EUROPEAN ATOMIC ENERGY COMMUNITY

EURATOM

THE COMMISSION

Documentation

attached to

EIGHTH

General Report

on the

Activities of the Community

(March 1964 - February 1965)

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SUMMARY

DOCUMENT No. 1

THE COST OF NUCLEAR ELECTRICITY

(Latest data on cost and profitability of proven-type reactors)

An outstanding event in the period covered by the present Report was the UN Third International Conference on the Peaceful Uses of Atomic Energy held at Geneva in September 1964. The results of the conference afford grounds for concluding that nuclear energy has now arrived at a stage in its development where it is to a large extent economically competitive, more particularly as regards proven-type reactors, i.e. the graphite-gas and light-water strings.

For power plants equipped with a proven-type reactor, experience with which over several years' operation has demonstrated the possibility of continuous running at a cost that can be calculated with a sufficient degree of accuracy, the pattern in the Community countries evolved as follows:

— France. EDF 2 was switched in to the national grid in February 1965. It was decided to undertake construction of a second EDF 4-type plant on the same site as the first (St.-Laurent-des-Eaux). Further, the French five-year plan relating to the period 1965-1970 has been published; this provides for the setting-up of five nuclear power plants at the rate of 500 MWe/year, that is to say, 2,500 MWe between 1966 and 1970 plus an additional 1,000 to 1,500 MWe at the end of the fifth plan in 1970.

— Germany. A start was made on the Kernkraftwerk Lingen (KWL) and Kernkraftwerk Obrigheim (KWO) plants. Construction of other power plants is currently under discussion.

— Italy. The SELNI power plant was commissioned. So far, no decision has been announced on the future programme.

On the international plane, there were special efforts on the part of the major constructors to sell nuclear power plant techniques. Price lists were published giving firm quotations for the construction of boiling-water reactors, including fuel fabrication, for a wide range of unit capacities. Meanwhile, lively discussion continues to centre around the problems involved in the choice of one reactor string rather than another.

A.D. 1

The cost and profitability outlook for the various reactor strings in the Community, based on latest figures, is detailed below.

I. Cost per kWh of proven-type reactors in operation, under construction or scheduled for construction in the Community

The cost per kWh generated at plants in the Community is shown in the table below.

It should be pointed out that the figures in the table are not directly comparable, since the basis of calculation differs in respect of such factors as annual instalments, direct and indirect taxation, utilization time, etc. and relates to reactors within a very wide range of capacities.
These reactors are:

SIMEA (Società Italiana Meridionale Energia Atomica) Latina
(gas-graphite)

SENN (Società Elettronucleare Nazionale) Garigliano
(boiling-water)

SELNI (Società Elettronucleare Italiana) Trino Vercellese
(pressurized-water)

KRB (Kernkraftwerk RWE - Bayernwerk GmbH) Gundremmingen
(boiling-water)

SENA (Société d'Energie nucléaire Franco-Belge des Ardennes) Chooz
(pressurized-water)

EDF 3 (Electricité de France) Chinon
(gas-graphite)

GKN (Gemeenschappelijke Kernenergiecentrale Nederland)
Dodewaard (formerly SEP)
(boiling-water)

KWL (Kernkraftwerk Lingen) Lingen/Ems
(boiling-water)

KWO (Kernkraftwerk Obrigheim) Obrigheim/Neckar
(pressurized-water)

EDF 4 (Electricité de France) St-Laurent-des-Eaux
(gas-graphite)

UNIT COST OF ELECTRICITY GENERATED AT PROVEN-TYPE NUCLEAR POWER PLANTS IN OPERATION OR UNDER CONSTRUCTION IN THE COMMUNITY (IN ORDER OF COMMISSIONING DATE)

Plant		**SIMEA**	**SENN**	SELNI	**KRB** (1)	**SENA** (1)	EDF 3	**GKN** (1)	KWL (1)	KWO	EDF 4
Capacity	MWe	200	150	257	237	266	480 (2)	52,4	240	283	480 (2)
Commissioned		1963	1963	1964	1966	1966	1966	1968	1968	1968	before 1970
Total installed cost	millions of u.a.	103.7	67	71.6	71.6	86.6	116 (3)	26.8	54.6	67.8	107.2 (3)
	u.a./kWh	518	446	279	302	326	242 (3)	512	228	242	223
Utilization factor	%	80	80	80	80	80	80	75	57	68	80
Annual instalments	% / year	10.56	10.56	10.56	13.2	10	8.1	9.8	10.24	11.40	8.1
Fixed capital charges	mills/kWh	7.82	6.74	4.21	5.70	4.76	2.78	7.63	4.34	4.22	2.57
Fuel cycle cost	mills/kWh	3.04	3.28	3.17	2.40	3.41	1.77	2.91	3.17	2.43	1.38
Operating and maintenance costs	mills/kWh	1.29	1.20	1.25	1.05	1.07	0.71	2.09	1.31	1.24	0.71
Insurance	mills/kWh	0.31	0.32		0.42	0.32	0.43	0.30	0.75	0.53	0.43
Cost of electricity (4)	mills/kWh	12.46	11.54	8.63	9.57(5)	9.56	5.69	12.93	9.57(5)	8.42(5)	5.09

(1) Joint enterprises (Status likewise sought for KWO).
(2) Second core.
(3) Figure exempt of French " added-value " tax, which in principle is paid by the end-consumer and thus is in fact a tax per kWh sold (Geneva 1964 — CONF/28/P37).
(4) Figures not comparable *inter se* owing to differing parameters such as capacity, utilization factor, annual charge on capital etc.
(5) Figure exempt of German " Umsatzsteuer " (turnover tax) and not including interest on borrowings.

Plants with Euratom participation are in heavy types. No figures for EDF 1 and EDF 2 plants.

II. Cost outlook for proven-type nuclear power plants

Nuclear power today has developed to the stage at which it increasingly commands acceptance as against conventional energy.

Where cost and profitability prospects for proven-type reactor plants are concerned, it can safely be claimed that the pace of technical progress is such as to augur further cost reductions. Four major factors contributing to the downward movement will be:

— the trend towards greater capacities
— higher burn-ups
— improved performance in other respects
— standardization and mass-production.

1. *Gas-graphite string*

This type of plant developed very quickly during 1964. The building of a second EDF 4-type plant (EDF 4 bis) (1) on the same site as the earlier one, i.e. at St.-Laurent-des-Eaux, will enable the benefits of duplication and the possibilities opened up by certain standardizations and smallseries productions to be turned to good account.

It is further planned to construct a plant at Bugey (EDF 5) (1) which will likewise have a 480 MWe net capacity. It will be equipped with a reactor with annular fuel elements internally and externally cooled. This will give improved heat removal and equal pressure on both surfaces of the element. Study of the characteristics of an annular-element reactor suggests the possibility of considerably enhanced performances, more particularly through a 9.5-fold gain in specific output and an increase in output per channel by a factor 10 as compared, for instance, with EDF 1. Moreover, these studies carried out in France have shown that, from the neutronics angle, burn-ups of as much as 5,000 MWd/t can be realistically predicted for the near future.

The recent agreement between France and Germany regarding construction of a Franco-German power plant on the Upper Rhine will provide both German constructors and operators of nuclear plants with opportunities of gaining further knowledge of French-designed proven-type gas-graphite reactors.

(1) Provisional designation.

The cost per kWh generated at a 500 MWe EDF 4-type plant to be commissioned around 1970 for an annual utilization time of 7,000 hours will be:

Cost per kWh	
Annual instalment	mills/kWh
8.1 %	5.1 to 6.4
10 %	5.7 to 7.1
13 %	6.6 to 8.2

From more recent data obtained in 1964 in connection particularly with the Franco-German project, the cost per kWh in 1970 seems likely to be nearer the lower limit.

2. *Light-water string*

The technique of this string, while already well established, still affords prospects of improvement, especially in regard to neutron economy, thermal efficiency and compactness of assemblies, all of which will make possible a reduction in cost. This reduction will be attributable to the following factors *inter alia:*

— Complete elimination of the secondary steam cycle in the large BWR units, by adopting the single-cycle system in which the whole of the steam used in the turbine is directly extracted from the core without any intermediate heat exchanger.

— Inclusion, even in the largest BWR units, of separators and steam-drying equipment in the reactor vessel.

— These two processes enable the volume of the steam-generating part to be reduced and facilitate the use of a pressure-suppression-type containment in place of a dome-type containment, thus affording substantial savings.

— Reduction of the number of control rods.

Interest in this reactor string continues to be displayed by electricity producers in the Community, especially in Germany, where projects for the construction

of 500 MWe units in the Rhineland and North Germany are currently under serious consideration. In Belgium, too, construction of a 500 MWe power plant is contemplated in the near future.

The cost per kWh generated at a 500 MWe light-water plant to be commissioned around 1970 for an annual utilization time of 7,000 hours will be:

Cost per kWh	
Annual instalment	mills/kWh
8.1 %	5.3 — 5.7
10 %	5.7 — 6.2
13 %	6.5 — 7.1

More recently acquired information offers hopes of achieving even lower figures than the minima set out above.

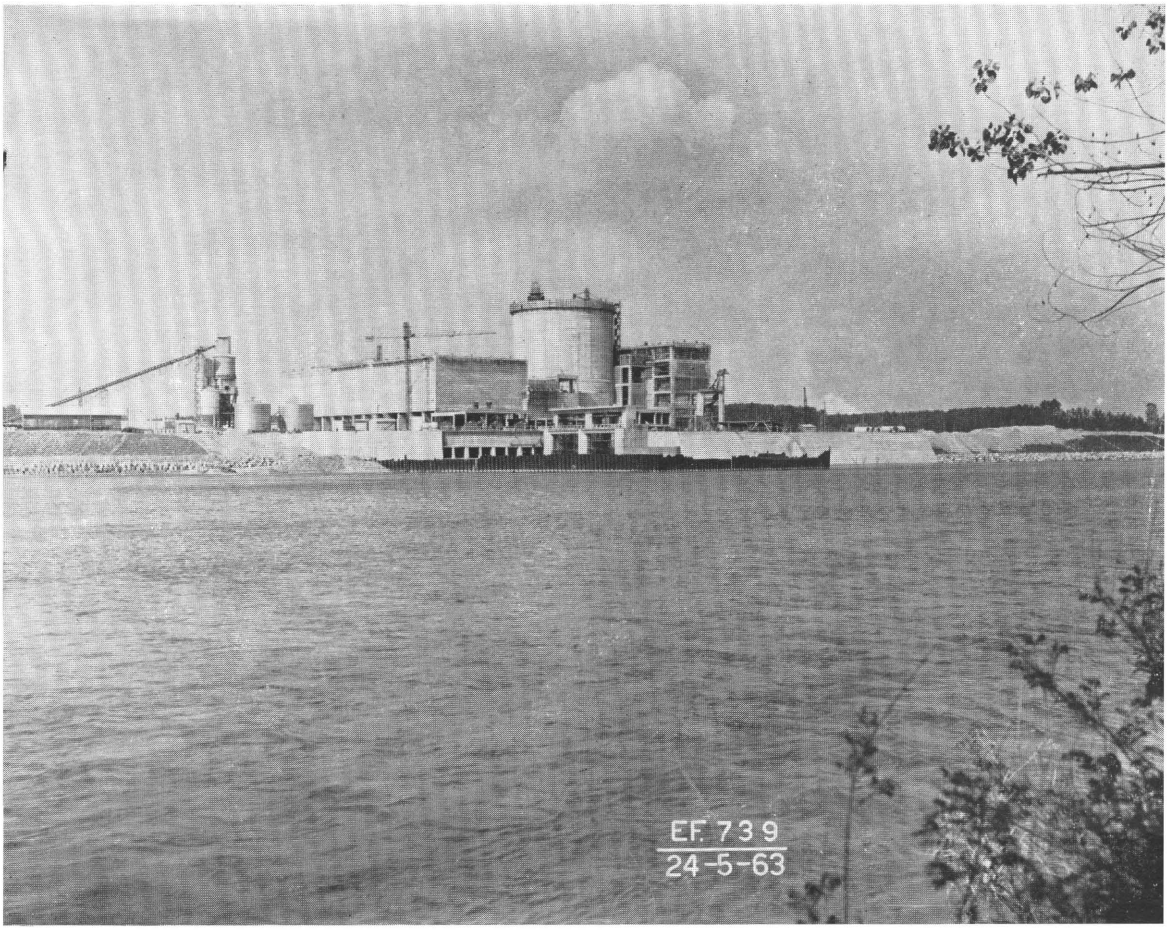
In fact according to one project under discussion, the overall cost of installing a plant of about 500 MWe would be less than 165 u.a./kWh and the cost per kWh between 6 and 6.5 mills (fixed charges 13%, annual utilization time 7,000 hours).

III. Condensed cost estimate per kWh in proven-type nuclear plants to be commissioned after 1970 and comparison with price per kWh in conventional generating plants

1. *Condensed estimate*

The cost pattern for the immediate future is summarized in the table below.

These figure are based on present offers relating to large capacity gas-graphite and light-water plants (400 MWe and over). They allow for a reasonably foreseeable diminution in operating and maintenance costs and also for insurance charges.



TRINO VERCELLESE (Italy) — GENERAL VIEW OF THE ENEL/SELNI POWER PLANT CONSTRUCTION SITE IN MAY 1963

(See other side of page for caption)

On-site construction work on this 272 MWe nuclear power plant started in June 1961. First criticality was reached on 21 June 1964. In October 1964 the plant began to feed electricity into the grid.

Cost per kWh in proven-type nuclear plants to be commissioned after 1970
(in mills/kWh)

Annual instalment	Annual utilization time	
	6,000 h	7,000 h
8.1 %	5.4	4.9
10 %	6.0	5.4
13 %	7.0	6.3

2. *Comparison*

In studies carried out jointly with the other European Communities, the following average parameters were recognized as applying to conventional thermal plants to be commissioned around 1970 with capacities of not less than 500 MWe:

— Cost of installation 125 u.a./kWe

— Specific fuel consumption 2100 kcal/kW or 300 gce/kWh

— Operating and maintenance costs 4 u.a./kWe/year

Compared with a conventional plant of the above specifications, the competitiveness of nuclear energy in 1970 may be expressed as follows:

High-power nuclear plants operating in 1970 will produce electricity at the same cost as coal- or fuel-oil-fired plants commissioned at the same period which obtain their fuel at the following prices per tce (7,000 kcal/kg delivered free at plant).

Fixed charges	Annual utilization time	
	6,000 h	7,000 h
8.1 %	10.1 u.a./t	9.6 u.a./t
10 %	10.8 u.a./t	10.2 u.a./t
13 %	12.1 u.a./t	11.3 u.a./t

Nuclear plants on which construction is to start shortly and be completed by the end of the present decade will thus be generating electricity at the same cost as conventional thermal plants obtaining fuel at 10 tot 12 u.a./tce delivered at plant. This only applies, however, to the large units (400 MWe and over) serving to cover the base load, i.e. with annual utilization times of 6,000 to 7,000 hours.

Coal and fuel-oil are the only primary-energy sources the exploitation of which can be suitably adjusted to the growing demand for electricity, which doubles every ten years, whereas other sources of energy like hydraulic power, lignite, blast-furnace gas and refuse coal (tailings and middlings) scarcely lend themselves to such adaptation.

As regards natural gas, even on the most favourable view only a minor contribution to electricity output can be expected.

Coal mined in the Community at present costs at least 15 u.a./t ex pit.

The table below gives the High Authority's published prices for the various grades of fat coal (washed fines):

Fat coal prices (washed fines) January 1965

Coalfield	Volatile matter %	u.a./t ex taxes	Taxes %
Ruhr, gewaschene Ess- und Mager-Feinkohle	18-30	16.68	4.16
Aachen, idem	19	18.24	4.16
Saar, gewaschene Flamm-Feinkohle	33-40	17.76	4.16
Belgium, fines lavées grasses	20-28	14.60/15.30	1.00
Nord-Pas-de-Calais, fines brutes flénus	18	14.59	11.11
Lorraine, fines lavées flambant industr.	36-39	14.79	11.11
Limburg, fines lavées demi-grasses	20-25	15.06	5.26

As regards the longer-term price curve, there seems to be no possibility of the rise in productivity exceeding or even equalling the rise in wages for any length of time, and the figures in the table above may be taken as representing minimum prices.

Steam-coal imported from the US (bituminous slacks) today costs roughly 9 to 10 u.a./t (fob Hampton Roads). The pattern of Atlantic freight rates suggests a figure of 4 u.a./t, so that on this basis the price of bituminous slacks cif European ports works out at 13 to 14 u.a./t. A target price unlikely to be below this level may be assumed for the future.

Heavy fuel-oil prices, inclusive of taxes and dues, differ widely from country to country; according to the following table published by the High Authority, they average between 17 and 20 u.a. per ton of fuel-oil ex refinery ([1]).

Heavy fuel-oil for industry in the Community
November 1964 — Prices in u.a./t

	Actual price (approx.)	Taxes	Actual price ex. taxes
Hamburg (delivered)	19.5-20.0	7.5 ([2])	12.0-12.5
Karlsruhe (delivered)	19.0-19.5	7.5 ([2])	11.5-12.0
Rotterdam (delivered)	16.4-17.2	3	13.4-14.2
Antwerp (ex refinery)	16.0-17.0	4.5	11.5-12.5
Dunkirk/Le Havre (delivered)	19.0-20.5	2.2	16.8-18.3
Marseille (delivered)	17.2-18.7	2.2	15.0-16.5
Genoa/Naples/Sicily (delivered)	15.2-16.0	5.0	10.2-11.0
Milan (ex refinery)	17.6-18.7	5.0	12.6-13.7
Munich (delivered)	19.0-20,25	7.5 ([2])	11.5-12.75

Actual per-calorie prices of fuel-oil ex refinery are thus generally below both ex-pit prices of home-produced coal and cif prices of imported coal. However, the customs or fiscal policies applied by Community countries which possess an important coal industry tend to align the price of cheap sources of energy, in particular fuel-oil, with high domestic coal prices. The probability, therefore, is that the future common energy policy will maintain a certain level of Community protection on coal. In view of this, assuming taxes or dues at a standard rate of 2 tot 4 u.a./t, the minimum ex-refinery price of fuel-oil in the Community around 1970 may be expected to be 16 to 17 u.a./t, corresponding to 11 to 12 u.a./tce.

([1]) ECSC High Authority, Luxembourg Bulletin No. 52.
([2]) With countervailing duties on entry at 4 % per ton of crude petroleum.

Conclusions

In nuclear plants to be started on in the near future and completed by the end of the present decade, electricity will be generated at the same cost as in conventional thermal plants purchasing their fuel at a delivered-plant price of 10 to 12 u.a./tce for an annual utilization time of 6,000 to 7,000 hours.

The minimum price to be taken as an effective basis of comparison in about 1970 will be:

— for Community-mined coal: not less than 15 u.a./t ex-pit;

— for steam-coal imported from the US (bituminous slacks): 13 to 14 u.a./t cif European ports;

— for fuel-oil: 16 to 17 u.a./t ex-refinery or 11 to 12 u.a./tce.

It may accordingly be postulated that the profitability outlook for nuclear power plants as outlined above will be borne out by events.

DOCUMENT No. 2 **PROVEN-TYPE REACTORS**

I. Light-Water Reactors

This year saw clear confirmation in the United States of the trend observed last year to the effect that light-water-moderated reactors, particularly those of the boiling-water type, would soon be competitive with conventional installations. Contracts were concluded for the construction of several power plants—Oyster Creek and Nine Mile Point, with a capacity of more than 500 MWe, and more recently Dresden-2, with an output of around 800 MWe, which shows that high-output nuclear power plants are now competitive in the United States.

This has largely been achieved by major reductions in the cost of investments, which, by the American system of accounting, total less than 100 dollars per installed kW in the case of the latest figures published, i.e., 15% less than the rate set by General Electric in September 1964. While it is not claimed that all the technical posers have now been completely mastered, these figures nonetheless indicate that the transition stage has been reached in which prototype plants make way for industrial plants which will be able to be further improved, particularly with regard to fuel cycling costs, by raising depletion rates as greater advances are made. These figures are also the result of extrapolations made on the basis of data acquired in the operation of plants now in service, and these extrapolations now have to be rendered more accurate or corroborated by statistical in-pile results.

In view of this spectacular progress sight should not be lost of the situation in Europe, which is lagging noticeably behind the United States and must be corrected by large-scale and carrefully selected action. This is one of the aims of the Euratom/US Agreement for Cooperation.

1. *Joint Euratom/US Programme*

In 1964 the Joint Board gave the go-ahead for the negotiation of 22 contracts in the Community, including 17 extensions, and 19 in the United States,

including 12 extensions. Commitments totalling around 45 million EMA u.a. —24 million in the Community and 21 in the United States—have been entered into since the launching of the Joint Euratom/US Programme. In addition to this, proper note should be taken of the rapid exchange of information obtained under the USAEC's own programme which is now in progress between about twenty American laboratories and their counterparts in the Community in the field to two-phase flow and plutonium recycling. It is regrettable that these exchange agreements cannot be backed up by adequate participation on the part of Community engineers in work now being carried out under contract in Europe and the United States. Owing to the limited personnel available it has not proved possible to maintain this participation at its previous level, which was already low enough.

Since January 1964 the results have been published every quarter in summary form in "Euratom Information" instead of in the "Joint Research and Development Program Quarterly Digest" as previously.

2. *Experiments on Power Reactors*

In the Seventh General Report mention was made of the present trend whereby laboratory studies are complemented by experiments carried out in the plants themselves. This was given concrete form with the coming into force of a contract drawn up with SENN, in collaboration with General Electric and the USAEC, the object of which is to amass, under normal operating conditions, additional data on reactor performance limits. The results should be applicable to other boiling-water reactors.

A computer is already being used for recording the numerous parameters of the plant and for sifting all the data obtained.

The Community industry has assigned the greatest possible number of engineers to the task of ensuring that the enterprises and laboratories concerned are kept well informed.

3. *Nuclear Fuels and Materials*

Major activities have continued to be devoted to uranium-oxide-based fuels, with a particular view to optimizing the preparation of molten powders suitable for use in vibration-compacted elements.

The basic properties of UO_2 were studied on single crystals over a wide range of temperatures and U/O rations. The fission gas diffusion studies

were continued on both single crystals and sintered pellets by means of two classical methods of post-irradiation out-of-pile heat treatment and continuous measurement during irradiation. The influence of high-temperature evaporation above 1700°C was evidenced in particular.

Vibration-compacted and pelleted rods were successfully irradiated up to average burn-ups of 20,000 MWd/t under very severe conditions until more than 30% of the volume of the rod, and, in the most loaded zone, about 70% of the cross-section of the UO_2, could be maintained in the molten state. This thus corroborates the hopes previously placed in the good behaviour of uranium oxide under rigorous specific power conditions substantially in excess of those encountered in the reactors now in service.

The irradiation behaviour of uranium nitride was verified up to burn-ups corresponding to fission of 5% of the uranium atoms. A swelling of 2-4% was observed.

The studies on the irradiation behaviour of uranium carbide were pursued despite difficulties which arose with the irradiation devices.

The zirconium-niobium-tin alloy developed in the Community was subjected to in-pile tests to compare it with Zircaloy-2. Owing to its mechanical properties its strength characteristics are about twice as good as those of Zircaloy-2 at normal operating temperatures while its corrosion resistance is about the same. It is planned to use this alloy for canning prototype fuels in a small power reactor in 1965.

Valuable results were obtained concerning the corrosion of stainless steels, in particular cracking due to the simultaneous action of mechanical stress and corrosion in water or high-temperature steam.

Fast tests in steam with the addition of chlorides and also in chemical media, both of which resulted in cracking very similar to that observed in reactors, revealed the extreme importance of the following factors:

— the purity and composition of the alloy, the study of which is being pursued by the controlled and selective addition of elements to a stainless steel prepared from high-purity metals;

— the surface state of the steel, which is an important factor affecting both fast and general corrosion;

— the oxygen content of the steam which, in dry steam, can be reduced from 25 ppm to a few fractions of one ppb by means of a platinum-based catalyst.

4. *Plutonium Recycling*

The studies in this field are being continued along the lines previously adopted. The programme was extended for a further period of four years, during which neutron measurements are to be carried out in pressurized light-water reactor lattice configurations, together with the optimization of fuel rod fabrication processes involving vibration-compacting and stringent irradiation tests. The twelve rods containing a mixed UO_2-PuO_2 oxide, which were placed in the BR-3 core in November 1963 were extracted in August 1964 at the end of the BR-3 experiment, after having reached the planned burn-up of 6,000 MWd/t in satisfactory conditions. Other rods, fabricated by the same process, are to be inserted into the BR-3/Vulcain experiment in 1965, during which they are to be subjected to an average burn-up of 30,000 MWd/t.

The scope of the studies on the uranium/plutonium/graphite and uranium/plutonium/heavy-water lattices was also extended and their value increased by virtue of the agreements concluded with the UKAEA concerning the exchange of technical data and close collaboration in the isotope analysis of plutonium samples.

Finally, preparation of the mixed UO_2-PuO_2 rods for irradiation in the Saxton reactor during the summer of 1965 is being continued in the United States. Pelleting and vibration-compacting techniques are being used, the plutonium oxide being intimately mixed with the UO_2 matrix. Before loading, critical experiments are to be carried out to check the calculation methods and to estimate the reactivity and power distribution of these rods.

5. *Thermodynamics and Hydrodynamics of Liquids*

The previous programme is progressing satisfactorily with the collaboration of the main specialist laboratories in the Community.

During the past financial year, the work on fog-cooling research was brought to a conclusion, sufficient data being obtained in numerous fields to warrant their use in a reactor design study (see new reactor types).

