta (EUR)	CISE/ Euratom	Ispra (CISE 180 ORGI)
I/711	Zylindrische Kapsel für Bestrahlungskörper	Berg (EUR)	Euratom	Petten
I/713	Vereinzelner von kugelförmigen Elementen	Hündorf (BBK)	BBK	KFA/BBK 003 RGAD
I/714	Vereinzelner von kugelförmigen Elementen	Landwehr (BBK) Braun (BBK) Handel (BBK)	BBK	KFA/BBK 003 RGAD
I/715	Vorrichtung zur Druckmessung an radioaktiven Medien	Machnig (BBK) Ottl (BBK)	BBK	KFA/BBK 003 RGAD
I/716	Verfahren zur Verdichtung von Brennstoffelementen für Kernreaktoren	Machnig (BBK) Ottl (BBK)	BBK	KFA/BBK 003 RGAD
I/717	Verfahren zur Reinigung von durch Kohlenstoffniederschlag gefährdeten Wärmetauscheroberflächen	Thrun (BBK)	BBK	KFA/BBK 003 RGAD
I/718	Behälter zur Bestrahlung von Werkstoffen mittels einer radioaktiven Substanz	v. d. Decken (BBK) Hantke (BBK) Münch (BBK)	BBK	KFA/BBK 003 RGAD
I/719	Schmutzfilter zur Reinigung von Gasen oder Flüssigkeiten	Schöning (BBK) Treubel (BBK)	BBK	KFA/BBK 003 RGAD
I/720	Vorrichtung zum Ein- und Ausbringen eines Behälters in einen abgeschirmten Raum	Braun (BBK) Landwehr (BBK) Handel (BBK)	BBK	KFA/BBK 003 RGAD
I/723	Niveaumessgerät	Becker (EUR)	Euratom	Ispra
I/725	Echangeur de température à double paroi	Kestemont(EUR)	Euratom	Ispra

File No.	Title of Patent	Inventor	Holder	Origin
I/726	Rechengerät zum Logarithmieren von Binärzahlen	Combet (EUR) Van Zonneveld (EUR) Verbeek (EUR)	Euratom	Ispra
I/727	Process to improve ductility of « metal-oxide » composite materials or dispersed phase alloys, particularly of aluminium-alumina composite materials	Jehenson (EUR) Bauwens (EUR)	Euratom	Ispra
I/728	Digitales Flipflopschaltwerk	Combet (EUR) Wilhelm (EUR)	Euratom	Ispra
I/732	Sonde portative à scintillation de grande surface	d'Adamo (EUR) Dominici (EUR)	Euratom	Ispra
I/733	Dispositif de blocage en rotation d'un télémanipulateur	Mas (CEA)	CEA	CEA 006 RAAF
I/734	Procédé d'obtention de bouffées de particules chargées et dispositif en comportant application	Duquesne (EUR) Pierson (CEA) Schmitt (CEA)	CEA	CEA 006 RAAF
I/735	Cibles pour accélérateurs destinés à la production de neutrons	Guillaume, Gueben, Delfiore, Peters, Govaerts, Winand (Institut de Phys. et de Chim. nucl.) Godar (EUR)	Euratom	University of Liège 050 RISB
I/736	Improvements in or relating to a method of, and apparatus for, rendering particles spheroidal-forming of spherical particles from grains	NYBØ (UKAEA)	UKAEA	Dragon case 80
I/737	Improvements in or relating to the manufacture of articles of a porous or cellular nature - Forming porous refractory particles by heat treatment in oxidising conditions	Horsley (UKAEA) Podo (UKAEA)	UKAEA	Dragon case 107
I/738	Isolement thermique pour parois de réservoirs servant au stockage et/ou au transport de gaz liquéfiés (see I/688)	Finzi (EUR) Faure (EUR) Lebrun (EUR)	Euratom	Ispra
I/739	Improvements in or relating to High Temperature Gas cooled reactors - Fuel configurations for power HTR	Marien (UKAEA)	UKAEA	Dragon case 75

File No.	Title of Patent	Inventor	Holder	Origin
I/740	Experimentiereinrichtung, insbesondere für Kernreaktoren (see add. patent I/741 GF)	Händel (GfK)	GfK	GfK 009 RAAD
I/741	Experimentiereinrichtung, insbesondere für Kernreaktoren (add. patent to I/740 GF)	Händel (GfK)	GfK	GfK 009 RAAD
I/742	Verfahren zum Verschliessen von Behältern mit rohrförmigen Stutzen, insbesondere von Kernreaktorbrennelementen	Bumm (GfK) Kaupa (GfK)	GfK	GfK 009 RAAD
I/743	Vorrichtung zur Masskontrolle von Stäben, Rohren, od. dergl.	Brückner (GfK) Müller (GfK) Seither (GfK) Wolter (GfK)	GfK	GfK 009 RAAD
I/744	Nucleares Spaltelement	Dorner (GfK) Schretzmann (GfK)	GfK	GfK 009 RAAD
I/745	Einrichtung zum Umladen von Kernreaktoren (add. patent to I/644 GF)	Müller (GfK)	GfK	GfK 009 RAAD
I/746	Kernreaktor	Cramer (GfK) Keiper (GfK) Schramm (GfK)	GfK	GfK 009 RAAD
I/747	Lösbare Verbindungsvorrichtung dünnwandiger Teile mit massiven Elementen	Händel (GfK)	GfK	GfK 009 RAAD
I/748	Flanschverbindung	Schmidt (GfK)	GfK	GfK 009 RAAD
I/749	Vorrichtung zum Abführen von Spaltgassen aus Kernreaktorbrennelementen (second add. patent to G40743VIIIc/21g; first patent see I/653 GF)	de Temple (GfK)	GfK	GfK 009 RAAD
I/750	Schleusenverschluss bei Strahlenschutzwänden von Kernreaktoren	Müller (GfK) Schramm (GfK)	GfK	GfK 009 RAAD
I/751	Verfahren zum Aufbereiten, insbesondere bestrahlter uranhaltiger Kernbrennstoffe	Koch (GfK)	GfK	GfK 009 RAAD
I/752	Spanneinrichtung für die Spaltzone von Kernreaktoren	Schmidt (GfK)	GfK	GfK 009 RAAD

File No.	Title of Patent	Inventor	Holder	Origin
I/753	Haltevorrichtung für Spaltzonen-elemente	Mühlhäuser (GfK)	GfK	GfK 009 RAAD
I/754	Einrichtung zum Sintern radio-aktiver Stoffe wie Kernbrenn-stoffe oder dergl.	Hagen (GfK) Schmidt (GfK)	GfK	GfK 009 RAAD
I/755	Kernreaktor	Cramer (GfK) Müller (GfK)	GfK	GfK 009 RAAD
I/756	Mit Kühlmittel gefüllter Isolier-mantel insbesondere für Nage-kühlte Kernreaktoren	de Temple (GfK)	GfK	GfK 009 RAAD
I/757	Procédé et dispositif pour aug-menter le flux thermique criti-que d'une paroi en contact avec un liquide en ébullition	Morin (EUR) Douguet (Thomsom)	Euratom and Thomson-Houston	Thomson-Houston Ispra
I/758	Inrichting voor het verpompen van suspensies	Spruyt (RCN)	RCN	KEMA 001 SUAN 002 NTAN
I/759	Process for the obtention of aluminium-alumina and similar composite material and semi-fi-nished and finished products made thereof	Bauwens (EUR)	Euratom	Ispra
I/761	Réacteur nucléaire refroidi par métal liquide	Gumuchian (INDATOM) Migadel (CEA) Sauvage (CEA)	CEA	CEA 006 RAAF
I/762	Dispositif d'extraction de cha-leur et réacteur nucléaire com-portant un tel dispositif	Vitry (INDATOM)	INDATOM	004 BGZC
I/763	Mécanisme de commande de barres de contrôle	Schoppen (EUR)	CEA	CEA 006 RAAF
I/764	Grappin à billes	Backs (EUR) Godin (OTER) Rivet (OTER) Maulard (CEA)	CEA	CEA 006 RAAF
I/765	Process to improve ductility of « Metal-oxide » composite mate-rials or dispersed phase alloys particularly of aluminium-alu-mina composite materials		Euratom	Ispra
I/766	Kinetisch induktiver Energie-speicher	Knobloch (IfP)	IfP	IfP 003 FUAD

File No.	Title of Patent	Inventor	Holder	Origin
I/767	Verfahren zum Herstellen von Kontaktleisten für Hochstromkontakte	Breit (IfP)	IfP	IfP 003 FUAD
I/770	Werkwijze en inrichting voor de bereiding van een gesmolten zoutmengsel	Stingele (EUR)	Euratom	Petten
I/771	Improvements in or relating to methods of analysing gas streams by gas chromatography-Valveless chromatograph	Gray (UKAEA)	UKAEA	Dragon case 104
I/772	Improvements in or relating to thermocouples — A thermocouple junction between electrophoretically coated wires	Jaques (UKAEA)	UKAEA	Dragon case 110
I/773	Heterogener Kernreaktor (see add. patent I/778 GF)	Fiebelmann (EUR)	Euratom	Ispra
I/774	Elément de combustible composite pour réacteurs nucléaires	Bonnet (EUR) Charrault (EUR) Lafontaine (EUR) Orlowski (EUR)	Euratom	Ispra
I/777	Verfahren zur Ermittlung von Dampfblasen in Flüssigmetallströmen auf elektrischem Weg	Grass (EUR) Kattowski (EUR)	Euratom	Ispra
I/778	Heterogener Kernreaktor, vorzugsweise für Raumfahrzeuge (add. patent to I/773 GF)	Fiebelmann (EUR)	Euratom	Ispra
I/779	Eigengekühlter Steuerstab für Klein- und Raumreaktoren	Fiebelmann (EUR)	Euratom	Ispra
I/780	Fixation étanche d'une gaine d'élément combustible sur son bouchon	Marchal (EUR)	Euratom	Ispra
I/781	Kapillar-gekühlte Kernbrennstoffanordnung	Fiebelmann (EUR)	Euratom	Ispra
I/782	Tronçonneuse à molettes pour tubes irradiés (add. patent to I/408 Be)	Bonnet (EUR) Di Piazza (EUR) Junger (EUR) Leroy (EUR) Mollica (EUR) Monzani (EUR)	Euratom	Ispra
I/783	Thermionischer Konverter mit an Emitter und Kollektorelektrode angeschlossenen Wärmeröhren	van Andel (EUR) Busse (EUR)	Euratom	Ispra