The work on twisted tape fuels confirmed that the specific power of a boiling-water reactor could be stepped up by about 30% under normal temperature and pressure conditions for this type of reactor.

Encouraging preliminary tests reveal that the assembly system has good

mechanical stability and indicate that vibrations will have no noticeable effect on corrosion.

Representatives of European contract-holders took part in the spring of 1964 in a study and information trip organized by the Euratom/US Joint Board to American laboratories working in the field of two-phase flow and extremely fruitful contacts were thus set up or strengthened on this occasion, which are to be maintained by a direct exchange of reports. Close collaboration has been established between the European and American programmes.

6. *Structural Materials*

The first stage of the studies on these materials, which is now well under way, covers problems relating to the working of steels (welding, plating, etc.) non-destructive control tests on heavy-gauge welded units and their behaviour under the mechanical stresses to which they are subjected during fabrication. Valuable results were obtained in the welding of heavy-gauge pieces with regard both to the relative merits of the various welding processes and techniques and the metallurgical phenomena involved in the welding operation. In particular, numerous sources of embrittlement during manufacture were pin-pointed and appropriate remedies suggested. Studies were carried out on the propagation of cracks and their arrest conditions, various original observations being made which pointed to the possibility of establishing brittle fracture resistance criteria in excess of those used at present.

In the second stage of the programme, which was commenced more recently, studies are to be carried out of the properties of the pressure vessels now in service and, in particular, of the way these properties are affected by irradiation.

The results obtained during the past year concern on the one hand basic problems such as research into the mechanism involved when the transition temperature of steels is raised by irradiation, the influence of the metallurgical state of nitrogen on the variation in the post-irradiation mechanical properties, studies on the nature of the irradiation damage by measurement of the magnetic properties, and also problems of another type, such as the use on irradiated materials of experimental methods developed and tested for non-irradiated materials, the extent of embrittlement as a function of the irradiation temperature, etc.

II. Graphite-Gas Reactors

At the present moment, the eight reactors of the graphite-gas string now in operation or in the course of construction in the Community represent a total power of about 2,000 MWe. Under the Fifth Equipment Plan which begins in 1966, nuclear plants of this type with a total output of 2,500 MWe are to be built in France at the rate of about 500 MWe a year with a possible increase of 1,000-1,500 MWe at the end of the plan. Furthermore, there are plans for the erection of a joint Franco-German power plant and for a Franco-Spanish one. In Great Britain the 28 power reactors of this type already built or in the course of construction total a power of about 6,000 MWe.

During 1964 two nuclear power plants of the graphite-gas type supplied electric power under normal industrial conditions for a lengthy period on the territory of the Community (Latina in Italy and Chinon in France). During the last quarter of the year the load factor of the most powerful of these plants, at Latina, calculated with respect to the net monthly output, was an average of 91.4%, with a rated power of 200 MWe, which can be regarded as highly satisfactory.

From the economic angle, it is felt that nuclear power in the Community should be competitive with conventional sources when the EDF-3 and EDF-4 go into service in 1967 and 1968 respectively, and that the high-output plants to follow them hold out even more promising hopes.

It was in 1962 that the Commission began its activities in this field, in particular in the form of research and industrial development contracts, drawn up with industrial firms and the competent authorities, for a total budget up to the present of 5,522,000 EMA u.a., of which 4,785,000 were earmarked for the second Five-Year Programme.

Under the general scheme for the awarding of contracts, 76 research proposals were received. A total of 17 contracts have been signed so far.

Generally speaking, the Commission devoted its main attention to those research projects which were most likely to lead to a drop in the cost per kWh during the next few years, rather than the longer-term or more speculative activities. In order to assess the value of the projects, reference was made to a future reactor type having the following characteristics:

— power 500 MWe;

— tubular fuel elements of natural uranium; the problems posed by the use of annular fuel elements of high specific powers levels of the order of 10 MWth/t are also worth investigating;

— core and exchangers both housed inside a prestressed concrete vessel, the pressure of the CO_2 being 40 kg/cm^2 and the core being placed above the exchangers.

These data were used to determine the form of the majority of studies and tests described below.

1. *Development of Fuel Elements*

At the present moment work is being carried out on ternary uranium alloys of the following types to undergo burn-ups of around 5,000 MWd/t:

U-Mo-Nb	U-Nb-Zr
U-Mo-Zr	U-Nb-Si
U-Mo-Si	U-Nb-Fe
U-Mo-Cr	U-Nb-Cr

The alloy element content should not entail a neutron absorption greater than that of an alloy containing 0.5 wt.% molybdenum. These studies are to round off those being conducted elsewhere, notably by the French CEA. They concern the metallurgy of alloys, the irradiation of samples, the development of prototype fuel elements of different geometries and in particular large-diameter annular elements, together with the effecting of a bond between the canning and the fuel.

The results obtained hitherto, particularly as a result of thermal cycling tests, have shown that work should centre round the following alloys:

U-0.8 to 0.12 Nb-0.2 Cr
U-0.2 Mo-0.7 Nb
U-0.5 Mo-0.5 Nb
U-0.3 Mo-2 Zr

and on the use of titanium to effect a metal bond between the uranium and the canning. The irradiations of alloy samples will begin in 1965.

A study was made of the fabrication of magnesium alloy herringbone cans by precision-casting. Two processes were tried out at the same time—low-pressure and high-pressure casting. The aim is to reduce the cost of fabricating cans and to improve certain of their technological properties, such as creep resistance. As a result of this work it should be able to set up a firm offer for a pilot series.

An effort is also being made to determine the optimum possibilities for machining monobloc cans, with particular regard to the lenght, depth, thickness and number of fins in the case of four- and eight-segment cans. The complete can will be fabricated from one single extruded blank, thus obviating assembly work. This project will result in the supply of several prototype cans and a firm order for a pilot series.

2. *Heat Transfer*

It was decided to carry out studies of the as yet inadequately investigated phenomena involved in the natural convection of carbon dioxide under high pressure in order to obtain a better insight into problems relating to the thermal insulation of concrete vessels. The data thus acquired will help in the satisfactory execution of two projects now under way. The first is aimed at the industrial development, by a technique derived from that employed for boilers, of a thermal insulation device involving the use of "water screens". On a purely experimental plane, the results obtained with sections of full-size water screens in a pressurized containment are to be verified. The second project concerns the development of a new steel insulating material containing so-called honeycomb hexagonal cells.

3. *Structural Materials*

The corrosion of graphite could be of importance in the case of a reactor in which the annular fuel elements develop a high specific power (about 10 MWth/t) and the gas is subjected to a pressure equal to or higher than 40 kg/cm^2. It was therefore decided to fit the BR-2 high-flux reactor with a test loop to determine the behaviour in controlled atmosphere of the industrial nuclear graphite at present used.

Work is in progress on the temperature and irradiation behaviour of the concrete used in the construction of pressure vessels. The results obtained hitherto tend to confirm that in the majority of concretes studied the compression-resistance of the samples is not markedly affected by heating to 200°C, but that alternate residence in dry and moist atmosphere can lead to difficulties. This research is to be extended to high-strength concretes and heat-insulating and radiation-opaque concretes.

4. *Reactor Physics*

An attempt was made to determine the optimum degree of irradiation which can theoretically be obtained with this type of natural uranium reactor. The fuel elements were of the EDF-2 type, containing 1.1% of molybdenum. For the neutron calculations, use was made of the most recent thermalization models. It seemed reasonable, from the neutronics point of view, to envisage average final burn-ups of 5,000-5,500 MWd/t under economic conditions which can in future be regarded as optimum for all practical purposes.

The experimental measurement of the k-factor in uranium/graphite lattices was carried out for the first time in the Community on lattices of the Latina, Brookhaven and Marius type. This work was conducted in close connection with that undertaken on the Marius critical reactor by a different method. The preliminary results indicate that there is good agreement.

5. *Reactor Technology*

A new method for unloading reactors of the graphite-gas type is now being developed. A "loft" to house the loading and unloading machine is located in the upper part of the pressurized containment. This loft, which is separated from the core by a concrete slab for purposes of heat insulation and radioactive shielding, is kept in a pressurized CO_2 atmosphere of moderate temperature. There are various advantages with this set-up, notably, lightness and simplicity of the equipment, reduction in cost and simpler fuel replacement operation, due particularly to the fact that the machine has direct access to each channel. With this system it is possible to move the fuel around in the core. Satisfactory results were obtained from operating tests on a mock-up at stage 1 of the machine and of the breakdown robot.

Experiments were also carried out under this contract on new and smaller control devices, working mainly by means of chains.

The number of penetrations in a pressure vessel with integral heat exchangers is one of the factors to be taken into consideration in optimizing the steam cycle. A theoretical study of the steam cycle was carried out with regard to different configurations in the primary cycle and turbo-blowers upstream or parallel, with or without superheating, at one or two steam pressures.

Two study contracts were concluded with the aim of improving the prestressed concrete pressure vessels. The one concerned the use, for prestressing the installation, of hydraulic jacks into which a setting substance can be injected.

The other is based on a new method for ensuring the insulation, leaktightness and mechanical strength of the vessel. All this research should make a major contribution towards improving present techniques.

6. *Development Work Relating to the Operation of Power Plants in Service*

The Latina reactor will shortly be used for measurements aimed at the accurate determination of the reactivity curve as a function of the operating time. It is hoped in this way to check the accuracy of calculations which suggest that the burn-up could be raised from 3,500 to 5,000-5,500 MWd/t in power plants of this type, which would result in a reduction in fuel costs of almost a third. Measurements will also be carried out of different coefficients relating to the kinetics of this type of reactor.

DOCUMENT No. 3

HEAVY-WATER AND ORGANIC-LIQUID REACTORS

I. The ORGEL Project

1. *Technical and economic interest of the project*

In the Fifth General Report the Euratom Commission set out its reasons for deciding in 1959 to carry out a thorough investigation of heavy-water-moderated, organic-cooled reactors and to give this research pride of place among Ispra's activities.

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

— as things stand at the present, natural-uranium reactors contribute to Community self-sufficiency with regard to fuel supplies;

— it would certainly appear that the economy of an ORGEL-type reactor compares favourably with that of other types. In particular, the cost of the fuel cycle is very low; furthermore, it is unaffected by the uncertainties with which the costing of enriched-uranium fuel cycles is fraught, such as the buy-back price of plutonium and the reprocessing price;

— the capital costs for an ORGEL power plant are fairly low, since with this reactor string wide use can be made of proven techniques and cheaper construction materials and also because of the low pressure in the reactor vessel;

— in addition, the design allows of extrapolation for high power levels without any appreciable difficulty, as a result of which it is possible to reduce the specific investments further and to extend the potential applications of the string beyond that of electricity production;

— since the coolant outlet temperature is high, 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 output of plutonium is particularly large.

2. *Study of the ORGEL string*

During 1964 the Project Group continued its study on a reference power plant; more particularly, it examined the prospects for technical advances, the fuel cycle and the fissile- and fertile-material economy. Studies were also undertaken on the possible use of ORGEL for industrial steam production or water desalination, either separately or in conjunction with electricity production.

Among the significant technical advances studied, mention can be made of that in the means of control. The improvement consists in replacing the control rods in fuel-element positions by more suitable devices outside these positions, an experimental study being planned; this should lead to better utilization of the positions and to less pronounced flux distortions, resulting in better efficiency. Also worthy of mention is the adaptation of a simplified fuel-management system which puts less stress on the fuel elements without, however, adversely affecting the burn-up: the fuel is inserted at the top of the reactor and extracted at the bottom after passing through the core until it is spent.

Apart from the uranium fuel cycles adopted for the reference power plant, it is possible, in view of the favourable neutron economy of heavy-water lattices in general and of ORGEL in particular, to envisage the use of thorium. With a fuel having an initial U-235 enrichment of about 1.3%, the reactivity can be kept constant up to a burn-up of 40,000 MWd/t without any appreciable degradation of the fissile material, since the U-235 consumed is replaced by the U-233 formed. This forms the basis of the long-term prospects for a string of thermal breeders which would be particularly attractive in the event of a shortage of fissile material; a great deal of both theoretical and experimental confirmation is, however, still required.

Finally, the flexibility of organic-liquid cooling as regards the temperature levels obtainable has made it possible to plan a dualpurpose power plant producing both steam and electricity. Such a plant is of economic appeal and

could be built immediately, the temperature of the organic being reduced to 330°C. A water desalination plant is also under study at the moment.

To sum up, in view of the moderate capital investment required for an ORGEL reactor, the low cost of its fuel cycle, the saving it permits in fissile and fertile materials with uranium cycles and possibly also with thorium cycles, the vistas it thus opens up both for the launching of the fast-reactor string and for the construction of high-conversion-factor thermal converters, and, finally, the flexibility of the ORGEL concept as regards adaptation to various sizes and uses, the ORGEL string is among the most attractive of those at present being studied.

During 1964 the Ispra establishment of the Joint Research Centre continued to make an important contribution to the study of this reactor string in all its aspects and at the same time continued its collaboration with laboratories in the Member States, notably in the form of research contracts.

3. *Research and development programme*

a. *Chemistry*

The study of the behaviour of polyphenyls exposed to heat and radiations remains an essential point in the programme. Critical examination of the results obtained and comparison of them with those of similar investigations —chiefly American—have shown the importance attaching to the exact measurement of the decomposition rate under specific conditions (composition of the liquid and irradiation conditions) if the influence of the various parameters is to be determined.

With the aid of an in-pile loop tests were also carried out under conditions similar to those prevailing in a power reactor by placing in the irradiation capsule an electric heating element giving off 100 W/cm^2 and capable of attaining a surface temperature of 490°C. It was found that the presence of such a hot wall had no visible effect on the decomposition of the polyphenyls. The Ispra laboratories pursued their efforts with a view to understanding the phenomena in question. In this connection, studies on the kinetics of polyphenyl pyrolysis are now in hand as a result of which it will be possible to ascertain the mechanisms involved, notably to the influence of various pressurized gases. In addition, magnetic resonance techniques are proving useful in the study of these problems.

In the field of chemical analysis numerous results are now available from

the routine application of the methods developed in the course of previous investigations. The work is being continued with the aim of standardizing and improving the techniques.

In conclusion, research on new organic liquids has been suspended, to be resumed when circumstances permit.

b. *Physical chemistry*

The basic research mentioned in the Seventh General Report was continued at Ispra. The establishment has been working on improving the ductility of sintered aluminium powder (SAP), a composite material based on aluminium and aluminium oxide. Studies on the behaviour of graphite in an organic medium yielded excellent results, which, however, have yet to be confirmed under irradiation. Further efforts were made to ascertain the behaviour of zirconium and certain of its alloys in polyphenyls; studies on the corrosion of Zircaloy-2 and the alloy ZrNb3Sn1 revealed that the former is slightly superior to the latter. The most important factors are the chlorine content and temperature of the organic liquid, the exposure time and the water content.

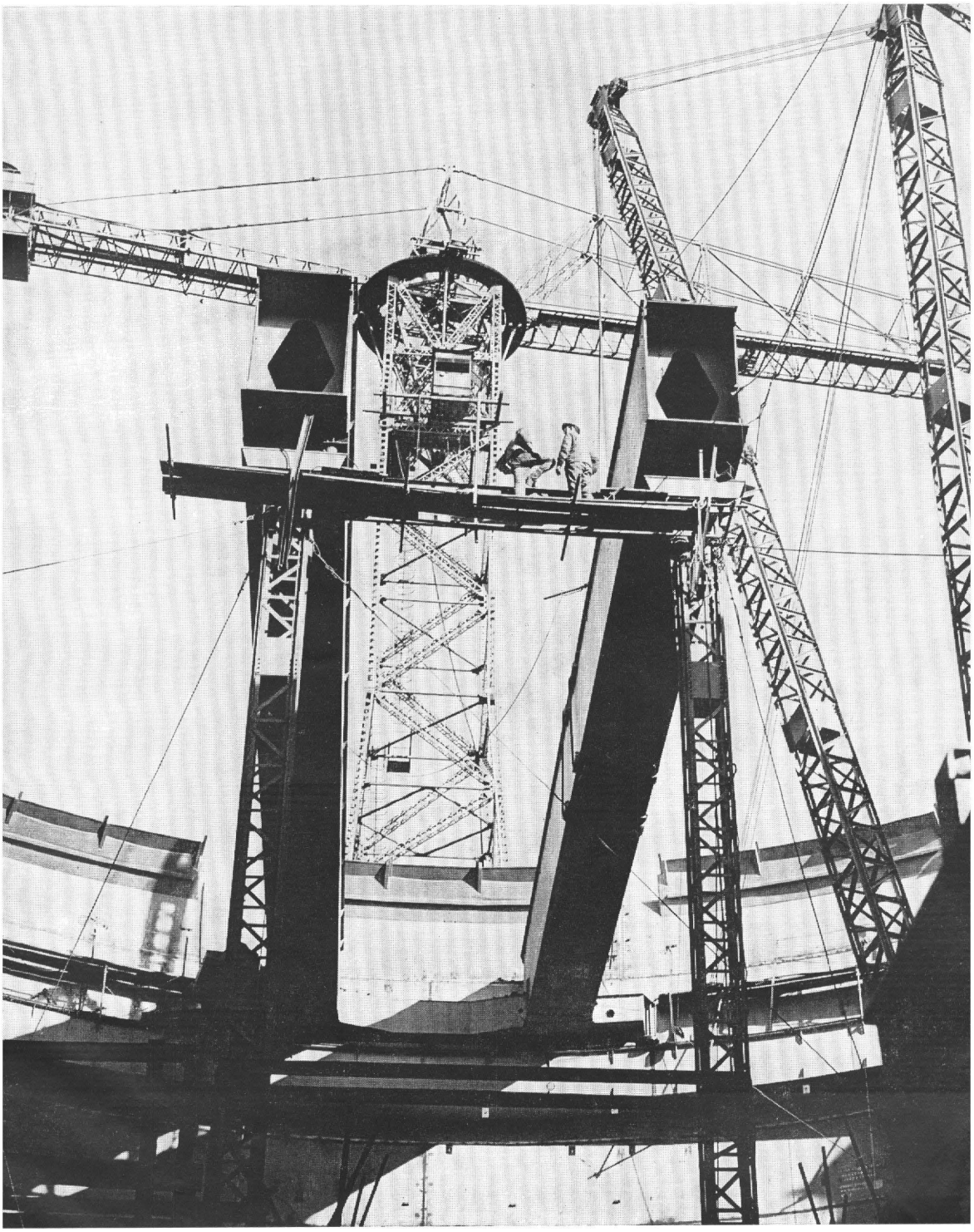
c. *Neutron physics*

The neutronics theories do not permit a sufficiently accurate forecast of the reactivity balances in an ORGEL reactor. Parallel with the further elaboration of these theories, some experiments were conducted in the ISPRA-1 reactor (resonance absorption) and in the Expo exponential assembly (uranium-carbide lattices); others are being prepared for the ECO and RBI reactors (at Ispra and Bologna respectively) with the aim of acquiring a better knowledge of virgin and irradiated uranium-carbide lattices via reconstitution of plutonium-containing elements.

d. *Heat transfer*

Two heat-transfer loops installed at establishments which have contractual associations with Euratom were used to determine the influence of coolant composition, temperature, pressure and velocity, as well as that of the thermal flux transmitted by the can, on the transient boiling state that occurs between normal cooling of the fuel elements (forced convection) and an accident which results in the can melting (burn-out).

These activities, previously carried out mainly under contract, were progressively taken over by the Ispra establishment, which will henceforth have two



ISPRA — ESSOR REACTOR SITE — ERECTION OF THE GANTRY CRANE

(See other side of page for caption)

The ESSOR reactor, cornerstone of the ORGEL programme, is at present under construction on the precincts of the Joint Research Centre establishment at Ispra.

The photograph shows a stage in the erection of the gantry crane, which will serve principally for the loading and unloading of fuel elements as well as for moving the shielding plates and unshipping the top head of the reactor vessel.

heat-transfer loops in operation. The work is to be extended to analysis of the effects of the surface condition of the cans.

e. *Fouling Study*

The work was continued in the hope of revealing the relative importance of the thermal hydraulic and physico-chemical parameters.

These experimental checks are not easy; in the absence of full-scale installations the best that can be done is to simulate an in-pile channel as closely as possible; one of the major tasks is the development of a device for the rapid and simple determination of the fouling rate. It is known, however, what minimum conditions must be fulfilled in order to prevent the formation of undesirable deposits, and the primary object of the work is to attain greater flexibility in the specifications.

In conjunction with these studies the Commission is continuing to investigate methods for the purification of partly decomposed liquids. A device which uses the difference in solubility to remove the heavy decomposition products has operated on a laboratory scale and yielded extremely promising results.

Research on the mechanism of absorbent beds was continued and it is hoped that an early start can be made on the tests to be carried out in collaboration with CNEN.

f. *Technology*

All the activities of the Ispra Technological Service are devoted to the ORGEL project. Data on the pumps, valves and measuring apparatus operating in an organic medium at 400°C are now available in a sufficiently large number from the installations put into use in 1962 for a statistical evaluation to be feasible. Several types of full-scale channels were tested in an out-of-pile loop. The prototype channel for the ESSOR reactor was the subject of a special effort, its behaviour being studied during a number of tests, totalling 500 hours, which showed a few minor modifications to be necessary.

The installation for the study of safety problems in pressure-tube reactors was used to carry out several channel-burst experiments for the ESSOR reactor which were of great help in acquiring an insight into the effect of shock waves. The methods and apparatus developed by the Technological Service for the measurement of stresses and pressure levels gave excellent results and their development is being continued in the very fast range.

Among the results of the other studies in hand mention can be made of the selection of products for the improvement of SAP/SAP friction conditions,

the development of organic leak detectors and leak-tight joints, the promising outcome of research on sprayed-on solid insulation, as well as insulating gas, which is still the reference substance, and the necessity of abandonning the studies on organic-based insulation materials.

g. *Metallurgy and fuel elements*

This part of the programme is being carried out primarily at the Ispra establishments, 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.

The study on the use of sintered aluminium as a cladding and structural material was continued; further improvements were achieved in the fabrication of the powders (elimination of iron inclusions, reduction of the carbon content), resulting in better ductility and greater reproducibility of the mechanical properties. The checking of smooth cladding tubes no longer presents any problems and that of pressure tubes hardly any; only that of finned clads still forms the subject of continuing research.

Uranium carbide continues to be the basic ORGEL fuel. The checking of the composition and acceptance of the 7.5 tons supplied for the ECO reactor are almost completed and have shown that tight specifications could in future be stipulated for large deliveries. It should also be mentioned that the process for the preparation of UC by reducing UF4 with aluminium, developed in the laboratory by the Chemical Department under another programme, is being studied with a view to its application for the reprocessing of waste in the present process for working up uranium carbide for ORGEL.

The workshop for prototype fuel-element fabrication assembled fuel elements for the ECO reactor and constructed mock-ups of the first elements to be tried out in the experimental zone of the ESSOR reactor; these mock-ups have already successfully undergone endurance tests in an out-of-pile loop as well as various thermal cycling tests.

The irradiation preparation programme was brought to a successful conclusion and is expected to lead to in-pile insertions in various reactors early in 1965.

4. *Studies and constructions*

— *The ORGEL critical and exponential assemblies*

Construction of the ECO critical assembly was held up owing to tech-

nical difficulties encountered during assembly. Tests using light water are scheduled for the very near future.

The programme of studies on uranium-carbide ORGEL lattices was started in the Expo exponential assembly, in which a complete series of experiments was conducted with fuel elements made up of seven uranium-carbide fuel pins.

— *ESSOR (Essai ORGEL) test reactor*

Construction work on ESSOR proceeded according to plan during 1964. The rough work on the 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 was manufactured and installed. The outside buildings are 70% complete.

Orders for the construction of the various reactor subassemblies were placed throughout the year and construction commenced at the suppliers. 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, after a call for bids, the order for these fuel elements was placed at the end of the year.

5. *The EURATOM/Canada agreement and tripartite cooperation*

Cooperation with Canada continued normally during the past year, notably in the irradiation field. However, having decided to concentrate their resources on the CANDU reactor string, Atomic Energy of Canada Limited began to cut back their research effort on the organic liquid/heavy water programme. Nevertheless, it is proposed to maintain and even reinforce the "irradiation" activities in Canada, chiefly through intensive use of the U3 loop and, subsequently, of the WR1 reactor. It is along these lines that the renewal of the EURATOM/Canada Agreement for Cooperation is envisaged.

There has been a revival of interest on the part of the USAEC in the reactors of the ORGEL string, as was shown by an ambitious programme proposal. This is resulting in an intensification of contacts at the technical level.

II. The HALDEN reactor

The Commission's participation in the Halden reactor came to an end on 30 June 1964. The experimental work was finished at the end of 1963, as planned, and the first six months of 1964 were devoted to the interpretation of the results and the compilation of reports. The spontaneous power fluctuations noticed during operation of the reactor on its second fuel charge were attributed to the formation of vapour bubbles in the moderator owing to expansion caused by a pressure drop.

III. The PRO project

The Commission's negotiations with the Comitato Nazionale per l'Energia Nucleare (CNEN) resulted in a contract of association which took effect on 1 April 1964, since when the programme has related mainly to the following three points:

— Heat transfer with organic liquids in an undersaturated nucleate-boiling state under conditions of natural or forced circulation was studied, together with the determination of the critical flux and measurement of the void fraction. Tests were carried out at temperatures appropriate to an organic-moderated reactor (300°C).

— Development of a rack-and-pinion drive mechanism for control rods was completed.

- – Numerous operating tests were performed with ball-bearings and metal bellows in an organic medium.