File No.	Title of Patent	Inventor	Holder	Origin
I/784	Druckbehälter (add. patent to I/589 GF)	Benzler (EUR)	Euratom	Euratom
I/785	Improvements in or relating to power plant — Integral HTR/ Gas turbine	Coast (UKAEA) Lockett (UKAEA)	UKAEA	Dragon case 111
I/787	Verfahren zur Optimierung der Wärmeübertragung bei hohen Temperaturen (add. patent to I/452 GF)	Merz (EUR)	Euratom	Petten
I/788	Nucleaire energie reactor installatie voorzien van één of meer warmtewisselaars	Bonsel (RCN) Weevers (RCN)	RCN	RCN 007 PIN.N
I/789	Auswertegerät für Temperaturmessverfahren (add. patent to I/573 GF)	Meier (EUR)	Euratom	CEN Mol GEX BR2
I/790	Inrichting omvattende een procesvat of een stoomgenerator, voorzien van een ondersteuningsconstructie die de thermische lengteverandering van verbindingspijpleidingen toelaat	Feliks (RCN) Weevers (RCN)	RCN	RCN 007 PIN.N
I/795	Improvements in or relating to heat exchangers — A removable heat exchanger for an integral reactor	Cook (UKAEA) Hosegood (UKAEA)	UKAEA	Dragon case 109
I/796	Verfahren zur Unterscheidung verschiedener Sorten von Brennstoffelementen eines Kernreaktors	Lüders (BBK) Machnig (BBK)	BBK	KFA/BBK 003 RGAD
I/797	Vorrichtung zum selbsttätigen Festhalten eines Stabes eines gegenläufig bewegbaren Stabpaares in einer bestimmten Endlage	Handel (BBK) Braun (BBK) Landwehr (BBK)	BBK	KFA/BBK 003 RGAD
I/798	Verfahren zur Messung des kernphysikalischen Verhaltens von zu untersuchenden Körpern	Rausch (BBK) v. d. Decken (BBK) Bachus (BBK)	BBK	KFA/BBK 003 RGAD
I/799	Bruchabschneider für kugelförmige Elemente	Schönig (BBK) Kirschner (BBK) Braun (BBK)	BBK	KFA/BBK 003 RGAD
I/800	Einrichtung zur Kontrolle der Ankupplung eines Stabes an einen Haftmagneten	v. d. Decken (BBK) Drechsel (BBK)	BBK	KFA/BBK 003 RGAD

File No.	Title of Patent	Inventor	Holder	Origin
I/801	Vorrichtung zur Anzeige der Stellung eines Ventils	Helfrich (BBK) Schöning (BBK) Volz (BBK)	BBK	KFA/BBK 003 RGAD
I/802	Verfahren zur Regelung der Leistung von mit Dampferzeugern bestückten Kernreaktoranlagen	Binckebanck (BBK)	BBK	KFA/BBK 003 RGAD
I/803	Wärmeaustauscher-Anordnung für gasgekühlte Kernreaktoren	Treubel (BBK) Schöning (BBK)	BBK	KFA/BBK 003 RGAD
I/804	Vorrichtung zur Fernanzeige der Stellung eines Ventils	Bräumer (BBK)	BBK	KFA/BBK 003 RGAD
I/805	Vorrichtung zur Anzeige der Stellung eines Ventils	Helfrich (BBK) Schöning (BBK)	BBK	KFA/BBK 003 RGAD
I/806	Vorrichtung zum Abschalten des Antriebes eines in ein Kernreaktorcore eingefahrenen Abschaltstabes	Handel (BBK) Braun (BBK) Landwehr (BBK)	BBK	KFA/BBK 003 RGAD
I/807	Steckbolzenkupplung	Münch (BBK) Hoffmann (BBK) Gnutzmann (BBK) v. d. Decken (BBK) Handel (BBK)	BBK	KFA/BBK 003 RGAD
I/808	Spannbetonbehälter	Machnig (BBK) Lupberger (BBK)	BBK	KFA/BBK 003 RGAD
I/809	Entnahmevorrichtung für Gasproben aus einem gasgekühlten Kernreakor	Schöning (BBK) Braun (BBK) Landwehr (BBK)	BBK	KFA/BBK 003 RGAD
I/810	Vorrichtung zur Entnahme von Aerosolen aus einem Gasstrom	Schöning (BBK) Braun (BBK) Bräumer (BBK)	BBK	KFA/BBK 003 RGAD
I/811	Thermionischer Konverter	Busse (EUR) Caron (EUR)	Euratom	Ispra
I/812	Dispositif pour mesurer l'autoindustance d'un moteur à courant continu	Arhan (EUR) Barbaste (EUR)	Euratom	Ispra