— A CIRO in-pile irradiation loop was installed in the ISPRA-1 reactor and the test section prepared. A large number of out-of-pile tests was carried out on mock-ups with a view to this experiment. An operating manual for the post-irradiation tests and a draft safety assessment were compiled.

DOCUMENT No. 4

HOMOGENEOUS REACTORS

During 1964, studies were continued in collaboration with the KEMA on the development of an aqueous-suspension reactor.

The irradiation behaviour of suspensions received particular attention as a result of the considerable uncertainties still obtaining in this area. Certain advances were achieved in connection with physics, instrumentation and the development of special components, so that a start could be made on evaluation studies for this reactor string.

In the present circumstances, the Commission has decided against making any financial contribution to the construction of the KSTR reactor experiment. This reactor is at all events to be built by the KEMA, which will bear the entire costs, but the fuels developed under the contract of association with Euratom will be able to be tested in it.

DOCUMENT No. 5

FOG-COOLED REACTORS

The studies on medium-power reactors moderated by heavy-water and cooled by low-density water/steam mixtures or fog (CIRENE project) were carried out entirely under the direction of CISE (Centro Informazioni Studi ed Esperienze) of Milan, under a research contract financed jointly by Euratom and CNEN. This contract, which was negotiated during the second half of 1964, will be submitted forthwith to the interested parties for approval. The main objects of the CIRENE project under the current five-year plan are as follows:

— 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;

— to study a high-power CIRENE reference reactor;

— to draw up a preliminary design for a prototype reactor.

1. *Technical and economic interest of the project*

The interest of the CIRENE concept lies in the fact that it combines the advantages of heavy-water, pressure-tube reactors with those of boiling-water, direct fuel-cycle reactors whilst eliminating the drawbacks of both. The interest of heavy-water, pressure-tube reactors was described in Document 3 in connection with the ORGEL project. Fogcooling is advantageous because the coolant used is the familiar light water and because the steam cycle is direct, without intermediate heat-exchangers. Finally and most important, the concept is based largely on experience gained with proven-type water reactor strings as regards all problems of technology and materials.

2. *Design studies*

The primary object is to compare the merits of the two reactor versions corresponding to the two types of fuel suitable for CIRENE, namely uranium metal in the form of tubes internally clad with Zircaloy-2 by co-extrusion, and uranium-oxide rodlets clad with Zircaloy-2 and assembled in clusters.

Optimization studies for these two reactor versions were carried out, consideration being given also to cases in which the critical conditions in the channels are exceeded.

Furthermore, the mechanical design of the channels for both reactor versions was started and dimensioning of the steam circuit was effected, account being taken of the special exigencies as regards safety and stability.

Fuel management and the design of the charging machines were studied by SORIN. A cost evaluation for these units was also carried out.

3. *Research and development programme*

a. . *Neutron balance*

In order to arrive at a better forecast of the neutron balance in the CIRENE lattice and the evolution thereof as a function of fuel exhaustion, various calculation codes were developed, based on the mass of experimental data shown in the special documentation attached. As regards lattices with internally-cooled uranium-metal tubes, a programme of critical tests and determinations of the fine flux structure was successfully carried out on the Aquilon-II reactor at Saclay. A sub-critical assembly for measurement of the cell parameters was also constructed. This device, which is installed at the Milan Polytechnical Institute, will be fed with neutrons from the thermal column of the L-54 pile.

b. *Thermal and hydrodynamic balances*

Heat-transfer tests were carried out with the aim of ascertaining the influence of various parameters on burn-out, the nature of the heat transfer in cases where boiling crisis conditions are exceeded and the density of water/steam mixtures. Two loops were used for this purpose, one at Genoa for heating cross-sections simulating cluster geometries, the other at Plaisance for cross-sections simulating annular bores.

The density of the water/steam mixtures, which is important on account of the effects it has on the neutron balance of a CIRENE reactor, was studied by analogy in an adiabatic loop, in the cold state, with water/argon mixtures.

Density measurements in conditions representative of a reactor channel will be performed with the aid of a loop now being constructed at Plaisance.

c. *Fuel*

The main effort in this sector related to the tubular uranium-metal fuel element. An extensive literature search was carried out by SORIN on the properties of this metal and of Zircaloy-2, the methods of fabricating these tubes, their behaviour under irradiation, etc. In addition, a few internally clad uranium-metal tubes were prepared by Nuclear Metals by the co-extrusion process.

At CISE, moreover, an installation was built for the study, under fully representative conditions, of the compatibility of the uranium metal with the coolant in the event of a canning burst.

As regards uranium-oxide fuel, vibration-compacting tests on rodlets were carried out in a small installation in which air/water mixtures were circulated.

Finally, a detailed design study was recently started on a loop for the large-scale irradiation testing of CIRENE channels, to be installed in the ESSOR reactor.

d. *Dynamics and stability*

A special effort is being made in this field in view of the reactor's positive power coefficient. A number of codes were developed for estimating the space- and time-stability and transientstate behaviour of a CIRENE power plant.

With the collaboration of CNEN analog simulations were performed on the computors at the Cassaccia centre.

The safety studies, notably as regards the consequences of a primary-circuit burst, were also started in view of the positive void coefficient.

Finally, at the experimental level, determinations of the power/coolant-density transfer function were carried out by analogy in an adiabatic loop, in the cold state, with circulation of gas/water mixtures. These measurements are to be continued under representative conditions in a loop at present under construction at Plaisance.

e. *Chemistry and physical chemistry*

In-pile corrosion tests on samples of Zircaloy-2 and stainless steel in contact with water/steam mixtures were continued during the first half of 1964.

They will be resumed at higher power in the spring of 1965, when the Avogadro reactor at Saluggia is started up again. The chemical tests on the water were also continued, together with the determinations of the efficiency of filters for the retention of corrosion products.

Finally, a small out-of-pile installation was built at CISE for studying the fouling of heating surfaces when the critical flux (burn-out) is exceeded.

DOCUMENT No. 6 **ADVANCED GAS REACTORS**

1. *DRAGON Project*

In November 1962 the Commission took part in the extension of the DRAGON agreement to March 1967. This agreement will in future cover, in addition to the construction and operation of the reactor experiment, a comprehensive research programme together with technical and economic studies and the fundamental plans for a high-temperature power reactor based on the same principle as DRAGON and incorporating the know-how gained with it.

Construction of the reactor experiment, begun in 1960, is virtually completed. It went critical on 23 August 1964 and will reach full power in the spring of 1965. It will be used for testing fuel elements for future power reactors of the same type (particles of uranium and thorium bicarbide coated with pyrolytic carbon and sometimes silicon carbide) as well as for studying various engineering problems such as the operating behaviour of gas-bearing blowers, the leaktightness of the primary circuit and the helium coolant clean-up.

In 1964, prototype fuel elements were tried out in several piles in Europe (Studsvik in Norway, Riso in Denmark, Würlingen in Switzerland and PLUTO in England) and in a high-temperature helium-cooled loop installed in the BR2 reactor. The tests were carried out in conditions approximating to those which will obtain inside a power reactor of this type. The results provide grounds for hope that burn-ups of around 100,000 MWd/t may be achieved in power reactors without any need for fission product elimination and with no risk of undue contamination. This, at least, is the conclusion to be drawn from the test conducted in the PLUTO reactor at Harwell, where a fuel element half as long as a DRAGON element was irradiated for six months under thermal conditions virtually identical with those in DRAGON, with direct cooling, without any purge system and with an active gaseous isotope release rate of the order of 10^{-5} to 10^{-6} of the formation rate.

The technicians working on the DRAGON project have completed the fuel element fabrication line and have produced thirty zirconium carbide elements

(feed zone) and ten thorium elements, which are representative of the fuel elements used in a power reactor. Work was commenced, and is to continue in 1965, on developing fuel by new methods by means of which, in particular, new fuel elements can be fabricated by remote-control from reprocessed irradiated elements.

The physics group continued to prepare the ground for the start-up of the reactor experiment. Work was continued on the evaluation and optimization of the neutronics of a power reactor based on DRAGON. A preliminary study of the general concept of this reactor was completed in 1964 with reference to a 1250 MWth (535 MWe) installation. The study was carried out in collaboration with a group of industrial firms in the Community, to which a design study contract was awarded at the beginning of 1963. This confirmed the economic appeal of a high-temperature gas-cooled thorium power plant. Owing to the use of a fuel cooled directly by helium, without any purge system, and of a prestressed concrete pressure vessel, the general design of the reactor has been simplified considerably. The prestressed concrete vessel makes it possible to apply higher helium pressures and thus to reduce substantially the size of the heat exchangers and the pumping power required. The cost per installed kW—which emerges from the study—is about $ 145 (£ 52), not including the site costs, which would normally be borne by the buyer. It thus ties up with the estimate already made of the tender price (turn-key basis).

Mass transfer problems are still being carefully investigated. The main point concerns the leaktightness of the exchangers, but the problem of the carbon deposit in them should at the same time not be ignored. In this field the DRAGON reactor itself will not yield accurate data. From the point of view of temperature and operation, its exchangers are not typical of those in power reactors. Experience on an industrial scale can only be obtained from the AVR reactor at Jülich or from that at Peach Bottom.

Unforeseen difficulties recently arose owing to the dimensional instability of graphite under irradiation, for it was found that the shrinkage of the graphite observed even at low temperatures increased as a function of temperature, particularly above 1000°C. This problem could probably be solved by keeping the graphite at temperatures of 800-900°C or perhaps by using new types of graphite which are less susceptible to this phenomenon.

2. *THTR Association*

Alongside the DRAGON project, the Community also signed a contract of association with the Kernforschungsanlage Jülich Nordrhein-Westfalen and

the firm of Brown Boveri/Krupp in 1964 for the development of a thorium pebble-bed reactor with the indirect financial backing of the German Ministry for Scientific Research. The contract of association is made up of three more or less parallel stages:

a. a research and development programme relating to the following points:
- — fissile and fertile fuel elements with irradiation tests and post-irradiation examination;
- — reactor physics;
- — reactor technology: loading/unloading circuit with burn-up measurement of each pebble, pressure vessel, exchangers, auxiliaries, etc.;
- — reactor chemistry.

b. prototype design:

This will lead to the design of a prototype having a thermal power of about 500 MWth. The design study will commence as soon as sufficient data are available. The technical details of the prototype will have to be fairly accurate to permit their extrapolation to economically feasible high-capacity installations without involving any fundamental modifications.

c. operation of the AVR reactor:

A contract has been concluded between the THTR Association and the AVR Company covering the operation of the AVR reactor at Jülich which, right from start-up, can serve as a full-scale technical experiment to yield fresh data on the operation of a pebble-bed reactor and on fuel element behaviour.

DOCUMENT No. 7

FAST-NEUTRON REACTORS

The Commission's programme in the fast-reactor field, together with the installations necessary for its implementation, were described in the preceding report. Chapter II of this report outlines the state of progress of the work being carried out under the major contracts of association. Mention is also made of the agreements drawn up for supplying fuel for the SNEAK and MASURCA critical assemblies. Furthermore, the range of the activities involved has been widened by two important decisions taken in 1964. The first was the conclusion in June of an "exchange-of-information agreement" with the USAEC, the second the signing of a supplement to the contract of association with the CEA, extending its scope to development of the fast-neutron reactor string.

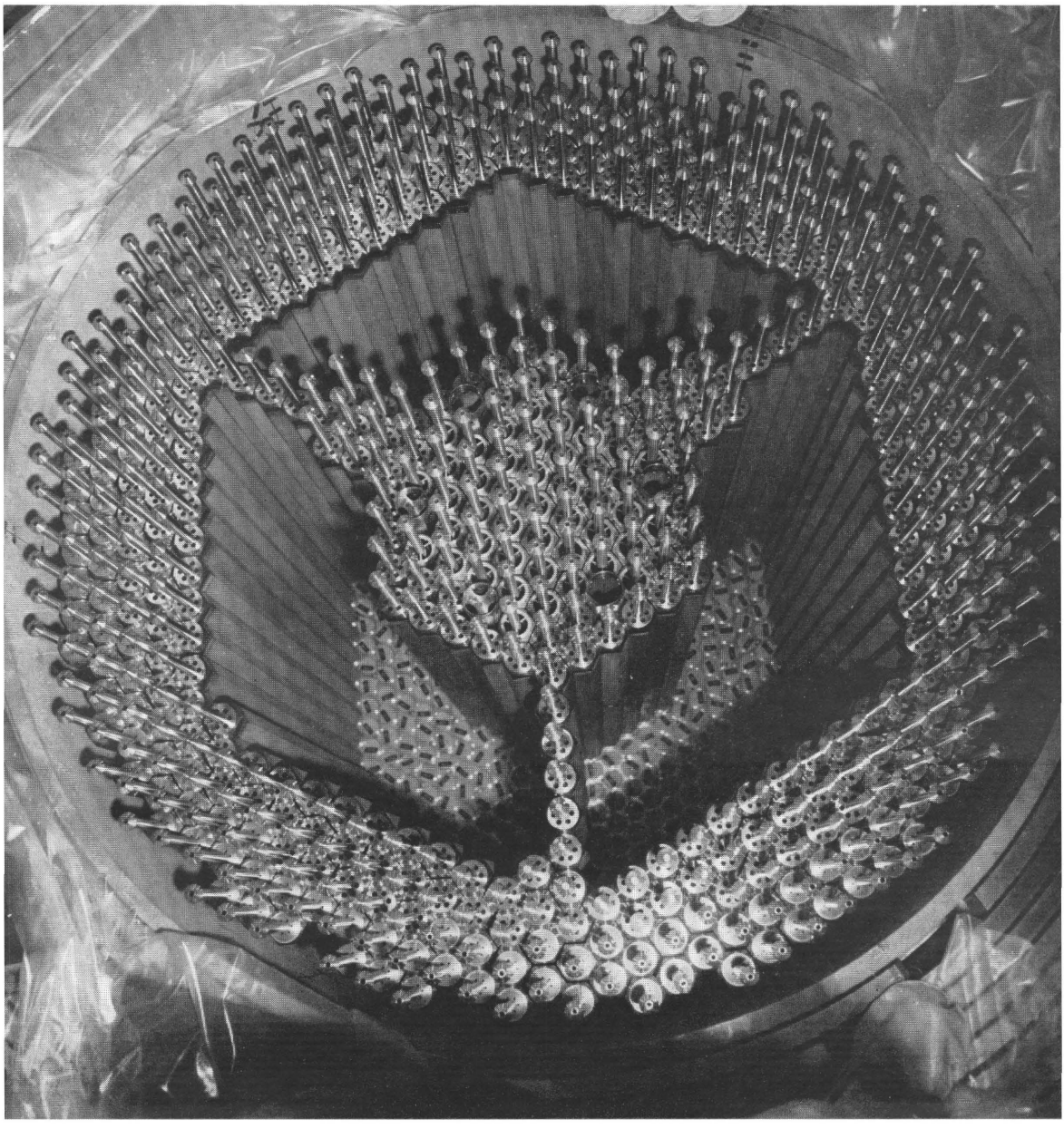
The agreement for the exchange of information with the USAEC will relate to the results of scientific and technical research or development work on the design and construction of non-nuclear test installations, critical assemblies, experimental reactors and reactor prototypes, including their fuel cycle, coolant and components; operating data in respect of these plants; information on the progress of this work and on the programmes and time-schedules for future activities.

This exchange of information will be effected by the following means: official and non-official reports (e.g., research and development memoranda) relating both to specific subjects and to the status of the work; drawings of equipment, components and installations; correspondence on particular subjects between appointed employees of the parties to the agreement (and of their respective contractors and associates); visits by personnel and long-term secondings.

This exchange will be limited to non-classified information. The parties will pass on to each other, without delay, important technical information in a sufficiently detailed form to enable one or the other to design, construct and operate fast-neutron plants and experimental and prototype reactors, as well as all pertinent information concerning research and development, safety and economy.

With regard to the supplement to the contract of association concluded with the CEA, the object is to carry out studies and work relating to the develop-

ment of the fast-neutron reactor string, including in particular studies on the large fast reactors of the future (500 and 1000 MWe) and the finalization of the prototype reactor which is to confirm experimentally and on a smaller scale (100 MWe) the validity of the solutions chosen, and certain additional tests relating to the RAPSODIE reactor fuel.



CADARACHE (France) — FULL-SIZE MODEL
OF THE RAPSODIE REACTOR VESSEL

(See other side of page for caption)

RAPSODIE is a 20 MWt experimental fast reactor which is sodium-cooled and uses a plutonium-based fuel. It is being constructed at Cadarache under a contract of association between the French Atomic Energy Commission (CEA) and Euratom. Start-up is scheduled for the end of 1966.

The photograph shows the arrangement of the hexagonal fuel assemblies and the circular control rods inside the reactor. The framework supporting the fuel assemblies can be seen between the three spaces not yet occupied.

DOCUMENT No. 8

CONTROLLED THERMONUCLEAR REACTIONS

At the present moment the hopes that the energy from controlled nuclear fusion, which would be available in virtually unlimited quantities, can be harnessed for peaceful uses are bound up with the possibility of creating and confining, i.e. isolating from the material walls a plasma of hydrogen isotopes raised to a temperature of some hundreds of millions of degrees with a density and a lifetime the product of which must exceed a certain limit value (about 10^{14} sec/cm^3 under the most favourable conditions).

Confinement of this nature only appears possible with the aid of magnetic, or more generally electromagnetic fields.

A magnetically confined plasma is necessarily in a thermodynamic non-equilibrium state from the standpoint if its geometrical configuration and frequently from that of the velocity distribution of the component particles. It follows that the confinement can only be of a temporary nature. The question is to determine whether this lifetime, which is necessarily limited, is sufficient for the purpose. Studies must therefore be carried out on the numerous processes which are likely to lead to the breakdown of the confinement. Of all the various processes involved, that of diffusion due to particle collision is the most apparent. If this were the only snag, the problem would be near solution, but unfortunately other mechanisms about which little is as yet known, particularly instabilities, have an even more serious effect. Thus the main effort is centred on these instabilities and, as a corollary, to those production methods (accumulation and heating) and confinement configurations which are least likely to give rise to them.

With regard to magnetic configurations, mention was made in the 1963 Report of new types (magnetic wells) which indicate the possibility of archieving a certain stability. Studies on them were continued in 1964 on both the theoretical and experimental levels and yielded, partially at least, encouraging results.

With regard to the production of a hot plasma, mention should be made, in addition to the continued work on methods devised in the past (e.g. resonance), of studies on the development of new concepts aimed at making use of certain non-disastrous instabilities (turbulent heating).

As well as these advances in the classical field of confinement, which, although unspectacular, are nonetheless of undeniable value, note should be made of certain trends aiming to achieve fusion by instantaneous accumulation of a large quantity of energy in a small volume inside a fusionable mass. Work in this direction, too, is fraught with a number of problems and is at the moment at too early a stage for any assessment of its potential value to be made.

I. Theoretical Studies

The theorists continued their work on problems of a general nature and on special studies related to experiments now under way or in the course of preparation. Their activities thus cover an extremely wide field, ranging from studies on such fundamental problems as irreversibility to the calculation of electrical circuits and magnetic windings.

In the sphere of basic studies, mention should be made of the work on kinetic theory, its connection with macroscopic phenomena and irreversibility (Garching) and the studies on the thermodynamic aspect and on transport coefficients (Fontenay-aux-Roses, Garching).

Boltzmann the collisionless equation has formed the subject of many studies, particularly with regard to solution methods (Jülich) and certain deductions of a general nature (Jutphaas). Work is continuing, notably at Jülich and Frascati, on studies dealing with the movement of charged particles in a magnetic field. Stability theories and the conditions for their validity were investigated at Fontenay-aux-Roses in particular.

With regard to activities bearing more closely on the experimental work, mention should be made of a number of studies concerning the stability of special configurations and under particular conditions, such as toroidal configurations with diffused current (Fontenay-aux-Roses) and surface current (Garching) and tubular pinch configurations of the straight or toroidal type (Fontenay-aux-Roses) and M+S configurations (Garching).

Numerous calculations have been carried out on the dynamics of theta pinches, mainly at Garching but also at Jülich and Frascati.

Fontenay-aux-Roses continued its research into the stability of magnetic wells, account being taken particularly of the effect of the plasma's finite pressure.

Investigations have been carried out at Garching on the theoretical side of the non-linear interactions between the powerful light-beams emitted by lasers and a plasma, with a particular view to diagnostic purposes. The Frascati

laboratory also dealt with the possibilities offered by lasers with regard to plasma production and compression.

Studies on the use of high-frequency electromagnetic waves for heating, confinement and acceleration were vigorously pursued at Saclay and Jutphaas, the work being based on both the movement of individual particles and on macroscopic models.

Almost all the laboratories showed interest in the different types of waves which can be propagated or set up in a plasma, as well as in the stability.

The Frascati team engaged on the production of very-high-density plasmas tackled the theoretical aspect of several problems linked with the work in progress, such as the dynamics of convergent liners, the diffusion of very intense magnetic fields in metals and the physical properties of high-density plasmas. Studies were also carried out at Frascati on means of triggering off a thermonuclear reaction by the impact of fast macroparticles and also on acceleration methods.

II. Experimental Pinch Research

The zeta-pinch experiments were conducted only with regard to basic research into plasma physics with special fieldprogramming conditions. This work was carried out with the aid of the Garching linear devices and the FOM-KEMA at Arnhem, or toroidal ones, such as the TA-2000 at Fontenay-aux-Roses, which is highly suitable for diagnostic purposes and is supplying important data on the ionization phase of plasma and its behaviour under the effect of impurities. With the HARMONICA device, now under construction at Fontenay-aux-Roses, it will be possible to verify the existence of new stability zones predicted by theory.

Our laboratories are engaged on numerous projects relating to theta-pinch, which, despite the brief duration of the confinement, is of great interest for studies of heating processes (by shock waves, adiabatic compression etc.) energy losses (by radiation, thermal conduction, diffusion across the lines of force of the magnetic field end, losses, etc.) and stability. Generally speaking, plasma densities of the order of 10^{16} - 10^{17}/cm^3 were obtained in this way, at temperatures ranging up to several million degrees and for a confinement period of several microseconds.

The experiments carried out on the small and medium-size linear devices (5KJ at Jülich, 40-100 KJ at Garching, 144 KJ at Frascati) were encouraging, but owing to axial plasma losses, put down to the low dimensions of some

of these devices, it was decided to design two larger experiments. One at Jülich, of 0.6 MJ, is already in operation and has been improved to reduce the plasma drift due to the non-uniformity of the magnetic field, while one at Garching, which is designed to run ultimately at 2.6 MJ, is now at the testing stage.

Theta-pinch devices in a toroidal geometry, equipped with additional windings (M+S) to counteract the lack of equilibrium inherent in this type of geometry, have gone into service at Garching (QUASILIMUS) and Munich (DREHFELDTORUS). An increase in the lifetime was observed, thus confirming the planned influence of the M+S windings.

Alternative pinch experiments (Jutphaas) were planned in order to obtain mixed configurations of magnetic fields with longitudinal and azimuthal components combined in a variable proportion, with provision for a field rotating versus time. So far no sign of instability has been detected in the particular case of helicoidal pinch and the discharges were found to be reproducible.

With regard to mixed-configuration pinch, mention should also be made of the tubular pinch experiments carried out at Fontenay-aux-Roses and Garching, in which a tube of plasma is confined between an internal azimuthal magnetic field and an external longitudinal field. With the EPPE device at Fontenay-aux-Roses it was already possible to obtain a confinement lasting 250 μ/sec. with a density of $2 \times 10^{15}/cm^3$, but at a relatively low temperature (500,000°C). This temperature, obtained by ohmic heating, was limited by the maximum current intensity compatible with stability and by the cooling of the plasma on the electrodes. The first of these limitations resulted in the installation of a cyclotron heating device and the second in the design of a STATOR toroidal device, which will soon go into operation.

At Garching, experiments of this type have been directed mainly at the creation and study of cylindrical-symmetry shock waves.

III. Magnetic-Mirror Machines

The experiments aimed at the build-up and confinement of a plasma in magnetic mirrors or in more advanced configurations were pursued with the aid of different methods of plasma production.

a. *Energetic ion injection* (Fontenay-aux-Roses and Jutphaas).

At Fontenay, the MMII device gave a density of 10^7-10^8 ions/cm^3, together with a confinement time of the order of several hundred micro-

seconds, which is compatible with a loss mechanism due to charge exchange. No instability was observed. The work was concentrated mainly on improving the magnetron ion source (current injected up to 200 mA) and on the improvements introduced in the vacuum system by means of cooled titanium pumps.

Furthermore, the CAPEL A and B devices were used for experiments on plasma build-up by the temporary capture of particles injected (for the time being only electrons) into a mirror configuration in which the lines of force of the magnetic field display undulations.

At Jutphaas, the device for the injection of ions into an intense four-pole magnetic field has just gone into service and the initial observations bear out the lifetime calculations. An attempt was made, in particular, to step up the ion current, as a result of which a figure of several hundred MA was reached.

Generally speaking, as technical developments stand at present, and as moreover, has been observed in Britain (PHOENIX), the United States (ALICE and DCX) and the Soviet Union (OGRA), the densities of trapped ions are still very limited with this method of injection owing to the presence of neutral gas (charge exchange and incomplete burn-out) and plasma rotation due to instabilities.

b. *Injection by plasma guns*

At Fontenay-aux-Roses the performance of the DECA-II machine was improved by adding four-pole Joffé bars (setting up a magnetic well). Densities of 10^{10}-$10^{14}/c^3$ were observed for a plasma of over 10,000°C. The total confinement time was stepped up, being appreciably greater than 200 μ/sec at low densities (10^{10}) and above 50 μ/sec at high densities (10^{14}).

However, although this modification has improved stability, secondary phenomena, due to the low dimensions of DECA-II, prevent the build-up of a plasma of the required temperature, density and volume, for which reasons work has been started on a new, larger unit - DECA-III.

In connection with these injection problems, mention should be made of the activities dealing with plasma guns.

At Fontenay-aux-Roses a gun has been evolved which is fitted with three coaxial electrodes and with which plasmas of various characteristics can be

obtained, depending on the operating conditions, namely, densities from several 10^{12} to several $10^{13}/cm^3$, velocities from several 10^6 to several 108/cm/sec and temperatures from several 10^4°C to 10^6°C.

The radial gun at Jutphaas yielded results in good agreement with the theoretical findings, the frontal velocity exceeding 5×10^7 cm/sec and the final density 10^{16} ions/cm^3. Furthermore, a start was made on improving the purity of the plasma with a view to its injection into a cusp configuration. Guns fitted with a progressive-wave acceleration system (Jülich) enabled velocities of 10^8 cm/sec to be obtained, which can doubtless be increased when the present modifications are finished. Apart from their possible use in fusion, guns of this type might also find application in spacecraft propulsion.

Studies were carried out at Fontenay-aux-Roses by means of a two-gun device (BETA-A) on the collision of two plasma puffs the ion temperature and density of the post-collision plasma, together with the influence of these factors on its diamagnetism, being determined as a function of time with the aid of spectroscopic measurements. Another device (BETA-B), of more sophisticated design and of larger dimensions, is now being tested.

Work is in progress at Garching on a project for the build-up of a dense, hot plasma in a mirror with a superimposed multipole field, based in the principle by which ions and electrons are simultaneouslyheated up by electromagnetic expectation of their respective cyclotron frequency.

With regard to plasmas rotating in mirror configurations under the effect of perpendicular magnetic and electric fields, KRUISVUUR-1 at Amsterdam has yielded densities of $5 \times 10^{15}/cm^3$ at temperatures of up to 100,000°C. An improved device KRUISVUUR-2, fitted with a better vacuum system and designed for use in stability studies on rotating plasmas, is now being assembled.

Certain experiments on theta-pinch were combined with a magnetic cusp-type configuration.

IV. Build-Up of Very High Density Plasma

A large proportion of the work carried out in the Frascati laboratory is devoted to the production of very high density plasmas. The MIRAPI experiment, which concerns the radial contraction in vacuum of a thin cylindrical layer of plasma by means of a Z-pinch mechanism, yielded an axial cord of very

dense plasma. The drawback was revealed relating to the method used in the build-up of the initial layer, it being found that the energy supplied to the plasma is partially dissipated in the layers following the main front. Studies are being carried out on new techniques, such as the pulsed release of hydrogen by a wall of palladium and the hypersonic injection of a gas jet.

With regard to the MAFIN experiment, which involves the compression of a magnetic field and, subsequently, a plasma cord by the implosion of a metal liner propelled by chemical explosives, studies were continued on the generation of magnetic fields of several million gauss in different geometries. The device for building up the plasma due for compression has already been constructed. Improvements have been introduced in the methods for measuring very high fields by Faraday's effect. In addition, use was made of chemical explosives for generating currents of very high intensity.

Finally, work was commenced, also at Frascati, on studies relating to the build-up of plasmas by lasers. In the HOT-ICE experiment, a light beam emitted by a very powerful laser (about 500 MW) is concentrated on a small icicle of hydrogen which is thus converted into a plasma. A preliminary test showed the efficiency of the device. A much more powerful laser (about 10,000 MW) is now being assembled. Note should also be made of the IRMA experiment (Fontenay-aux-Roses) on the interaction of lasers and matter with a view to plasma formation.

V. Build-Up and Confinement of a Plasma by High Frequency - Miscellaneous Research

The research carried out at Saclay with the aid of the ICARE II and IV devices on the build-up and confinement of a plasma by a high frequency electromagnetic field with or without the presence of a static magnetic field have corroborated the theoretical trajectory calculations.

Studies were carried out of the physical properties of the plasma under pulsed conditions on ICARE II and in continuous operation on ICARE IV, and measurements were also carried out of the energy spectra of the electrons (1,000,000°C without cyclotron resonance, 3,000,000,000°C with cyclotronic resonance) and of the ions (100,000 to 500,000°C).

The work conducted at Jutphaas dealt with the formation of low-density high-temperature stationary plasmas in resonant cavities excited by radio-frequency and also their behaviour in the vicinity of the cyclotron resonance of the electrons. In contrast with the theoretical findings, the observations

made seem to indicate that there is a non-adiabatic movement of the particles in the RF field and a secondary emission of electrons beyond the walls of the cavities, as a result of which the design of the apparatus has been modified.

At Garching, the ohmic heating experiments were continued on a high-density plasma built up by an arc in the presence of a longitudinal magnetic field, enabling a temperature of 100,000°K to be reached. Tests on heating by gyrorelaxation were commenced on the same plasma.

In several of our laboratories research was carried out on stationary alkaline plasmas. The experiments at Garching (ALMA I and II) were devoted to diffusion, at Jutphaas to studies of the oscillations in a caesium vapour arc, and at Frascati (PETER) it was found, in line with the theoretical predictions, that if the alkaline plasma is marked by a certain ion velocity distribution, unstable ion waves can be set up.

An important piece of work was the study of the interaction between an ion or electron beam and a plasma. Research at Fontenay-aux-Roses (ECLAIR - electron beam) revealed very efficient conversions of the directed energy of the oscillating plasma beams in the vicinity of the plasma's resonance frequency, which represents a very useful heating method. The EOS ion-beam device is now in course of assembly. At Amsterdam (FOM) instabilities were observed to occur at well-defined frequencies in the interaction between an electron beam and the plasma and, in some cases, their growth rate was measured.

Experiments on beam/plasma interaction are also being carried out at Garching, which is equipped with an accelerator for generating intense beams of energetic ions and electrons.

Effective cross-section measurements, which are useful for thermonuclear fusion, were continued at Saclay using a collision between an H_2+ beam and a target beam. The preliminary studies showed that the phenomena observed do in fact stem from the interaction of the charged particles and not from the effect of the re-emitted neutral particles.

VI. Diagnostics and Technology

One of the essential tasks in plasma physics is to observe and measure in extremely brief periods of time a large number of parameters the values of which are frequently beyond the range of conventional techniques. For this reason a substantial effort is being devoted by our laboratories to the development of diagnostic methods:

a. Measuring probes—mention should be made of the Langmuir electrostatic probes for measuring the density and electron temperature at Utrecht and the HF-plasma resonance probes at Garching.

b. Optical methods for measuring the indices of refraction, the diffusion and the polarization of light. Particularly noteworthy is the work on diagnostics involving the use of lasers for determining the electron and ion densities and temperatures of dense plasmas. At both Garching and Frascati studies were carried out on the diffusion of a laser beam (under giant pulse operation) by a plasma, while at Jülich magnetic fields were measured by Faraday rotation in the infra-red region.

c. Studies on electromagnetic radiations concerned all frequency ranges from microwaves to X-rays. Note should be taken of the work at Saclay on microwaves, at Fontenay-aux-Roses, Garching and Jülich in the infra-red region, and at Jülich and Garching in the ultra-violet and far ultra-violet region. Certain improvements were made to interferometry techniques (FAFNIR, Fontenay-aux-Roses).

d. Particle spectrometry methods for determining energy distribution were used at Jülich, in particular, on accelerated beams.

From the technological angle, thermonuclear research raises problems which mean breaking new ground. The need for equipment which can operate under conditions of unusual severity has led to the development of systems capable of ever-increasing performance from which industry can benefit.

Mention should be made in this connection of developments concerning the components of high-energy capacitor banks at Garching and Jülich (switches, crowbar spark-gaps, etc., collectors, mechanical vibration damping system, etc.); vacuum techniques (in all our laboratories); supraconductors (Garching and Fontenay-aux-Roses) the recent progress with which, despite the difficulties which remain to be solved, holds out hopes that it will soon be possible to generate continuous magnetic fields more cheaply; explosives and their use for the rapid stepping-up of a magnetic field up to very high levels; lasers (Frascati); microwaves (Saclay) and, finally, the improvement of systems for recording and displaying results (Fontenay-aux-Roses) and of image-converters (Garching).

DOCUMENT No. 9

STUDIES RELATING TO DEVELOPMENT OF STRINGS

I. Radioactive Waste Processing

Since the last report, the Commission has entered into seven research contracts, covering the following main fields:

— application of lyophilization techniques to the processing of medium- and high-activity liquid waste;

— fixation of medium- and high-activity chemical compounds (cations and anions) on natural inorganic substances;

— detailed studies of conditions for the storage of active residues either under the ground (desert regions) or in suitable geological formations (salt mines or salt domes).

These studies were only commenced recently, and consequently there are no major results to record in this year's report.

In addition, research on the dilution of waste by the current of Lake Maggiore—a problem of immediate interest to the Ispra establishment—and on the migration of radioisotopes in different types of terrain has been pursued under contracts previously concluded with Pallanza Institute of Hydrogeology and the CEN respectively.

II. Chemical Reprocessing of Irradiated Fuels

The programme aimed at the development of a method for the recovery of uranium and plutonium in ceramic fuels by fluorination was continued along the lines mapped out in the Seventh General Report.

The hot laboratory pilot unit (capacity 4 kg of fuel) is now nearing completion and the first "hot" tests are to start during the second half of this year. The construction schedule for this project has been put back somewhat owing to the long delivery dates for items of equipment made of special alloys resistant to corrosion in a fluorinated medium.

Furthermore, intensive work has been carried out on the development of gaseous chlorine trifluoride. The results obtained indicate that this method has a decided advantage over the conventional technique involving fluorine attack, for chlorine trifluoride selectively converts uranium oxide into the corresponding volatile hexafluoride, the plutonium remaining in non-volatile form. After separation of the uranium by volatilization, the plutonium can be separated from the fission products by the formation of the hexafluoride in the presence of fluorine at high temperature.

Once the laboratories for handling fluorinated plutonium compounds are fitted out, it will soon be possible to tackle the technological problems connected with the preparation and transportation of plutonium fluorides. Two Euratom officials, one of whom has undergone an 18-month training period at the Argonne National Laboratory, are participating in this work, which is being carried out under contract by the CEN.

Limited studies are being carried out in the Ispra Chemistry Department on the development of a technique for the electrorefining of uranium and of a method for treating irradiated fuels by dissolving them in a bath of alkaline hydroxides (Sodex process). This work is underpinned by several research contracts covering studies of phase diagrams of ternary or quaternary metal systems, the direct carburization of uranium dissolved in a molten alloy and the development of crucible materials which are resistant to reducing attack by uranium-containing liquid metals.

DOCUMENT No. 10

REPROCESSING AND TRANSPORTATION OF IRRADIATED FUELS

I. Reprocessing

During the period covered by this General Report, two events influenced the development of activity in the irradiated fuel reprocessing industry. First, the board of directors of Eurochemic decided to arrange for the Mol plant to reprocess MTR fuels as well as natural or slightly-enriched uranium fuels from power reactors; secondly, the Steering Committee of the Italian Atomic Energy Commission (CNEN) confirmed its intention of building the Eurex plant. As a result of these two decisions, there will now be a new facility for proceeded as far as the resolution of all commercial and contractual questions. ditions are being modified to allow more scope for research projects.

The Commission's negotiations with the UKAEA on the reprocessing in Great Britain (Dounreay) of MTR fuels from the BR2 and HFR reactors, proceeded as far as the resolution of all commercial and contractual questions.

At the same time, the Commission carried out a new detailed survey of the various facilities for reprocessing used BR2 and HFR fuel at Savannah River, Eurochemic, Eurex and Dounreay, which showed that for the reactors in question the Eurochemic formula would be the most favourable. This conclusion naturally took into account the uranium leasing charges entailed by reprocessing at different periods according to the facilities envisaged.

On the strength of this survey, the Commission authorized the opening of negotiations with Eurochemic for the reprocessing of BR2 and HFR fuels.

French and German operators of research reactors were kept abreast of the progress of these negotiations and studies so that they could evaluate the findings in terms of their own reprocessing requirements.

The negotiations with the CNEN resulted in the signing of an agreement on the building, operation and utilization of the Eurex plant for industrial research purposes.

This plant has a rated capacity of about 40 kg. of uranium and aluminium a day equivalent to the processing of six MTR fuel elements. According to present estimates, utilization of Eurex would be in the approximate proportions of 20% as to MTR fuel reprocessing and 80% as to research work.

On this basis, the agreement provides that the CNEN, in consideration of a financial contribution of 3,000,000 EMA u.a. from the Commission, shall:

— carry out a programme, in line with the programmes of other organizations concerned with reprocessing in the Community, aimed at obtaining information of industrial and economic value. Work under this agreement will include research into processes based on amines and on mixed systems based on amines and other extracting agents, as well as technological research to determine the best operating and equipment conditions. The findings will then be applied to a wide variety of fuels ranging from highly-enriched to natural-uranium;

— reprocess, at a predetermined price, the MTR elements sent to Eurex by the Commission or by any person or enterprise that the Commission may designate;

— fulfil a series of obligations relating to reports and information to be supplied to the Commission, the seconding of personnel, the use of information, and the patent and licence system.

The implementation of the Eurex agreement with the CNEN will enable work at that plant to be attuned to the activities of other bodies concerned with the industrial reprocessing of irradiated elements in the Community.

With this prospect in view, the Commission took part in studies carried out in the various divisions of Eurochemic for the purpose of establishing the directives to govern that company's activities.

II. Transportation

1. *Transportation of Consignments*

In 1964, the Commission's major concern was to determine the procedure to be adopted for transporting the first loads to be removed from the overcrowded storage ponds containing the irradiated fuel-elements unloaded from research reactors for which the Commission is wholly or partly responsible.

It was decided that for the moment only fuel-elements from the HFR (Petten) and Ispra 1 reactors should be evacuated; there is less urgency in the case of the BR2 (Mol) reactor, which has a greater irradiated-fuel storage capacity.

As to destination, the Commission has proceeded on the assumption that Eurochemic will doubtless be able to reprocess the HFR and BR2 fuels and Eurex the Ispra 1 fuels. Arrangements have therefore been made to send some 200 HFR fuel-elements and some 150 Ispra 1 elements to Eurochemic and Eurex respectively in 1965.

Transportation details were finalized at a rehearsal held towards the end of 1964 (sequence of loading and unloading operations on departure and arrival, route, speed, safety instructions, etc.), in which the authorities empowered to issue the requisite permits took part.

The container adopted, of French design, weighs 8.8 tons and holds nine fuel-elements.

A decision on the carriage of the BR2 irradiated elements has been deferred, for the reason already stated, until the Eurochemic plant comes into operation.

2. *Insurance cover in respect of nuclear third-party liability*

The insurance terms for nuclear third-party cover in respect of these consignments were fixed with due regard to the contract provisions which define the limits of the liability incurred on the one hand, by the despatching and receiving plant-operators and, on the other hand, by transport firms, in order to avoid a situation in which all the parties concerned would pay premiums for the same risk.

For the carriage of irradiated fuels from the Ispra 1 reactor to Eurex, negotiations between the contracting parties—pursuant to the provisions of Italian Atomic Law No. 1860 dated 31 December 1962, which stipulates a cover of about 5,000,000 dollars—led to the drawing-up of a satisfactory insurance policy.

As to the carriage of irradiated fuels from the HFR reactor to Eurochemic, an insurance policy has been agreed on which, in accordance with the Netherlands legislation currently being drafted, requires a risk cover of about 15,000,000 dollars.

DOCUMENT No. 11

LABELLED MOLECULES AND RADIOISOTOPES

I. Labelled Molecule Research

Through the agency of the Labelled Molecule Bank and by means of research contracts, the Commission endeavoured to supply users with rare or commercially unobtainable compounds, to establish essential ties between producers and users, to help to create at the industrial level the conditions necessary for the balanced production of compounds and to develop an exchange of know-how on the synthesis of labelled molecules and related problems.

As a result of twelve contracts involving collaboration with users who had prepared for their own requirements compounds unobtainable on the market, the number of products held by the Labelled Molecule Bank was raised to 54.

Under research contracts, too, new synthesis methods were developed, product purity improved and techniques for the preparation of over 200 compounds simplified.

The Universities of Heidelberg and Milan, for instance, prepared a series of compounds which can be used in research on the growth of normal or pathological cells.

Furthermore, the University of Milan and the Belgian Inter-University Institute of Nuclear Science have prepared new steroid and thyroid hormones labelled with iodine, tritium and carbon for the investigation of endocrinology and protein synthesis. All the signs are that these products will be used for diagnostic purposes on an ever-increasing scale.

The Paris Faculty of Science carried out the synthesis of over thirty compounds labelled with stable isotopes for research on the mechanisms of chemical reactions.

The Collège de France has finalized a new method for preparing iodine or tritium-labelled proteins and hormones which involves biosynthesis with the aid of isolated organs.

The firms of Sorin and Montecatini each continued their work on the preparation of iodine-labelled proteins and phosphoruslabelled insecticides by original

methods offering the advantages of simplicity and low cost. With regard to the proteins, products can be prepared by this technique which retain all their biological activity. In the case of the insecticides, the high specific activity obtained enables the action of these products to be studied under conditions which are not injurious to plant life.

The Belgian Nuclear Study centre at Mol has developed a method in which the radiations from irradiated nuclear fuels are used for the synthesis of ordinary labelled molecules. By means of this technique, the energy of fission products can be put to some economic use and at the same time the cost of labelled substances can be reduced, since chemical synthesis is obviated.

The Munich Institute of Technology has also devised a radiochemical technique for the preparation of labelled compounds. Here the recoil of certain fission atoms is used to obtain, without chemical synthesis, products labelled with chromium, molybdenum, iodine and ruthenium. Professor Weygand of the same Institute has elaborated a method for separating labelled compounds in optical diastereoisomers, with the aid of which mechanisms can be studied more searchingly, particularly in the field of biochemistry.

In addition, the University of Rome, the Collège de France and the University of Cologne have improved methods for storing high-activity labelled compounds such as amino-acids, hormones, hydrocarbons and fatty acids. As a result, these products can be employed more widely in future, since their use was hitherto limited owing to marked autoradio-decomposition.

By means of supply and research contracts, it proved possible to initiate work of general interest which could not have been undertaken without the substances concerned.

Products supplied by Euratom to both member and non-member countries were used for work on the treatment of cancer with the aid of substances which "home" on cancer cells. These products are heavily labelled and can act by localized internal irradiation.

Tritiated nucleic acids were employed in order to further studies on cell growth and genetic-code transmission in particular.

Carbon-labelled gibberellic acid was used to pinpoint the mechanism, little known hitherto, by which the acid affects the stimulation of plant growth.

Finally, large-scale use was made of deuterium-labelled compounds to check theoretical chemical data on aromatic molecules. In particular, the mechanism of the carcinogenic action of these products was studied and determined by molecular spectroscopy.

The Commission set about the task of greater centralization of information on the requirements and availability of rare products. As a result, producers were able to benefit from the work carried out under contracts, to market several products without having to undertake research beyond their means and to map out a definite course for their programmes.

Ten information bulletins sent to over 7,000 laboratories during 1964, circulated the requirements of these establishments with regard to rare substances. These bulletins also contained details of new methods of synthesizing labelled molecules and of improvements following on their use.

The Commission published the proceedings of the first international conference on methods of preparing and storing labelled molecules, held in Brussels in 1963, as well as those of the symposium on the preparation of medical applications of labelled molecules, which took place in Venice in August 1964 and was attended by over a hundred delegates from the Community and from twelve non-member states.

The Commission also decided to disseminate each quarter references to scientific publications on methods of preparing labelled compounds and related problems. The first two reports contained over a thousand abstracts of scientific articles.

II. Radioisotope Research

As in the past, the Commission's activities in this field had three main focal points, namely, improvement of production techniques, recovery of fission products and development of new applications.

With regard to the improvement of methods of producing radioactive and stable isotopes, research was initiated under contracts, in particular on the development of new tritium targets, the elaboration of a method for producing high-activity Cl-36 and the preparation of carrier-free Na-24. Work is continuing satisfactorily on the development of a new method for producing radioisotopes by means of monokinetic neutrons or neutrons having a predetermined energy spectrum. The current production target is P-32-free, carrier-free P-33. Mention should also be made of the fact that work is now nearing completion on the construction of a portable neutron source with a flux which is high in comparison with conventional sources and is extremely cheap. Quite apart from the interest it offers, this device will form a major outlet for radioisotopes extracted from solutions of fission products.

Finally, an international meeting of specialists, held in 1964 on 17 and 18 February in collaboration with the University of Liège, dealt with targets for particle accelerators geared to the production of neutrons.

The Commission felt it advisable to postpone until a later date other projects relating to the improvement of methods for producing radioactive and stable isotopes, since in view of the limitation of the credits available it preferred to concentrate its efforts on a problem rendered more immediately urgent by the development of nuclear energy, namely, that of the recovery of fission products. As well as enabling methods for disposing of effluents to be simplified, the solution of this problem would permit the production of intense sources of radiation, and it is with this aim in view that the work of the CEN and CEA on fundamental and technological problems has been continued on a contractual basis.

In view of the difficulties to be overcome, notably those relating to pilot plants, the results obtained may be regarded as highly satisfactory. Under the CEN contract, for instance, the recovery of Cs-137 was effected by means of ion exchangers such as zirconium phosphate and "molybdate ferrocyanide", which was discovered and developed in the Mol laboratories. With regard to the recovery of Sr-90, the discovery of a new, highly selective ion exchanger, polyantimonic acid, represents a great step forward, since with it strontium can be fixed selectively in an acid medium of 0.5-2 M HNO_3.

A hot separation cell (max. inner activity 100 Ci), was built and put into operation in order to check the suitability of the method for recovering Cs-137 and Sr-90.

Under the contract with the CEA for devising ways of ensuring a more complete recovery of Cs-137 and Sr-90, a team of 25 scientists continued their work satisfactorily. Owing to technological necessities, however, the programme as originally conceived had to be modified somewhat; thus, while extraction by solvent as a method of recovering Sr-90 was not entirely ruled out, efforts were directed to separation by mineral ion-exchangers. The contract work has now advanced far enough to guarantee recovery of Cs-137 in appreciable quantities and of high purity ($<5.10^{-4}$% of the original Ce-144 and $<5.10^{-3}$% of the original Sr-90). The basic and technological studies on Sr-90 and rare earths are proceeding most promisingly.

Coordination of the research activities of the CEN and CEA is furthered by frequent meetings between the specialists in charge of the various projects.

Other preliminary work, also under contract, is now in progress on Tc-99 and Kr-85.

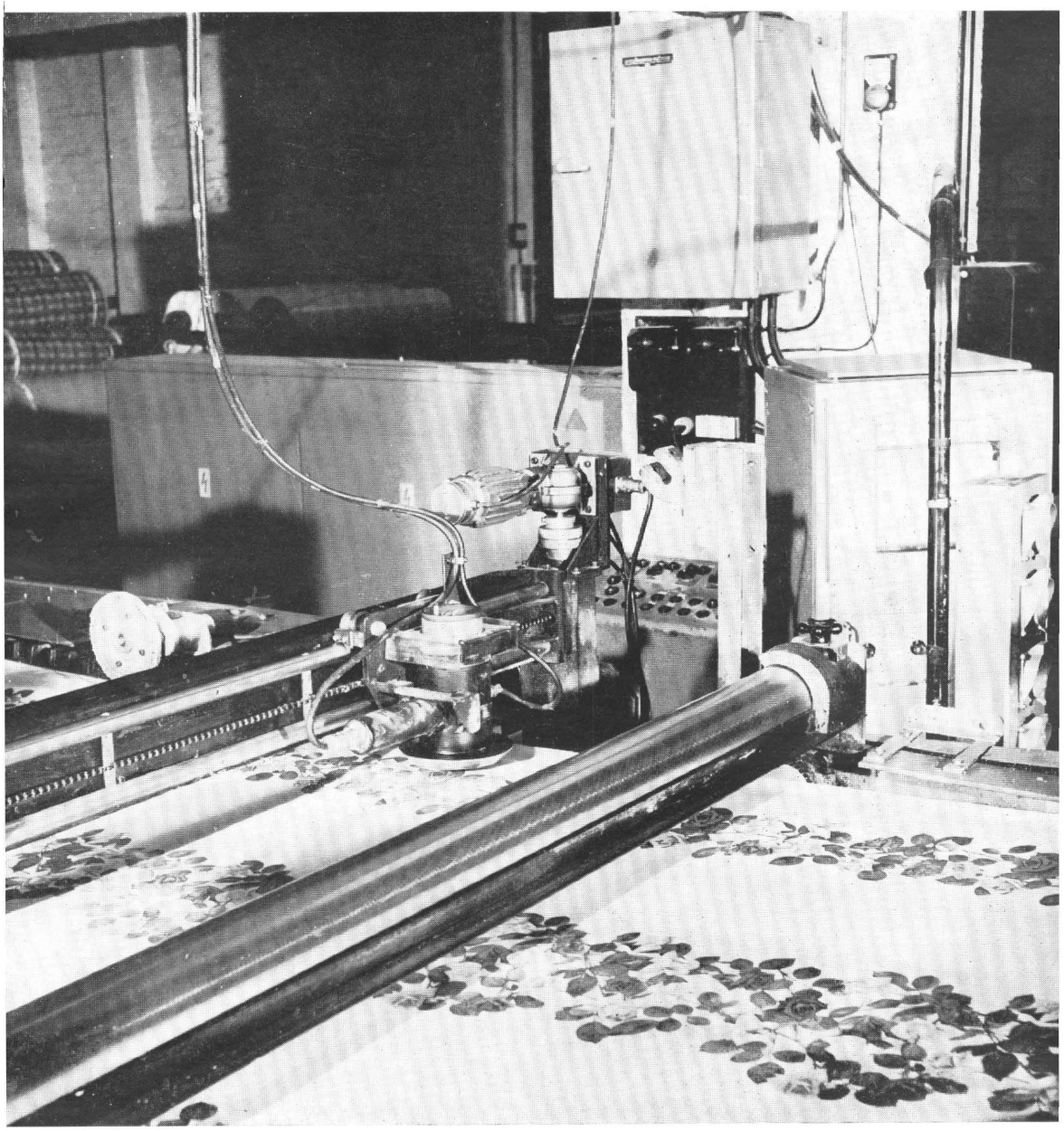
With regard to new applications of radioisotopes, the Commission accepted a proposal from the University of Paris on research into photo-activation.