File No.	Title of Patent	Inventor	Holder	Origin
I/814	Quarzlinsenverbindung in Anlagen zur quantitativen Bestimmung der Konzentration von Dämpfen in einem Trägergas, und Verfahren zur Herstellung der Verbindung	Verheyden (EUR) Klein (EUR) Cappelletti (EUR)	Euratom	Ispra
I/815	Kernreaktor mit Flüssigmetallkühlung	Grass (EUR) Kottowski (EUR)	Euratom	Ispra
I/816	Verfahren und Anordnung zum Nachweis des Siedens in Flüssigkeiten	Grass (EUR) Kottowski (EUR)	Euratom	Ispra
I/817	Verfahren und Vorrichtung zum Auflöten von Dehnungsmessstreifen auf Körper aus gesintertem Aluminiumpulver	Schlittenhardt (EUR) Klein (EUR)	Euratom	Ispra
I/819	Dosismessfilmrahmen zur Aufnahme einer grösseren Anzahl von Personendosismessfilmen	Oberhofer (EUR)	Euratom	Ispra
I/820	Werkwijze ter vermindering van de vorming van aanslag op oppervlakken die in aanraking komen met organische koel- en/of moderatorvloeistoffen	van Rutten(EUR) Höpper (EUR) Diletti (EUR)	Euratom	Ispra
I/821	Improvements in or relating to a method of assembling a regular polygonal article from a number of blocks	Hosegood (UKAEA)	UKAEA	Dragon case 112
I/822	Improvements in or relating to spheroidal nuclear fuel elements. Grooved fuel spheres	Acciari (UKAEA)	UKAEA	Dragon case 114
I/823	Improvements in or relating to the manufacture of graphite — Method of marking an isotropic graphite from anisotropic raw materials	Graham (UKAEA) Price (UKAEA) Redding (UKAEA)	UKAEA	Dragon case 117
I/824	Improvements in or relating to graphite/HX-30 graphite	Longstaff (UKAEA)	UKAEA	Dragon case 118
I/825	Ionenquelle	Blauth (IfP)	IfP	IfP 003 FUAD
I/826	Mikrowellen-Interferometer	Makios (IfP) Walcher (IfP)	IfP	IfP 003 FUAD
I/827	Viscosimètre électromagnétique	Gaeta (Lab. LIGB-Napoli)	Euratom	CNR-CNEN 012 BIAI

File No.	Title of Patent	Inventor	Holder	Origin
I/828	Procédé de protection de métaux	Armand (UGINE) Charveriat (UGINE) Salmon (UGINE)	UGINE	UGINE 173 ORGF
I/829	Einbettverfahren zum Sintern bezw. Schmelzen von Partikeln	Wolff (NUKEM) Venet (EUR)	NUKEM	BBK/KFA 003 RGAD
I/830	Dispositif d'étanchéité	Pflugrad (EUR) Brunet (Sté d'ét. ind.) Jadot (Sté d'ét. ind.)	CEA	CEA 006 RAAF
I/831	Source d'ions	Etievant (CEA) Hubert (CEA) Perulli (CEA)	CEA	CEA 007 FUAF
I/832	Mécanisme de commande d'un mouvement rectiligne vertical	Gerard (GAAA) Palomo (GAAA)	CEA	CEA 006 RAAF
I/833	Improvements in or relating to nuclear reactors (see I/681 UK)	Coast (UKAEA) Lockett (UKAEA) Mc Iver (UKAEA)	UKAEA	Dragon case 102A
I/834	Aire support pour réacteur nucléaire à boulets	Vitry (INDATOM) de Bacci (EUR)	INDATOM	004 RGZC
I/836	Verfahren zur Herstellung einer hochtemperaturbeständigen, stossfesten und niedrigohmigen mechanischen Verbindung zwischen den metallischen Elektroden und dem Halbleiterkörper eines thermoelektrischen Generators	Billot (EUR)	Euratom	Ispra
I/837	Procédé et dispositif pour le recouvrement de surfaces	Wurm (EUR) Beucherie (EUR) Block (EUR)	Euratom	Ispra
I/847	Noodkoelsysteem voor een kernreactorinstallatie	v. d. Bergh (RCN)	RCN	RCN 007 PIN.N
I/848	Appareil de manutention	Delisle (CEA)	CEA	CEA 006 RAAF