The Commission's activities in this same field in 1964 were also concerned with the following points:

— Research and development work on means of using isotopic tracers of high effective cross-section, irradiated by a neutron source and detected by either capture gammas or neutron absorption. A project is now under way along these lines;

— Research and development work up to the laboratory stage on the use of intense radiation sources for reactions in which catalysis phenomena are involved. Research being conducted under contract by the Battelle Institute at Frankfurt is aimed at trying to explain the mechanism of certain heterogeneous catalysis reactions which occur under beta-irradiation.

With regard to radioisotope-based electricity generators, the Direct Conversion Group at Ispra has developed a 5 We prototype and is working on close collaboration with the Radioisotopes Group, which is at present studying possibilities of supplying the isotopic source of Tm-170.



LYONS (France) — INDUSTRIAL APPLICATIONS OF RADIOISOTOPES — CHECKING THE THICKNESS OF THE PLASTIC BACKING ON OILCLOTHS

(See other side of page for caption)

The thickness of the plastic backing on oilcloths is measured by means of a back-scatter gauge consisting of radiation source and detector unit coupled to an appropriate electronic system. The fluctuations in the radiation emitted by the source are "read" by the detector and transmitted to the electronic apparatus, which translates the signals received into units of thickness. The source/detector probe, seen in the centre of the photograph, travels backwards and forwards scanning the full width of the cloth, which passes beneath the instrument.

DOCUMENT No. 12

INDUSTRIAL APPLICATIONS OF RADIOISOTOPES AND RADIATION

Work of the Bureau Eurisotop

The Bureau Eurisotop's task is to further the use of radioisotopes and radiations in industry. To this end it promotes the development of suitable media, instruments, methods of use and materials, through research and development contracts and, by acquiring and disseminating technical knowledge, encourages the application in practice of radioisotopes and radiations. It also studies and helps to improve the material and psychological conditions associated with their use (risk coverage, regulations, services provided by industry, etc.). Lastly, the Bureau assists in coordinating at Community level the activities originating within the Member States.

I. Contracts

The contracts placed by Euratom are aimed principally at solving numerous industrial difficulties, especially in the fields of instrumentation, activation analysis, and the technology and intensive use of radiation.

At present, the Bureau has some 60 contracts in operation and is negotiating about thirty more involving twenty-six branches of industry, such as metallurgy (blast furnaces), undersea construction, textiles, etc.

II. Information and documentation

The Bureau has a "specialist library" which at the moment comprises about 1,300 works and reports, 30,000 reference cards, and 600 offprints and photostats.

The Bureau's stand at the European Metallurgy Salon (19-30 September 1964) displayed exhibits representing its sponsoring activities in the field of metallurgy. This display material, which was supplied free of charge by three French and two German firms, can be used again on future occasions.

At Turin, the Bureau collaborated with ITALGAS and SORIN in organizing a conference, followed by a demonstration, on the measurement of leakages in underground gas ducts, and with the "Associazione Italia della Metallurgia" in arranging a one-day study of the uses of radioisotopes in metallurgy. A conference, with demonstration, on the measurement of the degree of humidity of source materials was held at Wildbad with the cooperation of Professor Berthold's laboratory.

A film for showing to engineers and technicians entitled "Radioelements in Industry" and illustrating the use of radioisotopes (with both French and Dutch sound-tracks) was completed in August 1964.

Reports stemming from the contracts programme are generally published by the Information and Documentation Centre (CID). Four publications and twelve articles have already appeared and others are to follow shortly. In addition the Bureau puts out the "Nouvelles du Bureau Eurisotop" and "Cahier d'Information du Bureau Eurisotop" for experts, users, enterprises and national bodies.

The "Nouvelles" appear monthly in four languages. Each number contains brief news affording a rapid survey of the Bureau's activities for the month and from five to ten documentary notes.

The aim of the "Cahiers d'Information" is to publicize the full range of nuclear methods and techniques, while providing accurate information on individual aspects of the industrial uses of radioisotopes.

The Bureau also makes available for interested groups "Working Papers" comprising a large number of articles, offprints and bibliographies on a given subject.

III. Coordination

It is essential, in promoting the use of radioisotopes, to coordinate the techniques employed in the various fields of use (e.g. industry, research, medicine).

Where this has been done by negotiation—hitherto usually in the context of research contracts—it has resulted in lower research costs, rational division of labour and efficient implementation of research projects.

In addition, working parties have been formed to study possible uses of radioisotopes in coastal protection, industrial and river water purification, and water-carriage systems.

As to activation analysis, working groups have been appointed to organize a network of analysis centres. An information service now being set up will assemble all existing documentation on the subject. Apart from this, research is in progress on the analysis of oxygen in steel. Most of the world's laboratories have been invited to take part in this work.

The principal effort, however, has been in the textile sector. A study programme organized by the Commission has had the cooperation of over 300 major textile enterprises and some 40 radioisotope experts. Four volumes containing technical papers for the working groups, as well as a very detailed subject index and an information handbook, have been published for the use of the participants. This activity will be completed in June 1965, when study reports will be published, working meetings arranged, and a development programme prepared.

Lastly, mention should be made of the negotiations on a project for a ship equipped with irradiation devices, to be used for irradiation tests and demonstrations in the immediate vicinity of the enterprises concerned.

IV. Legal and economic aspects of the use of radioisotopes

As regards the legal and economic aspect, the Bureau has compiled a reference library on enterprises that supply goods and services in connection with radioisotopes (including 250 non-Community firms). It has drawn up a list of the services that can be provided by industry and has started on a series of economic, technical and sociological studies of individual cases of radioisotope utilization.

Other studies, both legal and economic, are being conducted into application of sealed radiation sources and the consequences of employing radioisotopes in various other sectors, in addition to which a statistical report on the use of radioactive substances from 1953 to 1963 is due to be published in the very near future.

V. Cooperation with bodies in non-Community countries

As well as its relations with the major radioisotope-using research establishments, the Eurisotop Bureau maintains direct contacts with official bodies in certain non-Community countries, the following being cases in point.

A film on the use of radioisotopes has been shown in Moscow, Geneva, Vienna and in Iran.

A Swiss and an Israeli expert are participating in the campaign to further the use of radioisotopes in the textile sector. The Bureau is in contact with the British textile industry and is holding discussions with the Argentine Atomic Energy Commission for the conclusion of a contract.

Meanwhile, Austria too is showing a lively interest in these activities.

A delegate from the British gas industry attended the demonstration on the measurement of gas-duct leakages.

American, British, Israeli and Austrian laboratories specializing in activation analysis are working together on a research contract.

The Bureau has invited a large number of activation analysis laboratories in non-Community countries to collaborate with its permanent information service (see Chapter headed "Information, Coordination").

The Bureau and Foratom exchange information and hold joint working meetings.

In addition, the Bureau Eurisotop takes part in conferences, working parties, etc. within the IAEA and the ENEA.

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

Conclusion of the contract

The negotiations concerning Euratom's participation in the design, construction and operation of the "Otto Hahn" research vessel led to the conclusion of a contract with the GKSS in July 1964. The terms of this contract have been accepted by the constructor of the vessel, the Kieler Howaldtswerke, and by the supplier of the nuclear installation, the Deutsche Babcock & Wilcox and Interatom (International Atomreaktorbau GmbH) group. In return for its cooperation, i.e., the supplying of information and financing to the tune of four million EMA u.a., Euratom acquires certain rights, more particularly as regards the dissemination within the Community of the information obtained during the implementation of the contract.

Description of the project

The "Otto Hahn" was launched in June 1964 and is due to be delivered to the GKSS at the end of 1966. The reactor should reach full power during the summer of 1967. The ship selected is of the ore-carrier type, which offers certain advantages from a safety standpoint and costs less to build than other types.

It has a deadweight capacity of 15,000 tons, 10,000 shp and a speed of 15.75 knots. With a vessel of this size, it is possible to obtain operating and test results applicable to vessels of a higher tonnage and speed.

For the purposes of the research, the ship is equipped with several laboratories and can accommodate a scientific staff of 40. It also has a plant for the shipboard handling and storage of the radioactive parts of the reactor, in

particular the fuel elements. The pressurized-water reactor has a thermal power of 38 MW and will be of integral design, the reactor core and the steam generator being housed in the pressure vessel. Owing to the low boiling rate in the core, the primary pressure is only 63 kg/cm^2. No special pressurization system is required, the pressure being maintained constant by a layer of steam in the upper part of the reactor. It is mainly through these three characteristics that a substantial reduction in weight and bulk can be effected. When it passes into the core, the primary water records a rise in temperature from 266 to 278°C. The steam generator, which is of the forced-circulation type, is immediately above the core and provides slightly superheated steam at 273°C at a pressure of 31 atm. abs.

During the overall designing of the propulsion unit, economic factors were only taken into consideration if they were not liable to impose trammels on the vessel's suitability for research.

The reactor has the major advantage of a high degree of operational safety and accordingly lends itself particularly well to tests carried out in conditions likely to obtain on board ship for the purpose of acquiring the knowledge and experience with which marine reactors can be made to pay their way. For example, it is planned to install a second core, improved in the light of the results derived from operation of the first core, after only 500 days of full-power working. It will also be necessary to test certain reactor components of improved construction, and in particular the control-rod drives. By means of an accurate study of the reactor's self-regulating property, efforts will be made to improve and simplify the control system. Among the factors to be determined are the reactor's properties and its maximum power in natural-circulation-cooling conditions. Finally, it is intended to study the effect of the movements and vibrations of the ship on the void distribution in the core and its influence on the behaviour of the reactor.

To sum up, it may be said that the "Otto Hahn" will be a veritable "floating laboratory" and that no stone has been left unturned to acquire fresh information from it.

Status of the work

Construction of the ship is now far enough advanced to permit installation of the reactor, which, according to schedule, will start with the assembly of the containment shell during the first half of 1965. The pressure vessel, the primary pumps and the first control-rod drive mechanism are in the course

of fabrication. The orders for the auxiliary circuits, the electrical and electronic equipment and the ventilation system were placed towards the end of 1964.

II. Contract of Association with the Reactor Centrum Nederland

In 1964, the RCN's efforts were largely directed to drawing up an intermediate project, called NEREUS, aimed at assessing the status of the programme. The main object of the contract is to elaborate construction plans and compile sufficiently detailed data to evaluate the possibility of constructing a NERO-reactor prototype and also its economic advantages. The concept would be such as to enable advanced techniques to be applied to a pressurized-water reactor for marine propulsion purposes.

Although certain parts of the programme are still some way short of the target, the intermediate project has nevertheless shown that hopes of success may be entertained in view of the results of the experimental work under way or in preparation. Similarly, the Commission has found that the plans for the entire NEREUS reactor plant and several of its components, as well as those for its auxiliary installations, will be able to be used for the final project without the necessity of carrying out fundamental modifications so as to take account of the experimental results.

From the experiments performed on the KRITO critical assembly at Petten, it has been possible to compare the measured and calculated values and consequently to pinpoint the coefficients used in the neutron calculations. During the second half of 1964, a start was made on supplementary research in the form of tests on the sub-critical assembly. In addition, the high-pressure loop for the study of fuel-element cladding corrosion was commissioned towards the end of the year. Furthermore, the setting-up of the test-rig for the steam-generator and the high-pressure irradiation-loop is on the verge of completion.

The theoretical work included the development of a computer code for determining more accurately the effect on the core life of a burnable poison incorporated in the fuel, heat-transfer calculations in respect of the steam-generator and the improvement of the aforementioned neutron calculations in the light of the results obtained with the critical installation.

III. Contract of Association Fiat-Ansaldo

In 1964, work was continued, under the Euratom/Fiat-Ansaldo association, supported by the Italian Atomic Energy Commission (CNEN), on the development of a forced-circulation pressurized-water marine reactor, as resolved upon in the previous year. It may now be anticipated that the theoretical and experimental programme in progress will make it possible to draw up, around mid-1967, the construction plans for the optimum 50,000 dwt tanker project in which the reactor will develop about 23,500 shp. The establishment of an intermediate project for the study of possible improvements is proceeding satisfactorily and will be completed in 1965.

This project is modelled on a "compact" design in which several steam-generators and primary-circuit circulation pumps are located in the immediate vicinity of the reactor pressure vessel in order to reduce the bulk, and hence the weight, of the reactor. In addition, the core will be divided into two concentric zones each traversed in turn by the primary fluid, which will improve the heat-exchange conditions. Efforts have been made to obtain a long fuel life, propitious to economic operation of the vessel, by employing a burnable neutron poison dissolved in the primary water coolant while not neglecting the special requirements of marine propulsion. Fuel burn-up increases and local flux-peak reductions will also be obtained through the subdivision of the core into two enrichment zones and a system of control rods in cluster array.

Part of the current reactor studies is aimed at the accurate determination of the characteristics of the final project. In the experimental field, this involves in particular a study of the burn-out fluxes in a 600 kW heat-transfer loop able to withstand a pressure of 150 kg/cm^2 and also hydraulic tests on fuel-element and control rod mock-ups. The theoretical studies relate primarily to the development and adaptation of various codes for the calculation of the neutron-flux distribution, the heat-transfer and the nuclear characteristics of the fuel at high irradiation levels. The transient behaviour of the reactor according to the load variations in normal operating conditions or in the event of an accident has been analysed in a similar model of the nuclear installation.

IV. Collision Tests (Fiat-Ansaldo Contract of Association)

During 1964, progress was made with the part of the Fiat-Ansaldo contract of association programme relating to the study of the efficiency of some types

KIEL (Germany) — THE LAUNCHING, IN JUNE 1964, OF THE NUCLEAR-PROPELLED RESEARCH VESSEL "OTTO HAHN", OWNED BY GESELLSCHAFT FÜR KERNENERGIEVERWERTUNG IN SCHIFFBAU m.b.H. (GKSS), Hamburg

(See other side of page for caption)

The "Otto Hahn" is an ore carrier with facilities for experimental research; displacement 25,800 tons; deadweight capacity 15,000 tons; shaft horsepower 10,000; speed 15 3/4 knots.

Pressurized-water reactor of integral design, with a thermal power of 38 MW, using 3 tons of slightly enriched UO_2 fuel; 16 fuel elements; stainless-steel cladding; primary circuit 63.3 kg/cm², 266.8 - 278°C; secondary steam 31 kg/cm², 273°C with 36°C superheating.

The ship will go into service in mid-1967.

of anti-collision structure for use in ships. Three scalemodel tests were carried out with the aid of the Naples University testrig which had already been used in 1963 for the initial experiment. This unit, which was made available by the CNEN, consists of a ramp along which a model of the bows of the striking vessel, mounted on a bogie, runs into the anti-collision barrier of the rammed vessel, which is on a truck equipped with devices for simulating the resistance offered by the water to a ship which is displaced laterally as a result of a collision. The models were to the scale of 1:15, as for the initial test.

As a result of the tests, it has been possible to improve the experimentation technique appreciably, and in particular the attachment of the models to the trucks so as to allow for the elasticity of the overall structure of a ship, a feature which is lacking in a model of part of the hull but which can now be simulated by elastic attaching devices. One of the three tests in question was carried out with a rammed model of a standard tanker, i.e., without anti-collision structures, in order to evaluate the resistance of the anti-collision structures tested to date by comparing results obtained with and without such structures and also to compare the results obtained with the barrier-less model and the damage caused by the actual collisions of known aspect.

The pooling of information with a German Study Group engaged on similar research was stepped up in 1964 and has proved very useful. A study is now being conducted into the possibility of carrying out some tests under a jointly developed plan with a view to comparing the results.

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

Shielding tests at Geesthacht

Cooperation among the Euratom contractors engaged on the development of shielding of a minimum weight and volume for marine reactors became still closer. Of the four test-rigs with which the Geesthacht research reactor has been provided for this purpose, the ESTAGROP-I([1]) set-up merits particular attention. With this installation studies were carried out on a number

([1]) ESTAGROP: Einrichtung für Strahlen-Abschirmungsversuche mit grossen Platten (large-plate radiation-shielding test device).

of steel-water screens constructed of large steel plates (ranging up to $200 \times 250 \times 20$ cm^3) for possible use as shielding in the marine reactor developed by the Reactor Centrum Nederland. The tests in question are being supplemented by tests carried out at the Saluggia research reactor under the aforementioned Euratom/Fiat-Ansaldo contract. In order to obtain comparable results and greater reliability, use is being made of simplified configurations, the attenuation characteristics of which are being measured at both Geesthacht and Saluggia. The standard configuration consists of a steel plate surrounded by water, the thickness and the distance from the core being varied. The experimental data obtained from thoroughly familiar physical conditions are then accurately interpreted by means of reference calculations, thus paving the way for the establishment of the theoretical basis necessary for determining the efficiency of more complex configurations.

The same installation was also used for testing the mock-up of a penetration enabling the steam and water channels to traverse the secondary shielding of the "Otto Hahn" reactor.

Mention must also be made of the ESTAKOS ([1]) installation, which is used for the study of smaller-sized shielding plates (60×60 cm^2). The materials in this case being cheaper, it has been possible to study numerous configurations with polyethylene, paraffin-wax, terphenyl, boron-steel and concrete plates.

In the ESTAGROP-2 large irradiation channel, checks and improvements have been carried out on the handling devices used, in particular for the transfer, assembly and positioning of the protective-screen mock-ups. Additional television transmitters have also been installed.

With the aid of the irradiation channel, a study was made of the functioning of a semiconductor spectrometer developed by the GKSS for use in neutron-absorption measurements. A large number of spectra were determined which relate to radiation as emitted from the reactor and to attenuated radiation as obtained on emergence from absorbent layers of graphite, water and steel.

Theoretical study of shielding problems

Development of calculation methods for shielding optimization was carried a step further. The Ispra JRC participated in this study along-side the Commission contractors.

([1]) ESTAKOS: Einrichtung für Strahlen-Abschirmungsversuche mit Kollimiertem Strahl (collimated-beam shielding-test device).

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

At Geesthacht, the GKSS continued the tests on the rolling-rig designed to determine the mechanical strength of parts weighing up to 2.2 tons under accelerations ranging up to 3 g.

It was found that the secondary-shielding concrete plates of a marine reactor could usefully be replaced by a mere mixture of gravel and pieces of basalt. The mixture, after being placed in a container, was subjected in this assembly to movements identical with those of a vessel on a choppy sea. The mixture was found to retain a satisfactory homogeneity.

Finally, on the same rolling-rig, a loop simulating one in a boiling-water reactor was set up; this loop was constructed and financed by the Allgemeine Electricitäts-Gesellschaft (AEG). With a heating power of 335 kW, it will be used for studying the behaviour of a boiling-water reactor when subjected to the movements of a ship. The tests are now in progress.

DOCUMENT No. 14

MATERIALS-TESTING REACTORS

I. BR2 Test Reactor

The BR2 materials-testing reactor, operated jointly by Euratom and the Belgian Nuclear Study Centre (CEN), functioned normally throughout the year.

With a 20-element core, the thermal power output was 34 MW, corresponding to a maximum real thermal flux of 6.3×10^{14} n/cm^2/sec.

In the course of the 18 operating cycles the reactor produced an energy of 7570 MWd, representing a consumption of about 9 kg of U-235. The fresh-fuel charge was 163 elements and the average burn-up 25%. No particular incidents were reported, except for a few unscheduled shut-downs caused by accidental control-rod insertion.

The irradiations for the account of organizations in the Community and elsewhere were continued on a regular basis. About twenty experiments were carried out during each cycle, the core positions being occupied to about 70%. Of these, mention can be made of the irradiation of stainless steel and graphite up to 1200° for the UKAEA, the in-loop irradiation of graphite up to 1000° in the impurity-charged helium for the DRAGON project, the irradiation of zirconium for the CEA, the irradiation of fissile and structural materials for several German firms, the irradiation of transplutonium elements, the production of isotopes and the out-of-pile use of neutron beams for various physical research purposes.

The dismantling cell attached to the reactor was frequently used for the radioactive equipment.

The experimental devices were designed and constructed by the technological and industrial laboratory. The technology section developed a sodium loop for the irradiation (on behalf of the CEA) of plutonium pins capable of attaining a specific thermal power of 2500 watts/cm^3. Numerous other devices, ranging from simple to well-instrumented capsules, were developed. As a result more than a hundred experiments were carried out in the course of the year.

In the hot laboratory (LMA) a 1000-curie alpha cell, built by a Community enterprise, was completed and put to use for the analysis of transplutonium element targets. The 200-curie lead cells for post-irradiation metallurgical examinations were constructed and will gradually come into service between March and July 1965.

The physics department studied a new reactor-core configuration in which the central channel is surrounded by 30 fuel elements; this new core will be built in the spring of 1965. In addition, a larger number of high-flux irradiation channels and, consequently, a greater thermal power will be available.

Limited funds prevented construction of the very-high-activity laboratory. For the same reason certain important work, notably the reprocessing of spent fuel elements, had to be carried over to the third five-year programme, with a resultant increase in expenditure for the firing of uranium.

II. Petten HFR Reactor

Since November 1962, i.e., over a period of four years, the HFR reactor at Petten has been operated for Euratom by the Reactor Centrum Nederland (RCN) which during this time has given priority in the utilization of the reactor to its own research requirements. The reactor has been operating at a power of 20 MW since 1962. Expressed in accounting terms, the value of the irradiations performed in the HFR totalled 455,000 EMA u.a. in 1964. The outlook for the future operating economics of the reactor seem to be encouraging.

A team set up to carry out a detailed study of the problems arising from an increase in the reactor power has recommended that the power be stepped up initially from 20 to 30-35 MW and then from 30 to 40-45 MW. In this connection it is noteworthy that, for the same reasons, the American centre at Oak Ridge is preparing to boost the power of its reactor—of which the HFR is virtually a duplicate—to 60 MW.

The irradiation devices already installed or currently being built for in-pile installation in the near future can be divided into two categories, namely the rigs for non-fissile materials and those for fissile materials.

The devices for fissile materials (steel for cladding or for pressure vessels, graphite, beryllium oxide, zirconium hydride, etc.) are generally of the

revolving cylinder type, with temperature control by electric heating, the heat being evacuated to the cooling water through a thin gas layer.

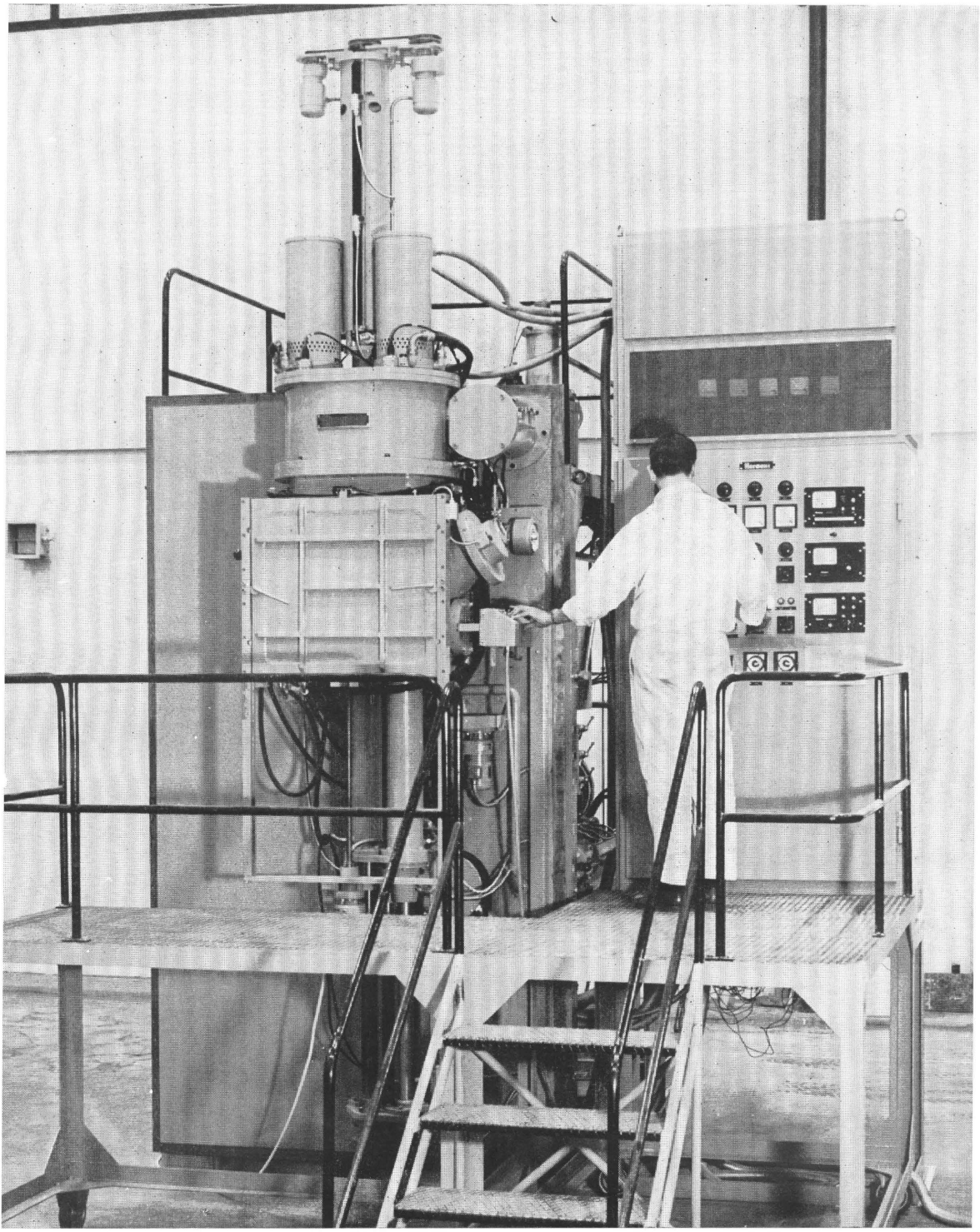
These devices are becoming fairly familiar; their limitations are due either to heat-transfer difficulties at low temperatures or to the behaviour and compatibility of the materials at temperatures above 1000°C.