File No.	Title of Patent	Inventor	Holder	Origin
I/853	Procédé de retraitement des combustibles irradiés par fluoration	Schmets (CEN) Francesconi (CEN) Pierini (EUR)	RCN	RCN 004 RZIB
I/854	Strahlenundurchlässige Durchführung für Reaktorgefässe und Abschirmungen	Bagge (GKSS) Richter (GKSS)	GKSS	GKSS 002 PNID
I/855	Improvements in or relating to nuclear reactors — Feed mechanismus for the Seed Fuel Balls in the seed and blanket H.T.R.	Pugh (UKAEA)	UKAEA	Dragon case 106
I/857	Dispositif de percussion, de mesure de température, et d'agitation pour un four à induction sous atmosphère contrôlée	Mercier (CEA)	CEA	CEA/037 RDF
I/858	Commande assistée de pont roulant (add. patent to I/542 Be)	Bonnaure (EUR)	Euratom	Ispra
I/859	Magnetohydrodynamischer Generator	Ohlendorf (IfP) Salvat (IfP)	IfP	IfP 003 FUAD
I/860	Magnetische Einrichtung zur elektronenoptischen Abbildung	Steinhausen (IfP)	IfP	IfP 003 FUAD
I/861	Détecteur de particules	Brisse (CEA) Renaud (CEA)	CEA	CEA 007 FUAF
I/862	Sedimentometer	Kalshoven (RCN)	RCN	001-002 SUAN
I/873	Dispositif de transfert d'objets radioactifs	André (CEA) Fradin (CEA)	CEA	CEA 025 RISF
I/874	Werkwijze voor het terugwinnen van een op een drager vastgelegd metalliek element	Baetsle (CEN) Huys (CEN)	CEN	CEN 001 WASB
I/875	Vorrichtung zur Anzeige eines Membranbruchs bei Membranpumpen und Kompressoren	Mauersberger (BBK)	BBK	BBK/KFA 003 RGAD
I/876	Improvements in or relating to means for the removal of solid blocks from a nuclear reactor core — Corkscrew type fuel element Grapple	Acciarri (EUR)	UKAEA	Dragon case 115

File No.	Title of Patent	Inventor	Holder	Origin
I/878	Verfahren und Vorrichtung zur Herstellung von Brenn- und/ oder Brutelementen für Kernreaktoren	Langen (KFA)	KFA	BBK/KFA 003 RGAD
I/880	Improvements in nuclear reactors — Feed fuel on-load, breed fuel Off-load, breed-feed H.T.R.	Acciari (EUR) Marien (EUR) Hosegood (UKAEA) Kierulf (UKAEA) Lockett (UKAEA) Pugh (UKAEA)	UKAEA	Dragon case 101A
I/881	Improvements in or relating to nuclear fuel assemblies interfitting core blocks for H.T.R. without keys	Acciari (EUR)	UKAEA	Dragon case 116
I/882	Improvements in or relating to examination of moving objects by X-ray cine-photo-graphy - high speed colour cine-fluorography	Holliday (UKAEA)	UKAEA	Dragon case 123
I/883	Dispositif d'évacuation de produits de fission pour réacteur nucléaire	Ferrari (EUR)	CEA	CEA 006 RAAF
I/887	Verfahren zum Betreiben von Kernreaktoren	Häfele (GfK) Vogg (GfK)	GfK	GfK 009 RAAD
I/888	Verfahren und Einrichtung zum Schutz der äusseren Begrenzungsflächen eines Behälters vor der Ablagerung von Staub, insbesondere von radioaktivem Staub	Hagen (GfK) Sebold (GfK)	GfK	GfK 009 RAAD
I/889	Verfahren zum Aufarbeiten von bestrahlten Kernbrennstoffen	Geithoff (GfK) Schneider (GfK)	GfK	GfK 009 RAAD
I/890	Verfahren und Vorrichtung zur Wärmebehandlung pulverförmiger Stoffe mittels eines Hochtemperaturplasmas	Weimar (GfK) Liepelt (GfK)	GfK	GfK 009 RAAD
I/891	Kernreaktor (add. patent to I/279 GF)	Häfele (GfK)	GfK	GfK 009 RAAD
I/892	Dampfgekühlter Kernreaktor insbesondere schneller Brutreaktor	Seetzen (GfK)	GfK	GfK 009 RAAD