For fissile materials two types of device can be used, depending on whether the irradiation samples are of small dimensions or represent a fuel slug. In the case of small samples (studies on uranium carbide or ternary metallic alloys of uranium), each sample is normally placed in a small metal box containing sodium or a mixture of sodium and potassium for heat transfer. These boxes are also equipped with electric heating elements for control of the irradiation temperature. The total heat from fission, gamma-heating and electric heating is transferred to the reactor cooling water by a thin layer of a gas or solid.

For the irradiation of fuel slugs (e.g., uranium oxide with a thin steel can) use is made of a different type of device which is based on the irradiation rigs employed on a large scale in the Oak Ridge Research Reactor under the gas-reactor programme. The slug to be irradiated is immersed in sodium or a mixture of sodium and potassium in a leaktight container. The heat produced in this container as a result of fission and gamma-heating is transferred to the water in the pool (devices installed in the pool-side facility) via a very thin layer of gas having a thickness of a few hundredths of a millimetre. The irradiation temperature is controlled either by varying the composition of the thin gas layer (e.g. helium, nitrogen) or by moving the rig on slides without interrupting the flux.

In view of the difficulties encountered during the development of the irradiation rigs described above and the need to estimate the future requirements of experimenters, the Petten Group is developing new types of irradiation rigs intended to extend the irradiation-temperature ranges or enable creep determinations to be carried out on cans.

In conjunction with the development of irradiation capsules for high and very high temperatures, Petten has also embarked on a programme of thermocouple irradiations at temperatures of over 1000°C. Certain standard capsules suitable for the irradiation of these thermocouples were developed, and these can occupy any free positions in the reactor, as a result of which the test thermocouples can accumulate substantial doses.



KARLSRUHE — ELECTRON-BOMBARDMENT MELTING FURNACE

(See other side of page for caption)

This furnace enables alloys and metallic or ceramic compounds to be melted under vacuum at high temperatures. Melting takes place continuously in a water-cooled copper crucible and without any adhesion of the melt to the crucible.

Used chiefly for melting alloys of uranium or thorium with low plutonium contents, the furnace has the advantage of leaving very little waste.

DOCUMENT No. 15

PLUTONIUM AND TRANSPLUTONIUM ELEMENTS

I. Plutonium

As in previous years, the Commission's work was again centred on the study of plutonium recycling in reactors. A description of this work will be found in Document No. 2 on proven-type reactors.

Pending completion of the buildings under construction at Karlsruhe (the main walls of all these buildings having in fact been erected at the time of writing), the European Transuranium Institute has pressed ahead with its programme and has embarked upon its activities in the field of plutonium. The institute's attention, it will be remembered, will be focussed on problems of both basic and applied research raised by the use of plutonium in nuclear reactors in technically and economically feasible conditions.

II. Transplutonium elements

Research on transplutonium elements has been pursued in collaboration with the research centres in the Member States.

At Mol (CEN), the construction and fitting out of a 1,000-curie alpha cell have been completed.

In April 1964, several grams of americium-241 from the United States were inserted in the BR 2 reactor. This experiment forms part of an irradiation programme for small quantities of transuranic elements for the purpose of studying heavy-element synthesis.

In January 1965, weighable quantities of berkelium and californium were separated from a highly-irradiated americium-241 pin for the first time in Europe.

Sixteen publications and four patent applications stemmed from the transplutonium-element research programme in 1964. In addition, the results of the work carried out by several research groups were reported at symposia

organized by the Institut interuniversitaire des Sciences nucléaires and Liège University on 16 March 1964 and by the Radiochemistry Section of the Koninklijke Nederlandse Chemische Vereniging on 23 October 1964 at Utrecht, while a colloquium on fused-salt chemistry held at Liège in September 1964 brought together our Community collaborators and European and American experts.

DOCUMENT No. 16

C.N.M.B.
NUCLEAR MEASUREMENTS

I. Neutron Parameter Measurements

It will be recalled that the CNMB measurements programme is based almost entirely on the demands of reactor constructors. These demands are regularly coordinated and discussed by the European-American Nuclear Data Committee and the corresponding committee of experts of the Community.

Van de Graaff Accelerator

— Effective and inelastic differential scattering cross-sections of iron were measured to an accuracy of between 0.45 and 2.3 MeV. The measurements have now been completed and calculation of the corrections is under way, together with similar measurements on silicon. Others on Pu-239 and lithium isotopes, are at the preparatory stage.

— The effective activation cross-section was measured with a very high accuracy, i.e. between 12.6 and 19.6 MeV, for the following threshold reactions:

Fe^{56} (n,p) Mn^{56}
Co^{59} (n,α) Mn^{56}
Cu^{63} (n,2n) Cu^{62}
Ni^{58} (n,2n) Ni^{57}
Cu^{65} (n,2n) Cu^{64}
Zn^{64} (n,2n) Zn^{63}
Cu^{63} (n,α) Co^{60}
Ni^{60} (n,p) Co^{60}
Ti^{46} (n,p) Sc^{46}
Na^{23} (n,2n) Na^{22}
Co^{59} (n,2n) Co^{58}
Mn^{55} (n,2n) Mn^{54}

The results have been published or are being printed. The angular distribution of the neutrons in the reaction $T(d,n)He^4$ was measured afresh and published.

The critical compendia of data on threshold reactions were completed and kept up to date by the publication of supplementary pages.

Preparations for measuring the total effective cross-sections of U-238 between 2 and 30 KeV are in progress.

Linear Accelerator

— Construction work on the building for the linear accelerator was sufficiently advanced in April to enable a start to be made on installing the machine. The first beam was obtained on 15 September. Final adjustment of the accelerator had not been completed by the end of the year but it is expected that the acceptance tests will be carried out early in 1965.

— Eight time-of-flight positions are now being installed. The equipment for the resonance energy measurements has been designed and much of it has already been set up. Preparations are now being made for the following specific measurements:

  — total effective cross-sections (U-238, U-235, Pu-240, Ca)

  — effective fission cross-sections (U-235, Pu-239).

Contacts were made with teams of physicists at the Belgian Nuclear Study Centre (CEN), the CEA (French Atomic Energy Commission) (Saclay) and the Jülich Nuclear Research Centre, who plan to use the time-of-flight positions during part of the year.

A system was devised for processing the unadjusted measuring results, so that the CNMB is linked directly with the electronic digital computers at Brussels and Ispra (CETIS).

Thermal Neutron Measurements

Analysis of the results arrived at for the effective fission cross-section of Pu-239 revealed that the accuracy obtained for this absolute value did not come up to the standards demanded in this field.

II. Determination of the Isotopic Ratios of Stable and Long-Lived Isotopes

The mass-spectroscopy unit has been moved from its temporary premises at the CEN at Mol to its new laboratories on the site of the CNMB.

A tandem mass-spectrometer was installed for accurate measurements of very low isotopic concentrations.

At the request of the National Bureau of Standards in Washington, the CNMB helped this body to draw up the first isotopic standard for plutonium. A very detailed study of mass discrimination enabled an absolute definition to be established for the isotopic composition of the CNMB stock of standard boron.

A recommendation by the European-American Nuclear Data Committee (EANDC) which appeared in a number of scientific journals suggests that the isotopic standards for boron adopted by the CNMB and the National Bureau of Standards be taken as primary references.

Two studies on isotopic dilution now in the press will afford greater accuracy in the quantitative determination of very small quantities of a solid element (10^{-6} g and less).

A report has been drawn up on methods of measuring the natural abundances of elements. A similar report, containing a thorough-going theoretical study of the calculation of atomic weights, together with a complete survey of the literature on isotopic abundances and the atomic weights of all the elements, is now nearing completion.

The laboratory carried out numerous isotopic analyses on targets and samples prepared by the CNMB. It was in this way that an isotopic fractionation was discovered during the evaporation of boron. The laboratory also lent its assistance to nuclear centres, universities and other bodies by conducting accurate isotopic measurements of samples submitted.

International collaboration was brought about with a view to ensuring the absolute definition of isotopic concentrations in heavy water.

III. Absolute Radioisotope Counting

The research on alpha-counting with low-geometry counters yielded an accuracy of more than 0.2%, and the results obtained were published. The work on high-precision counting by the liquid-scintillator method was also completed and the findings published.

A precision microcalorimeter was built and put into operation, and a report on the absorption corrections of 4π-counting finished. The research on high-precision gas-counting was continued and extended to C^{14} and Kr^{85}. Work was started on coincidence counting by the liquid-scintillator method, and also on fast 4π-beta counting and X-ray counting with intermediate-geometry counters.

Numerous calibrated sources of different isotopes were standardized with respect to other work in progress at the CNMB or at outside laboratories.

Measurements on the EC/β^+ ratio in Na^{22}, V^{48} and Mn^{52} were completed. The branching in Kr^{85} and the number of conversion electrons in Am^{241} were also measured. Analysis of the results of the accurate measurement of the Co^{59} effective cross-section for thermal neutrons is almost finished, and work is in progress on the calorimetric measurement of the half-life of Tl^{204} and a study of the decay scheme of Be^{7} and Mg^{54}.

IV. Central Sample Preparation Laboratory

The CNMB continued its efforts to satisfy all requests for samples. The laboratories prepared and analyzed over 2,250 samples, which they despatched to national centres (Karlsruhe, Mol, Saclay), other Joint Research Centre establishments and universities in the Community.

Neutron physics laboratories displayed a marked interest in detectors, large batches of which were supplied. Special processes for the fabrication, rolling and stamping of alloys were developed with this in mind.

Samples of boron, lithium fluoride, cobalt, indium and titanium were prepared, and a special unit set up for the ultra-vacuum evaporation of uranium. Several samples were made by electrovaporization and electrolysis.

The majority of samples were checked as to chemical and isotopic composition and by metrological techniques (homogeneity, thickness, dimensions, mass).

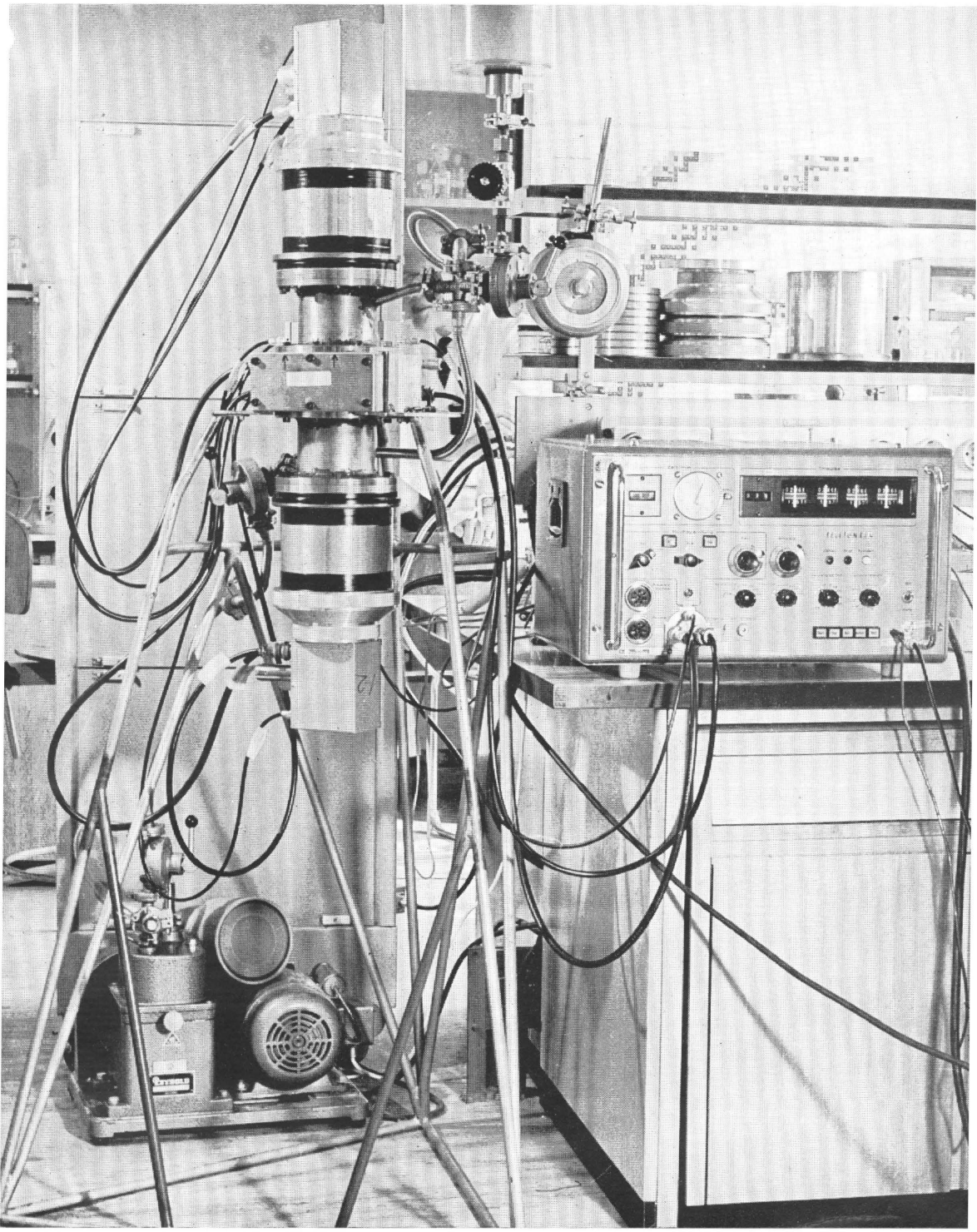
At the end of the year, 900 samples were at various stages of fabrication and checking and the number of requests received by the laboratory is constantly increasing.

V. Contacts with National and International Institutions

The broadened Euratom Nuclear Data Committee, comprising Community measurement and reactor experts, continued to coordinate the Community's measurement programmes and to prepare the ground for the work of the European-American Nuclear Data Committee and of the European-American Reactor Physics Committee.

The CNMB is still participating in the work of the Consultative Committee on Ionizing Radiations of the International Bureau of Weights and Measures and maintains ties with standards bureaux inside and outside the Community.

A Euratom observer attended the Vienna meetings of a working group set up by the International Atomic Energy Agency to deal with nuclear data on a world scale.



EQUIPMENT FOR NUCLEAR MEASUREMENTS
A SMALL COUNTER BUILT AT THE CENTRAL NUCLEAR MEASUREMENTS BUREAU (BCMN)

(See other side of page for caption)

This apparatus, which is remarkable for its simplicity of construction, enables measurements to be performed with an accuracy of about 99,8 %.

DOCUMENT No. 17

REACTOR PHYSICS

1. *Design Study of a Pulsed Source Reactor*

In 1964 a contract was concluded with the firms of Belgonucléaire and Siemens in order to fix the technical specifications of the SORA reactor, to draw up a design and to assess its likely cost.

The critical mass of such a reactor was calculated for various core compositions, and the reactivity of the pulsation system studied using a spherical or cylindrical geometry. The active part of this core has to be cooled by liquid metal, and the reflector by helium. The average thermal power is planned to reach 250 kW with a pulse frequency of 100 cps and a duration of 50 μ/s.

2. *Neutron Physics*

In the field of experimental neutron physics, work was continued on the studies relating to the interaction of thermal and cold neutrons with matter. The theoretical and phenomenological investigations on the thermalization of neutrons in a hydrogen-containing moderator were pursued, while at the same time preparations were made for experiments with the pulsed Van de Graaff accelerator.

A variety of methods was used for the studies on the phenomena of neutron transport. These activities have given rise to the kind of problem expected. The theory evolved concerning neutron background in reactors will be used for the deduction, by correlation experiments (in a critical experiment, for example), not only of the statistical nuclear data of a lattice but also its dynamic behaviour. Generally speaking, it is felt that an understanding of the transport phenomena involved will rapidly enable a sufficiently accurate analysis to be carried out of substitution experiments and tests with micro-assemblies, which could one day be used in place of costlier critical experiments.

3. *Reactor Shielding and Safety*

In the field of shielding studies, a theory and calculation method for neutron transport and gamma-radiation through materials was developed at the Ispra Centre.

Work was also carried out, in collaboration with the Institute of Physics of the University of Padua, on measuring the displacement cross-section of neutrons in water, and on fast neutron propagation in pipes immersed in water. In order to permit more intensive work on this type of measurement, the installation of a highly-enriched-uranium converter is now being prepared in the Ispra-1 reactor.

With more particular regard to reactor safety, some criticality calculations were performed for the storage of Ispra-1 fuel elements, while safety studies were commenced for the SORA reactor.

The theoretical studies on an excursion reactor (TESI) were abandoned during 1964 since it seems highly unlikely that such a reactor will ever be built in the Community.

4. *Fuel Cycles*

These activities actually overlap with the studies on heavy-water reactor physics and concern the use of plutonium on one hand and of thorium on the other.

In the field of fuel cycles, theoretical investigations were carried out on the properties of plutonium-containing lattices and the effect of the burn-up on the neutronics of light-water reactors.

The theory for the oscillation experiments with plutonium-containing fuel in ECO was elaborated. The experience acquired will help in the solution of problems relating to fuel shuffling and the use of thorium in the ORGEL string.

DOCUMENT No. 18 **THE « CETIS » COMPUTER CENTRE**

As a result of the findings of the *ad hoc* Committee appointed by the Commission in June 1964, CETIS continued to fix its sights on its principal rôle, that of serving as a computer centre for handling nuclear problems and all other Community work in the field of automatic data processing, with a certain potential for research into applied mathematics, programming and, in general, information processing. Its activities during the period under review may be summarized as follows:

— As regards computation activities, Table I shows the breakdown of computer use at Ispra, and Table II the number of hours of operation of these machines. The chief external users were the universities of Milan, Amsterdam and Georgetown (USA), Fiat (Turin), CISE (Milan), Praxis (Milan), Olivetti (Milan), CNEN (Rome), AEG (Frankfurt), Siemens (Erlangen), GAAA (Paris), RCN (The Hague), General Atomics (Zurich), EIR (Würenlingen, Switzerland), and the ENEA nuclear-code programme library.

A third IBM 1401, in respect of which CETIS accounted for 33 1/3% of the financing and staffing, has been commissioned in Brussels, involving the seconding of three of the Centre's personnel. Certain operations have been carried out with this computer on the responsibility of CETIS on behalf of the Directorates-General for Administration and Personnel, Budget and Finance and Industry and Economy, as well as the Central Nuclear Measurements Bureau (CNMB).

At the end of 1964, a proposal was drawn up by CETIS for the renewal of the digital computers during 1966, in view of the prospect of complete saturation of the present Ispra facilities as a consequence of the expected doubling of the work in three years' time. In addition, a project for a remote-control processing connection with Brussels has been finalized and CETIS has examined the possibility of carrying out direct-line computations for some of the establishment's laboratories with an auxiliary device.

Table 1

COMPUTER USE-TYPE OF WORK

(per cent)

	IBM 7090	IBM 1401/1	IBM 1401/2	PACE 231R/1	PACE 231R/2	PACE 231R/3
A. **Closed Shop Work** (1)						
1) *Computer operation and maintenance* (input-output, training, start-up, demonstrations, engineering changes, servicing, etc.)	10.4	66.6	18.0	11.5	12.0	13.16
2) *Operation of Programme Library and testing of programming system*	5.8	4.4	5.5	—	—	—
3) *Computation services*						
a) for Euratom scientific departments and Euratom contracts	6.5	0.9	1.0	84.2	84.0	74.52
b) for the European Communities' Statistics Office	14.2	7.3	8.4	—	—	—
c) for general departments of the Ispra Centre	1.0	0.5	30.4	—	—	—
d) for general departments of Euratom, Brussels	0.3	0.3	4.4	—	—	—
4) *Research Proper*						
a) automatic documentation and translation	2.3	0.7	18.3	—	—	—
b) other research : system programming (APACHE system, CARN monitor, automatic flow-charting, documentation compiler numerical analysis, nuclear-code full-testing and elaboration, special research into analog techniques, etc.)	16.6	5.8	2.0	4.3	4.0	12.32
	57.1	86.5	88.0	100.0	100.0	100.0

Table 1 (continued)

	IBM 7090	IBM 1401/1	IBM 1401/2	PACE 231R/1	PACE 231R/2	PACE 231R/3
A. **Closed Shop Work** (1)	57.1	86.5	88.0	100	100	100
B. **Open Shop Work** (2)						
1) *Work for Euratom account*						
a) Reactor Physics Department (use of library codes)	19.9	4.6	0.7	—	—	—
Reactor Physics Department (other questions)	10.8	2.8	1.3	—	—	—
b) Other Ispra Establishment departments	2.0	0.3	0.8	—	—	—
c) ORGEL	1.6	0.9	0.8	—	—	—
d) Head Office and other establishments of JRC	0.2	0.3	0.8	—	—	—
2) *Work for outside account* (Universities, nuclear research centres, scientific institutions, private firms, etc.) :						
a) Service-rendering contracts	3.2	1.2	3.0	—	—	—
b) Research contracts, contracts of association or special agreements	5.2	3.4	4.6	—	—	—
	100	100	100	100	100	100

(1) By CLOSED SHOP is meant computer work carried out by CETIS to solve problems referred to it by third parties or arising from research covered by its own programme. The latter items are grouped under point 4.

(2) By OPEN SHOP is meant computer work carried out by third parties themselves, only the computer time and operating being provided by CETIS. About half this work involves solely the use of routine library codes.

The closed-shop digital-computer departments have been responsible in particular for the development of general-purpose systems, the preparation of nuclear codes and the processing of problems for the scientific departments, as well as applied-statistics operations, and the final adjustment of programmes for the Information and Documentation Centre (CID) and the Ispra Library.

The analog computers have been used mainly for simulating the dynamics of the Essor and Sora reactors.

Table 2

COMPUTER TYPES

Total time employed (hours) (1 January — 30 November)

	Arithmetical				*Analog*		
	IBM 7090	IBM 1401/1	IBM 1401/2	IBM 1620	PACE 231R/1	PACE 231R/2	PACE 231R/3
1962	2 632	2 645	—	1 267	1 515	1 557	—
1963	3 742	3 274	2 055	770	710	918	1 085
1964	4 534	2 996	2 692	3 430	1 559	1 478	1 394

Research has been conducted into mathematical methods (probability and statistics, algorithm theory, functional analysis), calculation methods (hyperbolical differential equations, function approximation), analog and hybrid computation, future development of analog computers, introduction of certain modifications to analog computers for the purpose of combining the digital and analog techniques) and optimization techniques. In the programming system, a step forward has been taken by utilizing the MIDAS-programme (a simulator which enables a differential system expressed in analog block diagrams to be processed on an IBM 7090) in combination with the APACHE system.

Preliminary studies have been carried out on automatic flow-charting (initial phase in the reconversion of programmes from one computer to another) and the CARN monitor, with which it is possible to automate the calculation chain for a given type of reactor.

With regard to automatic documentation, there has been further cooperation with the CID. At the end of 1964, Ispra's activities in this field were cut down in order to satisfy its own requirements. The research on Russian-English automatic translation (contract with the University of Georgetown) was completed towards mid-1964. Since that date, translations have been prepared as and when requested.

Work on the study and development of nuclear codes originating outside the Community, together with the preparation of new codes, has been continued in collaboration with the Reactor Physics Department and the Nuclear Code Library of the ENEA.

DOCUMENT No. 19 **MISCELLANEOUS RESEARCH**

I. Solid State Physics

A team was set up at the Solid State Physics Section of the Ispra establishment to carry out post-irradiation studies on defect migration and fission product diffusion. The investigations into the optical and electric properties of ionic crystals under deformation and after the addition of chemical impurities were continued, together with the studies on X-ray diffraction through single crystals (Zn and Si) of varying degrees of imperfection. The plans for a high-precision MÖSSBAUER spectrometer were successfully completed in collaboration with certain other departments.

II. Magnetic Resonance

Basic research was conducted on the part played by free radicals in the decomposition of organic substances, by means of spectrometry and magnetic resonance (ESR). Magnetic resonance methods were also used to study solutions of organic radicals in toluene, deuterium-labelled diphenyls and irradiated organic crystals.