File No.	Title of Patent	Inventor	Holder	Origin
I/893	Vorrichtung zum Behandeln von pulverförmigen Spaltstoffen für Kernreaktoren in einem Mehrzweckofen	Hagen (GfK) Sebold (GfK)	GfK	GfK 009 RAAD
I/894	Verfahren zum Fluten eines dampfgekühlten Reaktors, insbesondere eines schnellen Brutreaktors	Schmidt (GfK) Keiper (GfK) Müller (EUR)	GfK	GfK 009 RAAD
I/895	Verfahren zur Extraktion von Metallen, insbesondere Kernspaltstoffen mittels eines organischen Extraktionsgemisches	Koch (GfK)	GfK	GfK 009 RAAD
I/896	Brennelementanordnung in einem Kernreaktor	Scharmer (GfK)	GfK	GfK 009 RAAD
I/897	Dampfgekühlter Kernreaktor	Müller (EUR) Schramm (GfK)	GfK	GfK 009 RAAD
I/900	Verfahren zur Herstellung von beschichteten karbidischen und oxydischen Kernbrenn- und Brutstoffpartikeln aus Grünlingspartikeln	Fleischhauer (NUKEM) Hackstein (NUKEM)	NUKEM	BBK/KFA 003 RGAD (under contract NUKEM)
I/901	Verfahren zur Herstellung von kugelförmigen Graphitelementen	Spener (NUKEM) Hrovat (NUKEM) Stemplinger (NUKEM)	NUKEM	BBK/KFA 003 RGAD (under contract NUKEM)
I/902	Kugelförmiges Brennstoffelement für Hochtemperaturreaktoren	Rachor (NUKEM)	NUKEM	BBK/KFA 003 RGAD (under contract NUKEM)
I/903	Verfahren zur Herstellung sphärischer, oxydischer und karbidischer Kernbrenn- und Brutstoffpartikeln durch innere Gelierung von Schwermetalloxid-Solen	Hackstein (NUKEM) Fleischhauer (NUKEM)	NUKEM	BBK/KFA 003 RGAD (under contract NUKEM)
I/904	Hochfrequenz gespeiste Plasmaquelle	Lisitano (IfP)	IfP	IfP 010 FUAD (Garching)

DOCUMENT No. 35 IMPLEMENTATION OF BUDGETS

I. Research and investment budget

The Commission had the following fixed appropriation at its disposal for the financial year 1965 :

	Millions of EMA u.a.
— 1965 research and investment budget adopted by the Council of Ministers on 2 February 1965	76.696
— Supplementary research and investment budget adopted by the Council of Ministers on 30 June 1965	6.688
— 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	29.428
Total:	112.812

The fixed appropriations entered in the books as at 31 December 1965 amounted to 90.158 million EMA u.a., the breakdown being as follows :

Heading	Chapter	Description	Fixed appropriations available in 1965	Amounts entered in books as at 31-12-1965
			(millions of EMA u.a.)	
I		*Staff expenditure*	17.323	17.288
II		*Operating expenditure*	5.207	5.144
III		*Joint Nuclear Research Centre*		
	30	Apparatus and equipment	7.119	6.291
	31	Real property investments	4.269	3.653
	32	Operation of HFR and services rendered by RCN for the account of the Petten establishment	2.190	1.981
Total under Heading III			13.578	11.925

Heading	Chapter	Description	Fixed appropriations available in 1965	Amounts entered in books as at 31-12-1965
			(millions of EMA u.a.)	
IV		*Reactor development and construction*		
	40	Gas reactor	6.600	6.405
	41	Light-water reactors	1.376	1.366
	43	Organic reactors	18.640	13.820
	44	Homogeneous reactors	0.668	0.636
	45	Fast reactors	17.691	11.412
	47	Nuclear marine propulsion	1.292	1.265
	48	Research and applied technology relating to proven-type reactor development and construction	6.724	2.560
	49	Power reactors	0.585	0.257
Total under Heading IV			53.576	37.721
V		*Other scientific and technical activities*		
	50	High-flux irradiation	2.539	2.167
	51	Fusion-plasma studies	7.234	5.401
	52	Biology	2.919	2.351
	53	Radioisotopes	0.761	0.335
	53a	Miscellaneous research	4.314	3.681
	54	General documentation	1.047	1.005
	55	Training and instruction	0.643	0.605
	56	Reprocessing of irradiated fuels	2.274	1.423
	57	Processing of active effluents	1.397	1.112
Total under Heading V			23.128	18.080
GRAND TOTAL			112.812	90.158

The payment authorizations covered by the 1965 budget amounted to 87.500 million u.a., while a total of 77.340 million u.a. had been paid out as at 31 December 1965.

Of the payment authorizations of 9.386 million u.a. brought forward from 1964 to 1965, 9.284 million u.a. had been paid out.

II. Operating budget

For the financial year 1965, the sum of 9,033.910 u.a. was available to the Commission under the operating budget (Section III).

Expenditure commitments during the financial year totalled 8,741.387.32 u.a. Actual expenditure in respect of these commitments amounted to 8,077,463.37 u.a.

DOCUMENT No. 36

STAFF BREAKDOWN UNDER THE RESEARCH AND INVESTMENT BUDGET ACCORDING TO PAYROLL [1]

(Posts filled as at 31.12.1965)

Budgetary Post	A	B	C	D	Establishment personnel	Total
Ispra and ORGEL	461	514	160	—	418	1,553
Transuranium Institute	40	53	32	—	38	163
CNMB	49	57	21	1	29	157
Petten	50	52	24	—	20	146
Fast reactors	40	12	2	—	—	54
Advanced gas reactors	25	3	3	—	—	31
BR2	17	19	9	—	—	45
Proven-type reactors	27	2	4	—	—	33
Irradiated fuel reprocessing	3	—	—	—	—	3
Waste	1	—	1	—	—	2
New type reactors	2	—	—	—	—	2
Marine propulsion	6	—	1	—	—	7
Radioisotopes	9	1	4	—	—	14
Fusion	64	23	7	—	2	96
Health and safety	9	3	1	—	—	13
Biology	47	7	8	—	3	65
Training	1	1	3	—	—	5
Directorate-General for research and other programme directorates	10	—	2	—	—	12
Dissemination of information	24	24	47	5	—	100
Total	885	771	329	6	510	2,501

(1) The discrepancies between the figures given in this table and those in Document 37 following are due to the fact that employees are not necessarily on the payroll of the establishment in which they work.

DOCUMENT No. 37 GEOGRAPHICAL DISTRIBUTION OF STAFF IN AND OUTSIDE THE COMMUNITY

I. In the Community

	Number of personnel
1. *Belgium*	
Brussels	206
CNMB Establishment, Geel	128
Ghent	1
Liège	1
Mol	50
Total :	386

2. *Germany*	
Transuranium Institute, Karlsruhe	137
Bonn	2
Bremen	1
Frankfurt	1
Freiburg	3
Günzburg	2
Hamburg	1
Jülich	6
Mannheim	6
Munich	17
Total :	176

3. *France*

Cadarache	24
Chooz	2
Dijon	1
Fontenay-aux-Roses	54
Genlis	1
Paris	2
Saclay	6
Strasbourg	1
Total :	91

4. *Italy*

Ispra Establishment	1159
Bologna	3
Casaccia	2
Fiascherino	1
Latina	2
Milan	2
Pavia	1
Rome and Frascati	18
Scauri and Minturno	1
Turin	1
Total :	1190

5. *Netherlands*

Petten Establishment	109
Amsterdam	6
Arnhem	4
Jutphaas	2
Rijswijk	2
Wageningen	5
Total :	128
Total in the Community :	1971

II. Outside the Community

1.	*Great Britain*	9
2.	*United States*	10
3.	*Canada*	1
	Total outside Community :	20
	Grand Total [1] :	1991

Add to this total :

Establishment	staff	working	at	Ispra	421
»	»	«	«	Karlsruhe	38
»	»	«	«	Geel	29
»	»	«	«	Petten	20
»	»	«	«	Fontenay	1
»	»	«	«	Munich	1
				Total	510

DOCUMENT No. 38 GRANTS AWARDED IN 1965

Sp. = Specialist's grant
Th. = Thesis grant
J.P. = Courses for young university teachers at nuclear research centres

Category	*Subject*	*Where working*
Sp.	Etude du comportement à la fatigue des matériaux soumis au fonctionnement en milieu organique. — Applications de méthodes statistiques aux essais d'endurance de composants	ISPRA
Sp.	Biologia — settore entomologico —	ISPRA
Sp.	Développement de nouvelles méthodes mathématiques pour la solution numérique de l'équation du transport neutronique de Boltzmann	ISPRA
Sp.	Diffusione dell'U del Pu in SAP con en senza irradiazione	ISPRA
Th.	Untersuchung der dynamischen Kernpolarisation in organischen Festkörpern mit paramagnetischen Zentren	ISPRA
Sp.	Fisica neutronica Sperimentale « Slowing down » in moderatori organici — misuri di « Fermi age »	ISPRA
Sp.	Bestimmung von Gitterschwingungssprektren von Kristallen aus Neutronenstreuexperimenten	ISPRA
Th.	Untersuchung atomarer Fehlstellen in Urankarbid nach Bestrahlen bei tiefen Temperaturen	ISPRA
Sp.	« Reliability » di componenti di reattori nucleari	ISPRA
Sp.	Etude et mise au point de codes nucléaires en particulier en ce qui concerne la standardisation des bibliothèques nucléaires	ISPRA
Sp.	Etude de la mesure de la conductivité thermique en cellule de plomb sur matériaux irradiés	ISPRA
Sp.	Etude et mise au point de codes nucléaires, développement des méthodes mathématiques associées	ISPRA
Sp.	Termocinetica e Termodinamica Applicata	ISPRA
Th.	Experimentelle Doktor-Arbeit auf dem Gebiet der Neutronenstreuung in Festkörpern	ISPRA
Sp.	Analisi numerica e in particolare applicazione alla dinamica dei gas	ISPRA