III. Direct Conversion

The study programme on methods for the direct conversion of nuclear heat into electricity was substantially revised owing to the invention of the heat pipe by Dr. Grover of Los Alamos, USA. With it, a certain separation can fundamentally be brought about between the nuclear heating and the point where electricity is generated by thermionic emission, so that the construction of a space reactor of about 100 kWh comes within the realm of possibility. A converter fitted with a heat pipe is now being manufactured for testing in the Ispra-1 reactor. Under the circumstances, it proved possible to construct a ceramic/niobium joint which is mechanically stable and vacuum-tight for temperatures of up to 1,200°C. Studies were carried out

on the technology of heat pipes, on corrosion problems and, under contract, on fuels (UO_2/Mo and UO_2/W cermets and pyrolytic-graphite-coated (UZr)C particles).

One effect of this development work was to hold up the research on the physics of thermionic converters. Promising results have been obtained by a study contract relating to the influence of CsF on the conversion yield and a contract for the fabrication of low-extraction-voltage anodes by the application of a semi-conductor layer.

IV. Low-Energy Nuclear Phenomena

During 1964 thirteen research teams continued their work on low-energy nuclear phenomena, as provided under the contract of association concluded between the Commission and the Italian Atomic Energy Commission (CNEN).

Research was carried on concerning the nuclear reactions triggered off by both neutrons and charged particles, on nuclear spectroscopy, nuclear photo-reactions and fission caused by photons and protons.

Among the most valuable results obtained, mention should be made of those relating to the Ericson effect and strong interactions, as well as of the demonstration of the nuclear fluorescence phenomenon. With regard to actual technical devices, note should be made of the 45 MeV azimuth-focussed cyclotron which went into operation in Milan.

DOCUMENT No. 20

IMPLEMENTATION OF CONTRACTS UNDER POWER REACTOR PARTICIPATION PROGRAMME

I. SENN Power Plant on Garigliano

1. *The power plant in industrial operation*

At the end of May 1964 the Garigliano power plant virtually entered the stage of industrial operation. The key dates during the past year were the following:

23 January: The generator was connected up to the grid in parallel, supplying it with nuclear electricity for the first time.

23 May: The installation reached rated electric power.

18 November: The official acceptance trials, lasting 100 hours at rated power, marked the end of the experimental programme, after which responsibility for the operation of the plant is assumed by SENN.

For about six months of the year the power plant supplied the power required by the grid. The installation operated at full power more or less non-stop, in fact, from the end of May to the beginning of October and from mid-November to the end of December.

The output and burn-up figures during 1964 were as follows:

— net electric power supplied to grid 680,200,000 kWh

— average burn-up at 31 December 1964 2,254 MWd/t

In industrial operation the installation was able not only to cope with the base load for a protracted period but also to respond to load fluctuations with remarkable ease. The load factor for the period 23 May through 31 December was 78.28%.

During the tests conducted during the course of the year, the net thermal power consumption was 2,725 kcal/kWh, or 6.4% less than the consumption guaranteed for a net efficiency of 31.5%, the design proportion being only 29.6%.

No defects were observed in any of the fuel elements.

A few technical details are now given on the work carried out during 1964.

On completion of the short-circuit tests on the alternator and after the group had been connected up in parallel with the grid (on 23 January), the test programme under power was resumed. The 220 kV link-up between Garigliano and Rome was completed on 25 January when the Garigliano-Latina section went into service.

During the 80 MWe tests, the turbo-generator set showed excessive overspeeding during load rejection, owing mainly to excess condensed water inside the turbine and the connected piping. As a result, modifications were carried out in several stages, which were in each case followed by control tests, this operation being conducted in two phases.

An attempt was first made to improve the drainage of the turbine and connected piping and to lower the emergency regulation cut-in value, as a result of which the tests could be continued and the rated power attained without any risk of a dangerous speed being reached. Owing to the energy requirements of the grid, the plant was then kept in operation and further modification aimed at the complete elimination of the snags were postponed until October, when a shut-down was scheduled.

These alterations consisted in the installation of a centrifugal humidity and drainage separator on the horizontal section of each of the two pipes connecting the high-pressure outlet and the medium-pressure inlet. Modifications were also carried out on the drainage systems of various stages of the high-pressure section and on the tapping system. Furthermore, a device was installed which, during load rejection provides for the simultaneous and early closure of the regulating valves and the non-return valves of the tapping system as well as the more rapid opening of the tapping system by-pass valves. Finally, a pre-emergency device was installed which, at a certain degree of overspeed, shuts the emergency valves and reopens them when the speed drops.

The shutdown in October was utilized to carry out some of the work on the installation, under the research and development programme, of a data-logger as well as on various servicing and repair jobs.

On 8 November the power trials were resumed and successfully completed. From 13 to 18 November the official acceptance test was conducted, lasting 100 hours, at the end of which SENN took over responsibility for the plant.

2. *Implementation of the contract*

a. *Secondment of personnel*

During 1964, the following personnel were assigned to the plant:

	Total	*Man/months*
Euratom employees permanently seconded	3	27.5
Engineers seconded by enterprises or organizations in the Community countries	7	10.5
Student trainees	3	6
Total	13	44

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

Engineers:	Belgium	1
	Germany	1
	France	3
	Italy	1
	Netherlands	1
Trainees:	Germany	1
	Netherlands	2

b. *Acquisition of information*

A total of 41 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. In addition, four reports were produced by student trainees.

II. ENEL/SIMEA Power Plant at Latina

1. *The power plant in industrial operation*

The plant was operated under normal conditions during 1964. Full power was maintained for nine months. A few data relating to this operation are given below:

— net electric power generated 1,462,300,000 kWh
— load factor 83.2%
— average burn-up of the fuel in the reactor at 31 December 1964 921.5 MWd/t

While the low-pressure stages of the three main turbogenerator sets were repaired, major servicing was also carried out on the six primary circuit loops. Minor output losses were observed as a result of slight leaks in the steam/water

circuit of the exchangers which necessitated the rapid but frequent repair of the exchanger insulation.

The behaviour of the fuel in the reactor was satisfactory. The maximum cladding temperature was increased from 450 to 455°C after a re-assessment of the maximum temperatures likely to arise in the event of an accident. This resulted in a 5 MW rise in the electricity output.

Five canning failures were detected during the first two months of the year. The corresponding channels were unloaded without any marked reduction in reactor power in the case of the last three.

The refuelling cycle commenced in September 1964, after sixteen months of power operation; the average burn-up was 750 MWd/t. Two hundred and eighty three of the reactor's 2929 channels were replenished. Generally speaking, the loading and unloading gear functioned satisfactorily, but some difficulties were encountered, in particular with regard to the operation of fuel element handling hook.

The operating expenses during the year totalled about 2,800,000 u.a., roughly 20% of this sum being spent on maintenance and approximately 30% on overheads.

A programme of measurements was commenced on the reactor in order to determine the pattern followed by the nuclear parameters as a function of fuel irradiation. It is to be carried out under a research contract awarded by the Commission, and is expected to yield data on, in particular, the reactivity curve for this type of reactor.

2. *Implementation of the contract*

a. *Secondment of personnel*

During 1964, the following personnel were assigned to the plant:

	Total	Man/months
Euratom employees : *a*) permanently seconded *b*) temporarily seconded	 1 1	 12 1
Engineers seconded by enterprises or organizations in the Community countries	12	6
Student trainees	2	2
Total	16	21

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

Engineers:	France	12
Trainees:	France	1
	Netherlands	1

b. *Acquisition of information*

A total of 29 reports and papers were drawn up during the year. This figure includes reports by engineers seconded from Euratom and organisations and firms in the Community countries and also papers presented by these engineers and representatives of the contractors at the last information meeting. In addition, two reports were produced by student trainees.

III. SENA Power Plant at Chooz

1. *Status of the work*

During the year, work progressed largely in keeping with the programme schedule. The difficulties encountered early on during the excavation work did not lead to any major hold-ups. Excavations of the galleries, wells and caverns is now completed and a total volume of 85,000 cubic metres has been hollowed out. After this, work was commenced on the concreting of all the galleries and caverns. The wells were either concreted or reinforced by concrete-injection. The reactor cavern was lined with 3 mm plating, by means of which, after installation of the locks and penetrations for cables and pipes, the atmosphere of the cavern can be controlled. All the weld seams were carefully inspected. In the same cavern, the concreting of the reactor swimming-pool, the supports and foundations of the primary circuit (steam generator, pressurizer, pumps, valves and piping) and of the intermediate levels was then carried out. This was followed by the installation of the overhead crane and the neutron shielding vessel, after which the supports and mountings for the steam generators were fitted, together with the stainless steel lining for the reactor swimming-pool.

In the auxiliaries cavern and that housing the electrical installations, work was also carried out on the concreting of the structures, i.e., the supports, foundations and intermediate levels. The overhead crane, several tanks and heat-exchangers were then installed in the auxiliaries cavern and a start made on laying the cable leads and ventilation system in the cavern housing the electrical installations.

Work was completed on the bridge over the Meuse linking up the various parts of the site, on the concreting of the turbine house, the electrical wing, the administration block and the purification and fuel element storage building, and on the water intake and discharge installations. Construction is continuing of the buildings to be used as workshops, storage blocks and radioactive waste processing points.

The steel structures of the upper part and of the roof of the turbine house have now been installed, but work is still in progress on the outer finish of the walls.

A feed-water tank was mounted on the roof of the electrical wing. The turbine building overhead crane has already gone into service. Installation of the first half of the condenser is completed and the necessary penetrations are now being bored. Work was started on fitting the water-processing unit and the compressed air station. The coolant water ducts linking up the water-intake unit, the turbine building and the discharge structure are now installed, together with the recirculation piping. Work is progressing on the drainage system and the access roads.

In November, after six weeks in transit, the pressure vessel arrived from Le Creusot. Pending its erection in the reactor cavern, it is being left on its trailer in the turbine hall, where it is protected against low temperatures by electrical heating elements and an insulation system.

Work is in hand on the fabrication of the pressurizer, various parts of the primary circuit piping and the turbo-generator group, and construction of the pumps and primary valves is particularly well-advanced. The test loops are now being checked and the steam-generators are to be delivered shortly.

To sum up, the SENA project is progressing according to schedule under which the reactor is stated to go critical in mid-1966.

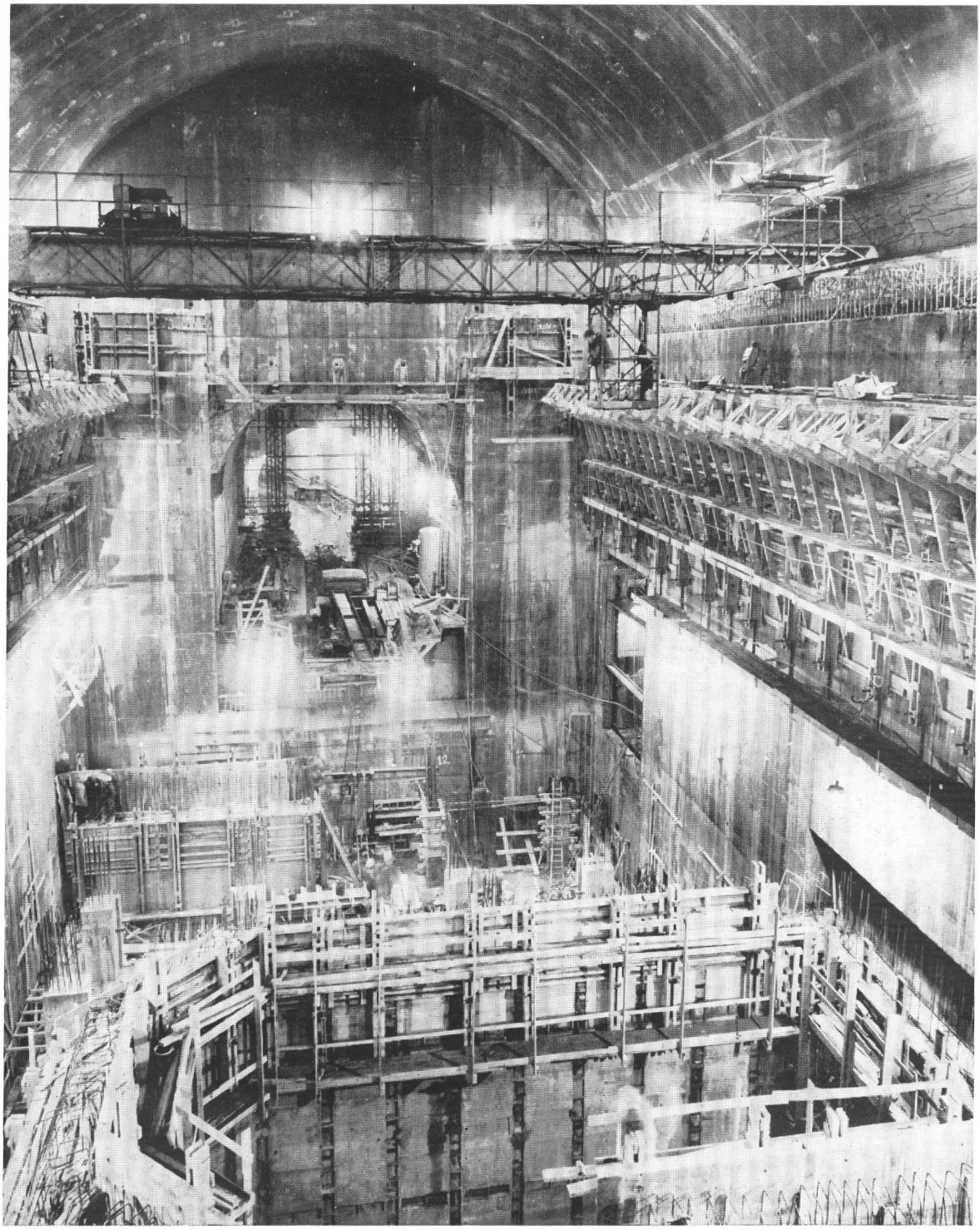
2. *Implementation of the contract*

a. *Secondment of personnel*

During 1964, the following personnel were assigned to the plant:

	Total	Man/months
Euratom employees permanently assigned	3 (1)	30

(1) One of these engineers was seconded to Westinghouse, Pittsburgh, for one year as of 15 January 1964.



REACTOR "SWIMMING POOL" AT THE NUCLEAR POWER PLANT
OF SOCIÉTÉ D'ÉNERGIE FRANCO-BELGE DES ARDENNES (SENA)

(See other side of page for caption)

This 266 MWe generating station is in an advanced stage of construction : excavation and concreting of the galeries, pits and caverns have been completed and the reactor vessel installed.

First criticality is scheduled for mid-1966 and the plant will become operational towards the end of the same year.

The SENA power plant forms part of Euratom's participation programme.

b. *Acquisition of information*

A total of 30 reports and papers were drawn up during the year. This figure includes reports by engineers seconded from Euratom and also papers presented by these engineers and the representatives of the contractors at the last information meeting.

IV. KRB Power Plant at Gundremmingen

1. *Status of the work*

In January 1964 an initial pressure test conducted on the reactor containment shell revealed certain faults, which necessitated modifications of certain parts, including the lock penetrations. The concreting of the inside of the containment could thus not be carried out on time, which meant that the project was several months behind schedule. Te second pressure test, performed in August 1964, was entirely satisfactory. A start could then be made on the concreting, which was pushed ahead to make up the leeway.

While modifications were being carried out on the containment, more attention could be devoted to other civil engineering work, so that the construction of the other buildings advanced more quickly than planned.

The fabrication at works of various parts of the power plant continued in a normal way. The main components, such as the pressure vessel, the secondary steam generators, the circulation pumps, the primary water clean-up system and the turbine, are now nearing completion. The works tests and delivery on site will take place during the first quarter of 1965.

The final characteristics of the initial core were determined. The fuel elements, the control rods, together with their drive mechanisms, the steam separators and the core structural components are now in the course of fabrication.

The construction schedule was recently revised to bring it in line with the status of the civil engineering work and the fabrication of the main equipment. Initial criticality is now fixed for May 1966, and the plant is due for commissioning, as planned, at the end of the same year.

2. *Implementation of the contract*

a. *Secondment of personnel*

During 1964, the following personnel were assigned to the plant:

	Total	Man/months
Euratom employees permanently assigned	2	24

b. *Acquisition of information*

A total of 17 reports and papers were drawn up during the year. This figure includes reports by engineers seconded from Euratom and also papers presented by these engineers and the representatives of the contractors at the last information meeting.

V. The SEP Power Plant at Doodewaard

1. *Status of the work*

The project is made up of three stages, the second of which (detailed design study of the plant) was completed during the year. The scheduled time of eighteen months estimated for this stage was thus adhered to.

The major modifications in relation to the preliminary design concerned the following points:

— Zircaloy-2, rather than stainless steel, is now to be used for fuel element cans, which will be of the self-supporting type and made in one piece. This will give a 19 % reduction in the active length of the fuel, leading to a 24 % increase in the average power density.

— As a result of the higher pressure drop stemming from the use of Zircaloy instead of stainless steel and the better knowledge of recycling phenomena acquired on a similar reactor—that at Humbold Bay, the height of the "stacks" on the fuel element channels had to be doubled.

— It was originally planned to mount the separators and the steam outlets on the walls of the main body of the pressure vessel. It was then decided to attach them to the vessel lid, thus giving better steam separa-

tion for the same pressure vessel height, as well as an improved flow distribution.

— The emergency condenser is now housed in a specially designed tank instead of in the irradiated fuel storage pond, thus obviating the risk of radioactive contamination from defect elements.

— The diameter of the pressure vessel was reduced from 305 to 279 cm.

— The average burn-up was stepped up by about 15 %.

On completion of the design studies, an estimate was drawn up of the precise cost of the plant. The ceiling fixed was 95 million florins, this being one of the conditions imposed by the SEP itself on the construction of the power plant.

The SEP arrived at its decision at the end of January 1965 and began to form a company, the Gemeenschappelijke Kernenergiecentrale Nederland NV (GKN), to run the plant. The Minister of Social Affairs has given his approval for the construction and critical experiment.

The preparatory work on clearing the site (earthworks, construction of a harbour, dikes and additional access routes) had already been started back in October 1964. Thanks to favourable weather, about a quarter of this work was finished by the end of the year. The site earmarked for the power plant was raised to "high-water" level so that the foundations could be commenced as soon as the Dutch Government gave its consent.

At the beginning of 1964, the SEP team consisted of nine engineers and three technicians. Six engineers, including one from Neratoom, were seconded to General Electric at San José until October to carry out detailed studies of the nuclear steam supply system. Another engineer worked at the SENN until the summer. The team now consists of twelve engineers and six technicians, including two engineers assigned to the SEP by Euratom's Directorate for Industry.

The management of the general project is in the hands of the SEP construction office at Arnhem. General Electric has undertaken to design the nuclear steam supply system, with the collaboration of the engineers assigned by the SEP. The other work, including the studies on the pressure vessel steel and the shielding calculation, is being performed by the Arnhem construction office. From 1 October to the end of December the drawing up of the final safety report was continued, while the Euratom Commission, at the request of the Dutch Government, charged a group of Community specialists to formulate an expert opinion.

In line with the terms of the Euratom/SEP contract of participation, the SEP kept the Commission supplied with all the specifications and final plans throughout the year.

Two engineers from Euratom's Directorate for Industry were seconded to the SEP as permanent representatives in order to keep the Commission informed about the status of the work. By virtue of their professional qualifications they were included in the working groups of the construction office.

2. *Implementation of the contract*

a. *Secondment of personnel*

During 1964, the following personnel were assigned to the plant:

	Total	Man/months
Euratom employees permanently assigned	2	14.5

b. *Acquisition of information*

A total of 16 reports and papers were drawn up during the year. This figure includes reports by engineers seconded from Euratom and also papers presented by these engineers and the representatives of the contractors at the last information meeting.

VI. Information supplied by the contractors

In return for its backing, the Commission receives, *inter alia,* information from its contractors as a result of which an overall body of information and data can be set up covering 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 test programmes;

— 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, modifications introduced during construction, main difficulties and incidents, steps taken to overcome them;

— information of a financial, technical and economic nature.

In line with the terms of the contracts, Euratom's partners regularly supplied the required information, representing a total of some 12,000 pages of text and drawings during 1964.

BREAKDOWN BY POWER PLANT AND TYPE OF DOCUMENT OF THE INFORMATION RECEIVED DURING THE YEAR

Information received	SENN	SIMEA	SENA	KRB	SEP	Total
Initial reports	—	—	23	—	—	23
Annual reports	1	1	2	1	1	6
Quarterly reports	5	3	5	7	4	24
Special reports	2	—	—	—	—	2
Safety reports	—	—	2	2	1	5
Plants, specifications, etc.	101	4	109	156	181	553
Total	109	8	141	166	187	613

VII. Dissemination of Information

The information supplied to Euratom under the terms of contracts of participation is placed at the disposal of bodies, enterprises and autorized persons and is disseminated in one of two ways:

1. *Dissemination of documents*

The following documents are distributed via the six national correspondents:

— reports of engineers seconded by the Commission;

— periodical lists relating to the reports of 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 Euratom head-office.

Documents microfilmed in 1964: The table below gives the number of microfilms requested per country for each power plant, together with the number of applicants per country.

Country	No. of Applicants	SENN	ENEL/ SIMEA	SENA	KRB	SEP	Total
Belgium	2	1	—	4	—	—	5
Germany	6	18	1	7	21	4	51
France	3	12	24	—	1	2	39
Italy	4	168	148	83	6	6	411
Netherlands	3	—	—	2	3	2	7
	18	199	173	96	31	14	513

In the course of the same year, the documents available at Euratom head-office were consulted by 233 persons, the breakdown being as follows:

Belgium	25	organizations	and	firms	sent	52	persons
Germany	28	»	»	»	»	50	»
France	28	»	»	»	»	62	»
Italy	12	»	»	»	»	34	»
Luxembourg	1	firm	sent			2	»
Netherlands	15	organizations	and	firms	sent	33	»
	109					233	

2. *Information meetings*

The fourth information meeting on the implementation of the contracts of participation in power reactors was held in Brussels on 13 and 14 May 1964. A total of 109 Community organizations and enterprises were represented at this meeting, breaking down as follows:

Belgium	25
Germany	28
France	28
Italy	12
Luxembourg	1
Netherlands	15

The meeting was attended by 250 people. The agenda covered discussions of general problems, organization, economic aspects and dissemination of information, while papers were read by engineers from Euratom and those seconded from Community firms and organizations and by representatives of the companies holding contracts.

These reports yielded valuable data on the present situation with regard to the five power plants and on various technical aspects of their construction. The main points dealt with were the results of the commissioning tests of the Garigliano and Latina power plants, the status of the work, design and construction problems at the Chooz and Gundremmingen plants and the design problems and certain technical questions relating to the Doodewaard plant.

DOCUMENT No. 21

THIRD-PARTY LIABILITY

European Conventions on third-party liability

In 1960, the majority of Western European countries, including all Member States of the European Community, signed the Paris Convention (of 29 July 1960 on third-party liability in the field of nuclear energy). In 1963 they signed the Brussels Supplementary Convention (of 31 January 1963, Supplementary Convention to the Paris Convention of 29 July 1960 on third-party liability in the field of nuclear energy). These Conventions have not yet come into force, however.

The establishment in Europe of a common system of nuclear third-party liability was dictated by the very nature of nuclear damage, the effects of which may transcend national frontiers, and by the need for aid from public funds in the event of major accidents. The European States propose to assume joint responsibility for this financial risk under a mutual compensation system. In the case of the European Community, another important factor was the nuclear common market, which demands a uniform system of third-party liability, since differing systems could result in cost disparities entailing undesirable distortions of competition.

Entry into force of Conventions

Ratification of the Conventions was delayed in most of the signatory states on account of the finalization of the text of the Vienna World Convention shortly after the signing of the Brussels Supplementary Convention. Although the Vienna Convention had been signed by none of the Member States of the European Community, nor by the United States, the USSR or Great Britain, provision had to be made for simultaneous accession to the European Conventions and the Vienna Convention. Additional protocols supplementing and modifying the former to make them compatible with the latter were accordingly signed in January 1964. Thus adjusted to their final form, the European Conventions are now ready for ratification.

The Commission believes that, in view of the growth of nuclear industry, speedy ratification and implementation of the Conventions in the Community would be highly desirable, and it has approached Member States on the matter. Ratification would enable procedures governing permits for the operation of nuclear plants to be simplified and speeded up and would make it possible to cut insurance costs.

Legislation by Member States

In Italy, an atomic law embodying the principles of the Paris Convention was enacted on 31 December 1962. Ratification of the Convention would require only slight changes in that law and so should encounter no great difficulties as regards an early passage.

In the Netherlands, an interim Bill on nuclear third-party liability has been tabled in Parliament and is to be voted on shortly. This likewise incorporates the principles of the Paris Convention and is to remain in force until the latter is ratified. Adapting it to the terms of the Convention will present no special problems. It is hoped that Italy and the Netherlands will soon ratify the Conventions.

Laws to ratify and implement the Conventions are currently under consideration in France and Belgium and the expectations are that they may be adopted during 1965.

In Federal Germany and in Luxembourg, work has not yet started on ratification and implementing legislation. The German atomic law enacted in 1959 does institute a system which corresponds broadly to the provisions of the Conventions save on certain points which will need modifying. As regards Luxembourg, the problem has not yet arisen at the time of writing.

Coordination of implementing legislation

On a number of matters the Conventions allow Member States considerable latitude as regards national implementing legislation. Nevertheless, the Commission feels that the European nuclear market might suffer distortion if Member States were to exercise their right to settle every one of these points as they think fit without prior coordination. During the autumn of 1964, therefore, it called on Member States to harmonize their laws for implementing the Conventions, specifying the items in respect of which it regarded harmonization as particularly advisable. In January 1965, a first meeting of experts

from the Member States was held for the purpose of comparing draft texts of laws to implement the Conventions. At this meeting, the Member States and the Commission agreed to proceed actively in their endeavours to coordinate the texts. The Commission put forward suggestions aimed at facilitating adoption of joint solutions on the principal points left to the discretion of contracting States under the Conventions. There is to be a second meeting in the very near future.