Cate-gory	*Subject*	*Where working*
Sp.	Expériences sur les neutrons polarisés	ISPRA
Sp.	Spécialisation dans le domaine de la sécurité de fonctionnement des réacteurs du point de vue neutronique	ISPRA
Sp.	Etude des différents schémas de désintégration entre autres event. V^{52} et Cs^{137} à l'aide du spectromètre beta	GEEL
Th.	Vinden van meetprocedure die toelaat preciese metingen uit te voeren aan Litiumisotopen	GEEL
Sp.	Radioimmunologie	HARWELL
J.P.	Ricerche sperimentali sul meccanismo delle reazioni nucleari a medie energie, per nuclei di peso atomico medio con particolare riguardo alle reazioni « proibite » dallo spin isobarico	HEIDELBERG
Th.	Etude des possibilités et utilisation des sources intenses à base de produits de fission en tant que sources de rayonnement et de chaleur	BRUXELLES/ ISPRA
Th.	Théorie quantique des champs appliqués à l'étude des forces nucléaires	ORSAY
Sp.	Effet de la désintégration du p^{32} et p^{33} sur la survie du lacteriophage	BRUSSELS
Th.	Etude de l'élargissement des raies spectrales dans un milieu ionisé	FONTENAY-AUX-ROSES
Sp.	Problemi connesso con gli sviluppi di teorie non lineari	CULHAM
Sp.	Untersuchungen zur numerischen Integration der Wlassov Gleichung	CULHAM
Sp.	Fisica dei reattori nucleari	MOL
Sp.	Una misura accurata delle sezioni d'urto per neutroni di energia da qualche eV a qualche KeV	SACLAY
J.P.	Translocation des macromolécules — leur incorporation dans les cellules et leur stabilité en relation avec divers processus physiologiques	MOL
Sp.	Metodi di spettroscopia dei radicali — Effetti dell radiazioni	ISPRA
Sp.	Recherche expérimentale sur les blindages de réacteurs	ISPRA
Th.	Etude de l'analyse quantitative par diffraction X des céramiques à base d'Uranium	ISPRA
Sp.	Costruzione di rivelatori di semiconduttore e loro impiego nella spettroscopia della radiazione nucleare	ISPRA
Sp.	Etude et mise au point de codes nucléaires	MOL/ISPRA

Category	*Subject*	*Where working*
Th.	Theoretische und praktische Einarbeitung auf dem Gebiete der Neutronenstreuung an Festkörpern.	ISPRA
Th.	Aufbringung dünner Schichten höchstschmelzender Metalle wie Niob, Zirkon, Titan, usw. auf metallische Unterlagen	ISPRA
J.P.	Metodi e tecniche Sperimentali della spettrometria dei neutroni linti nelle applicazioni allo studio della fisica degli stati condensati	PETTEN
Th.	Mesures de conductibilité thermique à très basses températures sur des solides réfractaires non fissiles — Etude des effets de l'irradiation	GRENOBLE
Sp.	Propulsione Navale Nucleare — Ingegneria del reattore — Integrazione del reattore alla nave	CADARACHE
Sp.	Ricerche nel campo dei servomeccanismi camionati	SACLAY
Th.	Etude des mécanismes de réactions des éléments transuraniens	LIEGE
Sp.	Spectroscopie Nucléaire — réactions nucléaires à moyenne énergie	REHOVOTH
Sp.	Physique des plasmas — phénomènes sur l'interaction « ONDES » — « PARTICULES » dans un plasma	GARCHING
Sp.	Fisica dello stato solido	MOL
Sp.	Théorie de la physique des plasmas — travail concernant la particule « test »	FONTENAY-AUX-ROSES
Sp.	Het gebied van gesmolten zouten technologie DMSP	DELFT
Th.	Les effets du transfert linéaire d'énergie au cours de polymérisation radiochimique de l'acrylonitril en solution	BELLEVUE
Sp.	Ricerche sui reattori veloci	CADARACHE

STUDENT TRAINEES
SITUATION FROM 1 JANUARY TO 31 DECEMBER 1965

	Univ.	*Techn.*	*Total*
Applications received	257	203	460
Applications withdrawn or cancelled	5	5	10
Valid applications	252	198	450
Applications rejected	81	98	179
Applications accepted	171	100	271
Grant offers waived	31	10	41
Applicants starting courses in 1965 (excluding those applied for in 1964)	107	55	162
Applications submitted in 1965 for 1966	9	17	26
Cases under consideration	24	18	42

BURSARY HOLDERS
SITUATION FROM 1 JANUARY TO 31 DECEMBER 1965

Applications received	93	
Applications withdrawn or cancelled	3	
Valid applications	90	
Applications rejected	31	
Applications accepted		59
Applications withdrawn after offer of grant		7
Grants accorded		31
Cases under consideration		21

34 extensions were approved for grant work in progress in 1965

VISITING SCIENTISTS - 1965

	Non-Community states	*Member states*		*Non-Community states*	*Member states*
Applications received :				27	7
Withdrawals :	1				
Valid applications :			26		
Rejected :	7				
Granted :	16	7			
Under consideration :	3				
Extensions :	9				

PUBLICATIONS DEPARTMENT OF THE EUROPEAN COMMUNITIES
3876/5/1966/6

For the two volumes :

FB	Ffr.	DM	Lit.	Fl.
FB 150,—	Ffr. 15,—	DM 12,—	Lit. 1.870,—	Fl. 11,—