DOCUMENT No. 22

NUCLEAR RISK INSURANCE

1. *Insurance of the Community's installations*

When considering the insurance of its own nuclear installations, the Commission had to contend with a dual problem, namely insurance against material damage and coverage of its third-party liability.

As regards nuclear damage insurance, the Commission, with the full agreement of the Council, deemed it unnecessary in 1965 to change the existing system, under which risks of this kind are not covered by means of the insurance market but from the Commission's own budget.

On the question of the coverage of third-party liability involved in the operation of the JRC (Joint Research Centre) establishments, discussions had already been held in 1963 and 1964 with the Council. The complex nature of the problem and the diversity of the solutions applied in the Member States made it difficult to lay down a general policy for the Community in 1964. For 1965, therefore, it was provisionally decided that the Community's liability for the Ispra Centre and the CNMB (Central Nuclear Measurements Bureau) should be covered by insurance and that as regards the hazards connected with the Transuranium Institute at Karlsruhe provisions should be made in the budget, the Community thus becoming its own insurer.

With the object of facilitating the adoption of a solution appropriate to all Euratom's own installations, the Commission last year entered into wide-ranging consultations with the sectors concerned in order to obtain further information.

The results of these consultations should, even though they have not entirely fulfilled the Commission's hopes—the nuclear insurance market not being sufficiently fluid to be completely competitive—enable it to determine in the course of 1965 the main lines of the policy to be pursued in covering third-party liability for the operation of its fixed nuclear installations.

2. *Practical problems of nuclear insurance*

As in previous years, the Commission concerned itself with the practical problems of nuclear insurance in general. In this context, a colloquy was held with nuclear insurers in the Community at Aix-en-Provence in May 1964, attended by observers from the Governments of the Member States. At this meeting, the Commission called attention to the medium-term expansion prospects held out for the nuclear insurance market by the development of nuclear energy and to the efforts which this trend will demand from insurers.

Even so, the special position of nuclear insurance in relation to other branches of this industry appears likely to persist for quite a long time. This situation is attributable mainly to the fact that nuclear risks are as yet imperfectly known, the number of existing nuclear installations still being very small. The probability of serious accidents is low, but a loss might prove an extremely costly business. It is still impossible, in the field of nuclear insurance, to calculate claim probabilities on the customary actuarial basis, i.e. from statistics. Another consequence of the dearth of existing nuclear facilities is that premiums will not suffice to cover any major losses that may be sustained. In contrast with other types of insurance, for which the insurers merely organize a community of co-insurance, the nuclear branch constitutes a real financial risk. It is for this reason that the various insurance and reinsurance companies only agree to assume relatively minor risks for their own account. Consequently, the insurance companies in the Member States have grouped themselves in pools for the purpose of co-insurance.

Among the conditions for the development of a Community nuclear insurance market, the insurers set particular store by the coordination in the Member States of the laws enacted in implementation of the Paris and Brussels Conventions. They expressed interest in any measures that might be taken in this direction by the Commission, to whom they have since made know their standpoint.

Finally, the insurers welcomed the Commission's intention to promote the standardization of the conditions applied by the pools for the insurance of fixed nuclear installations. Alignment of contract practices is calculated to encourage the development of reinsurance and to contribute to the reduction of insurance costs.

The Commission is at present working with the insurers on bringing into line insurance policies covering third-party liability for fixed nuclear installations. The principles governing a standardized insurance policy are in the

process of elaboration by a working group set up by the Commission and the insurers. As nuclear insurance assumes the concentrated form of pools, the Commission considers it desirable to fix the basic principles destined to govern insurance conditions in conjunction with all the parties concerned. The standardized texts will accordingly also be examined with the leading European associations of insurance subscribers before publication.

After insurance policies covering third-party liability in respect of fixed nuclear installations, standardization is to be applied to nuclear-damage policies, in addition to which there is to be an overhaul of third-party liability insurance in the field of nuclear transport.

DOCUMENT No. 23

MANAGEMENT OF INDUSTRIAL PROPERTY

There has been further growth in the number of patents filed with the Community. In a statement to the Council, the Commission defined the system governing patents stemming from contracts of association. This followed the definitions of the contract-research patent system (1961), of the system governing non-patentable information arising out of such contracts (1963), of that regarding "basic patents" held by contractors (1963), and of the Commission's attitude to the granting of licences in respect of these patents to non-member States and to persons or enterprises outside the Community (1963). The policy embodied in this series of definitions has been borne out by its smooth application.

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

Notification of patent applications as prescribed in Article 16 of the Treaty proceeded in a regular manner and within the time-limits laid down. By 31 December 1964, the Commission had received details of 11,322 patent applications, 1,361 of them notified in 1964. The number of inventions covered by patent applications communicated to the Commission in the form of either accounts of content or simple notifications totals 8,333.

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

At the end of 1964, the Commission's Patent Office had examined 634 inventions stemming from the research programme. Of this number, 247 were examined in 1964 as against 139 the previous year. Between the entry into force of the Treaty and the end of 1964, these inventions had been the subject of 532 first applications filed in one country on behalf of either the Community or the holders of Commission contracts, 181 of them being filed in 1964. The total number of requests for extension of patent rights to other countries had risen to 1,412 by the end of last year. As regards patent

applications lodged in countries where a preliminary examination is required, 59 have been granted; none has been rejected.

The following is a breakdown of inventions for which patents had been filed up to the end of 1964:

	1964	*Previous years*
ORGEL, ECO and ESSOR	14	73
Fast reactors	66	—
Controlled thermonuclear fusion	18	35
BR 2	6	20
Dragon	25	68
Miscellaneous	104	103

The breakdown by origin is as follows:

	1964	*Previous years*
Joint Research Centre establishments	61	91
Contracts of association	97	83
Other contracts	46	54
Dragon	24	67
Miscellaneous	5	4

A list of the patent applications filed during the period from 1 January to 31 December 1964 is given in Document No. 34 attached to the present General Report.

In addition, the periodical "Euratom Information" publishes the administrative data relating to the patents granted and their principal claims.

3. *Working of patents held in portfolio*

The JRC establishments and contract-holders are already using on a laboratory or semi-industrial scale a considerable proportion of the patented inventions stemming from the Community programme. The number of applicants for licences under Article 12 of the Treaty remains small. Applications for licences relate to patents of limited scope (minor equipment, measuring instruments, etc.) with other than purely nuclear applications. Apart from their use in the reactors of the Commission and its association contract-holders, demand for licences in respect of patents for reactors or reactor parts can only be expected to develop once the construction of prototypes has been decided upon. Moreover, the Treaty precludes sole licences, thus reducing

the licencee's protection in the market, and this hardly encourages enterprises in the Community to invest the capital which the marketing of new products demands.

In 1964, only one new licence was granted. It concerns a patent arising from research under a contract of association, the subject being a densimeter.

On the other hand negotiations for four other licences are well ahead. They are believed to deal with an electrostatic spray, a ceramic for melting uranium and its alloys, an apparatus for the purification of confined inert gas and one for measuring leakages from glove-boxes or α cells regarded as leak-proof.

4. *System governing patents in contracts of association*

The Council took formal note of a statement by the Commission with regard to the rules governing patents in contracts of association. The underlying principles, by which the system applied since 1961 to research contracts will be adapted to contracts of association, are the following:

— Generally speaking, patents to project inventions arising from a contract of association shall be filed in the name of the contractholder if the latter so desires. In exceptional cases, for instance in the event of a waiver by the contract-holder, they shall be filed in the Community's name. The cost of filing, issuing, maintaining and protecting patents shall be shared in the same proportions as the costs of the association.

— The Commission and the contract-holder shall enjoy the right to use free of charge for their own purposes patents arising from a contract of association, such right being non-exclusive and irrevocable.

— The Commission and the contract-holder shall by mutual agreement grant licences or sub-licences for nuclear applications. For non-nuclear applications, the associate shall freely grant licences, subject to notifying the Commission thereof.

In the case of nuclear applications, neither the Commission nor the contract-holder shall withhold agreement to the granting by the other party, to the Member States, persons or enterprises in the Community including joint enterprises, of a licence or sub-licence to work patents within the territory of Member States; the same shall hold good when the licence or sub-licence is not granted solely for conducting research, or for the export of articles made in that territory but part-manufacture of which is authorized in the country of destination if this is a necessary condition of exportation (legislative or

administrative provisions, terms of specification, customs tariffs etc. in the country of destination).

A licence or sub-licence may be granted subject to no conditions other than those set out on the foregoing sub-paragraph.

a. when it is granted solely for conducting research;

b. when it is granted to make possible exploitation of the results of research carried out by or on behalf of the contracting party granting it, in so far as the licence or sub-licence is necessary in order to exploit those research results.

In other cases:

a. the Commission may grant a licence or sub-licence only after satisfying itself that this accords with the Community's aims, that is to say, that it will help to create the requisite conditions for the speedy establishment and growth of nuclear industries in the Community.

b. the Commission may oppose the granting by an association-contract-holder of a licence or sub-licence which it regards as incompatible with the Community's aims.

— Royalty rates and general or particular terms of licences or sub-licences for nuclear applications shall be fixed by mutual agreement (even when mutual agreement is not required on the actual principle of granting the licence or sub-licence).

— Royalties shall be shared between the Community and the contract-holder in the same proportions as the costs of the association. The question whether the royalties for non-nuclear applications are to be shared shall be discussed contract by contract.

— Where necessary, the associated undertaking shall, in regard to basic patents, enter into commitments similar to those required, in relevant cases, when concluding research contracts financed as to 100%.

5. *Standardization of industrial property rights within the European Community*

The preliminary draft European Patent Convention, in the drawing-up of which the EEC and Euratom Commissions participated, is at present under consideration by the Council.

There are major political problems still outstanding, in particular the questions whether the Convention should create a Community or an international patent and whether or not access to it should be restricted to nationals of Member States signatories to the Convention.

DOCUMENT No. 24 **SAFEGUARDS AND CONTROLS**

1. *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			
	1.1.1962	1.1.1963	1.1.1964	1.1.1965
Regulation No. 7	83	97	117	135
Regulation No. 8	127	134	155	168

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.

2. *Notification of technical characteristics of installations (Regulation No. 7)*

Installations whose basic technical characteristics had been communicated to the Commission at 1 January 1965 are set out in the following table according to industry:

	Belgium	Germany	France	Italy	Netherlands	Community
Concentrate fabrication	1(1)	1	4	1(2)		7
Fuel fabrication	1	1	6			8
Fuel element fabrication	3(3)	2	4	1		10
Reactors	7(5)	22	24(4)	20	8	81
Irradiated fuel reprocessing			1	1		2
Laboratories	5	6	7	9(6)		27
	17	32	46	32	8	135

(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.

3. *Materials stocks and movements (Regulation No. 8)*

The figures hereunder show the position regarding the implementation of Regulation No. 8 at 1 January 1965:

a. Stocks held and stock movements within the Community:

— Ores: 10 enterprises send the Commission quarterly statements of output and stocks at 29 mines.

— Source and special fissile materials: 64 enterprises transmit to the Commission the balance-sheets and inventories of 139 installations.

b. Export and import transactions with non-member countries:

Twenty-two enterprises sent the Commission 341 import or export declarations relating to the transfer to or from non-member countries of the following:

	Imports	*Exports*
— natural uranium	25	26
— depleted uranium	19	6
— Thorium	22	57
— special fissile materials	157	29
Total :	223	118

One hundred and one of these imports and twelve of the exports involved materials delivered to the Community under agreements for cooperation.

c. The tables which follow 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 SPECIAL FISSILE MATERIALS

	31.12.62 Bilateral agreements concluded by		31.12.63 Bilateral agreements concluded by		31.12.64 Bilateral agreements concluded by	
	Community	Member States	Community	Member States	Community	Member States
Enriched uranium (U-235 kg)						
Research centres	2	98	1	151	43	453
Fuel production	1	138	130	473	217	593
Reactors	50	736	1,145	834	2,656	1,146
	53	972	1,276	1,458	2,916	2,192
Total for Community	1,025		2,734		4,948	
Plutonium (kg)						
Research centres	1	1	8	4	51	4.4
Reactors	0.2	0.1	0.4	0.2	2	0.2
	1.2	1.1	8.4	4.2	53	4.6
Total for Community	2.3		12.6		57.6	

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

	31.12.1962	31.12.1963	31.12.1964
Reactors	669	844	1,230

The following is a breakdown of enterprises, establishments and installations to which Regulation No. 8 applies:

	Bel-gium	Ger-many	France	Italy	Nether-lands	Commu-nity
Enterprises	7	24	16	17	8	72
Establishments	8	27	50	19	8	112
Installations	13	38	71	31	15	168
– Mines		2	26	1		29
– Concentrate fabrication		1	4			5
– Fuel fabrication	1	1	3			5
– Fuel element fabrication	1	3	6	1		11
– Reactors	6	22	22	19	8	77
– Irradiated fuel repro-cessing			1			1
– Laboratories	5	9	9	10	7	40

4. *Inspections*

During 1964, inspectors visited 110 installations, viz:

	No. of inspections
— Ore concentration plants	2
— Fuel manufacture plants	9
— Fuel element fabrication plants	12
— Power reactors	9
— Research reactors	55
— Research laboratories	23

DOCUMENT No. 25

ACTIVITIES OF THE SUPPLY AGENCY

The Euratom Supply Agency began its activities on 1 June 1960. At that date the nuclear industry was developing at a substantially slower rate than had been expected during the Treaty negotiations.

Natural uranium supplies.

Civilian demand for natural uranium was then fairly low, amounting in practice to the requirements of research and a few pilot industrial plants. Furthermore, in the ores and source materials market, supply conspicuously outweighed demand.

For these two reasons the Commission tried to establish a more fluid transactions procedure than the transitional system laid down in Article 222 of the Treaty, under which the conclusion of contracts relating to the supply of ores and source materials was subject to authorization by the Commission.

The Commission also considered that the procedures for comparing supply and demand could not be laid down without complete knowledge of the state of the market for each of the products governed by Chapter VI of the Treaty. It therefore instructed the Agency to launch a market survey. The findings of this survey—the first of its kind in the Community—which covered the period 1960-1965, convinced the Agency, as well as the qualified representatives of users and producers on the Agency's Consultative Committee, that the required procedure for transactions in ores and source materials ought to be made more flexible.

Thus after obtaining the Consultative Committee's opinion the Commission approved a regulation on the comparison of supply and demand, drawn up by the Agency, under which contracts relating to such materials could be concluded by a simplified procedure.

This simplified procedure, which is still in force, its utility having been borne out by a second market survey (1963-1967), while enabling producers and users to negotiate their supply contracts freely both within and outside the

Community, at the same time formally maintains the Agency's exclusive right to conclude contracts, this right being exercised by the expedient of compulsory notification of contracts.

Study of long-term uranium supply prospects

The information available on natural uranium resources was not particularly accurate, so the reserves were considerably overestimated. The general opinion was that there would be no difficulty over uranium supplies, even in the long term. In view of the prospects for nuclear power as set out by the Commission in its 1960 report, and especially of the early date at which it will become competitive with conventional power, thus boosting the demand for uranium, the Agency decided to undertake a thorough study in conjunction with its Consultative Committee, of the Community's uranium supply problems in relation to the Western world as a whole. The Consultative Committee issued a report on these studies which was published with the Commission's approval and found a wide audience. It helped to show governments and industry that the West's resources of economically workable uranium were by no means unlimited and that the resources available to the Community bore no relation to its foreseeable long-term requirements.

For the first time, Europe faced the problem of long-term uranium supplies. It was debated in the European Parliamentary Assembly which by unanimous resolution recommended the Commission to take any necessary steps to devise a solution.

The facts set out in the report by the Consultative Committee of the Supply Agency were corroborated at the Geneva Conference in September 1964. The interest taken by the Commission in the problem, with the backing of the various circles involved, is reflected in the number of practical schemes which it has initiated and which are described in Chapter III of the General Report.

Special Fissile Materials

The Supply Agency has played a distinctive part in the field of special fissile materials, owing to the character of these materials and the nature of their market structure, and in view of the Agency's full exercise of its right to conclude contracts.

Power Reactor Supplies

The Agency has so far concluded three contracts with the USAEC, for the supply of special fissile materials for power reactors:

	Approximate total quantity U-235	*Value in EMA u.a.*
SENN (Italy) (Società Elettronucleare Nazionale)	4,000 kg	30,000,000
SELNI (Italy) (Società Elettronucleare Italiana)	8,000 kg	73,000,000
SENA (Société d'Energie nucléaire Franco-belge des Ardennes)	8,000 kg	75,000,000
Total:	20,000 kg	178,000,000

These three reactors were able to obtain their fuel supply on deferred payment terms. Under this arrangement, payments for fuel consumed in the reactors can be spread over 10 years, interest of 4% per annum being charged on the deferred instalments. Immediate payment is required, however, for amounts above a predetermined ceiling related to the "inventory" of the fuel supplied. The supply contract also provides that the value of the enriched uranium recoverable from the fuel elements irradiated in the reactor is to be credited by the USAEC to the Agency for the purchase of fresh enriched uranium intended for the reactors the fuel for which is supplied by the Agency under the Cooperation Agreement or its Supplementary.

With regard to the SENN and SENA reactors, which come under the Euratom/USAEC joint power reactor programme, a second contract provides that the USAEC will purchase a limited quantity of such plutonium as cannot find a buyer in the Community.

Supplies for other power reactors are in course of negotiation:

	Approximate total quantity U-235	*Value in EMA u.a.*
KRB (Germany) (Kernkraftwerk RWE-Bayernwerk) (boiling water 237 MWe) (accepted under the joint power programme)	6,800 kg	55,000,000
AEG (Germany) (Kernkraftwerk Lingen GmbH) (boiling-water 160 MWe 250 MWe (superheated)	847 kg	6,300,000

KERNKRAFTWERK OBRIGHEIM (Germany) (pressurized water 280 MWe)	2,600 kg	21,000,000
Total:	10,247 kg	83,300,000

The same applies to certain firms which have asked the Agency to open negotiations to meet their requirements for industrial reactors, in particular:

	Approximate total quantity U-235	*Value in EMA u.a.*
GKSS (Germany) (Gesellschaft für Kernenergieverwertung in Schiffbau und Schiffahrt Hamburg) (pressurized-water (advanced) reactor for ship "Otto Hahn")	225 kg	2,000,000
Belgonucléaire/VULCAIN (Anglo-Belgian) (Société belge pour l'industrie nucléaire) (pressurized-water with variable moderation 20/25 MWe)	1,000 kg	10,000,000
AVR (Germany) (Arbeitsgemeinschaft Versuchsreaktor) (gas/graphite high temperature)	30 kg	360,000
Total:	1,255 kg	12,360,000

Thus as regards supplies to reactors for industrial purposes, the Agency, at the close of the current negotiations will have handled transactions involving a turnover of 272,660,000 EMA u.a. for 31,502 kg of U-235.

Supplies for research purposes

The Agency has always aimed at standardizing and simplifying transactions in fissile materials for research, grouping them wherever possible under framework contracts. Thus a sales contract was concluded with the USAEC on 24 May 1961, for the purchase of 1,000 kg of enriched uranium and 8 kg of plutonium to meet the requirements of the joint United States/Euratom research and development programme.

Under this contract, 25 kg of enriched uranium and 8 kg of plutonium were imported, with a total value of 100,000 EMA u.a.

Multi-lease contract

On 18 July 1962 the Agency and the USAEC signed a multi-lease contract for the hire of special fissile materials covered by the Supplement to the Euratom/United States Cooperation Agreement. A new lease, signed on 1 December 1963 and valid up to 30 June 1967, provides for supplies to several Community research reactors.

The most important orders already placed under this multi-lease contract are listed in the table below:

	Approximate total quantity U-235	*Value in EMA u.a.*
ISPRA 1 (Italy)	41.5 kg	500,000
BR 2 (Mol-Belgium)	126.8 kg	1,500,000
High Flux Reactor (Petten, Netherlands)	110.0 kg	1,300,000
PEGASE (French Atomic Energy Commission (CEA), France)	99.0 kg	1,100,000
Fast reactor programme	545.0 kg	6,300,000
Total:	922.3 kg	10,700,000

To enable the Community and its three associates (French Atomic Energy Commission (CEA), Gesellschaft für Kernforschung, Germany, and Italian Atomic Energy Commission (CNEN), to carry out their fast reactor programme, a short-term contract (valid up to June 1968) for the lease of enriched uranium was concluded, it an option to purchase to be exercised no later than that date. Under this contract the Agency leased or is about to lease the following quantities of U-235 from the USAEC:

	Approximate quantities
— for Gesellschaft für Kernforschung	444 kg U 235
— for CEA	224 kg U 235
Total:	668 kg U 235
Approximate value:	7,650,000 EMA u.a.

In the field of research, therefore, as regards enriched uranium the Agency's dealings entailed a turnover of 18,450,000 EMA u.a.

In the course of its contractual work, the Agency had occasion to explain the various measures required, especially as regards carriage and insurance, to the competant authorities and the users, many of whom were coming up

against these problems for the first time. The difficulties which cropped up some years ago in this connection are practically ironed out by now, and the greater part of this work is now undertaken by private initiative.

The Agency was called upon to negotiate and conclude very substantial plutonium supply contracts for the Community fast reactor programmes:

1. In the context of an authorization granted by the American Congress for the supply of 500 kg. of plutonium to Euratom, the Agency is negotiating a contract worth about 17,2 million EMA u.a., for 400 kg for use in the Cadarache and Karlsruhe critical assemblies.

2. Furthermore, on behalf of the French Atomic Energy Commission, the Agency concluded two contracts with the UKAEA for the supply of 90 kg of plutonium—the first core of the Rapsodie reactor (Euratom/CEA Association)—to the value of some 4,500,000 EMA u.a.

The Agency's turnover as to plutonium amounts, therefore, to roughly 21,800,000 EMA u.a. at the present time.

To sum up, in respect of special fissile materials only—leaving out of account contracts placed by the Agency under the simplified procedure and relating to natural uranium supplies—between June 1960, when it started activities, and mid-1965 the Agency will have exercised its right to conclude contracts to the approximate overall amount of 312,910,000 EMA u.a.

DOCUMENT No. 26

HEALTH AND SAFETY LEGISLATION ENACTED AND DRAFT TEXTS SUBMITTED TO THE COMMISSION UNDER ARTICLE 33 DURING 1964

Belgium

The following were communicated by Belgium to the Commission, for its recommendations, pursuant to Article 33 of the Treaty:

— draft "Ministerial Order on approval of a type of apparatus containing radioactive substances", received 14 February 1964;

— draft "Ministerial Order amending certain provisions of the general regulations for the protection of workers", received 9 April 1964;

— preliminary draft "Royal decree amending the general regulations for the protection of workers and relating to the establishment of industrial medical services and to the organization of first aid and emergency treatment for workers injured or contaminated", received 22 May 1964;

— preliminary draft "Royal decree amending the Decree by the Regent of 25 September 1947 prescribing general rules on health and safety measures for mineworkers".

Germany

The second decree on radiological protection ("Decree on protection against the hazards of ionizing radiations in schools") came into force on 30 October 1964.

Italy

Presidential decree No. 185 of 13 February 1964 on "Safety of installations and protection of the health of workers and of the general public against hazards of ionizing radiations arising from the peaceful use of nuclear energy" came into force on 16 July 1964.

Luxembourg

The Commission issued its recommendation on a draft "Regulation by the Sovereign of the Grand Duchy on the implementation of the law on protection of the public against hazards from ionizing radiations", received 23 January 1964.

DOCUMENT No. 27

BACKGROUND RADIOACTIVITY

The Member States of the Community possess a comprehensive network of stations for monitoring background radioactivity. The network has been in full-scale operation for three years now and the measuring equipment and methods are thoroughly tested.

The figures recorded are examined and utilized by the Commission. In 1964, a report was published giving all the monthly data supplied by the national stations with regard to the radio-elements and beta-activity in the atmosphere. The range of stations used comprised 118 atmospheric monitoring stations and 132 fall-out posts.

The graphs for the stations at Brussels, Ispra and Bari are given by way of an example.

The curves for 1964 are based on daily readings and thus afford an accurate idea of the radioactivity over a given period. In addition, the curves obtained with the monthly data are shown for the period 1958 through 1963.

For the period extending from the end of 1961 to 1964, which was marked by high activity, the following pattern emerges:

— end of 1961, a very pronounced upsurge, related to the resumption of nuclear weapons testing; after reaching a peak at the end of the year, values follow a steady downward trend until the third quarter of 1962;

— end of 1962, gradual rise, with a peak during the summer of 1963;

— in 1964, low values, marked only by a slight upturn in the middle of the year; in December 1964, the radioactivity figures dropped to a very low level, comparable to that for 1960.

From the health angle (protection of the population), the rate of atmospheric radioactivity in 1964 presented no hazard. At Ispra, for example, the mean total beta-activity in the air was only 1.14 pCi/m^3 and that for strontium (during the first quarter) 0.04 pCi/m^3. These values represent only a very small percentage of the "maximum permissible concentration" for the population. The same trend was observed at the other monitoring stations in the Community.

Radioactive Contamination of Milk in 1963

The radioactive contamination curve is followed with special interest in respect of milk, which accounts for approximately 50 % of the total strontium intake of adult males. From the attached graphs, an idea can be obtained of the variations observed for 1962 and 1963 in the level of strontium-90 and caesium-137 in the milk supply. The values recorded in the US and Canada are also given for comparison purposes.

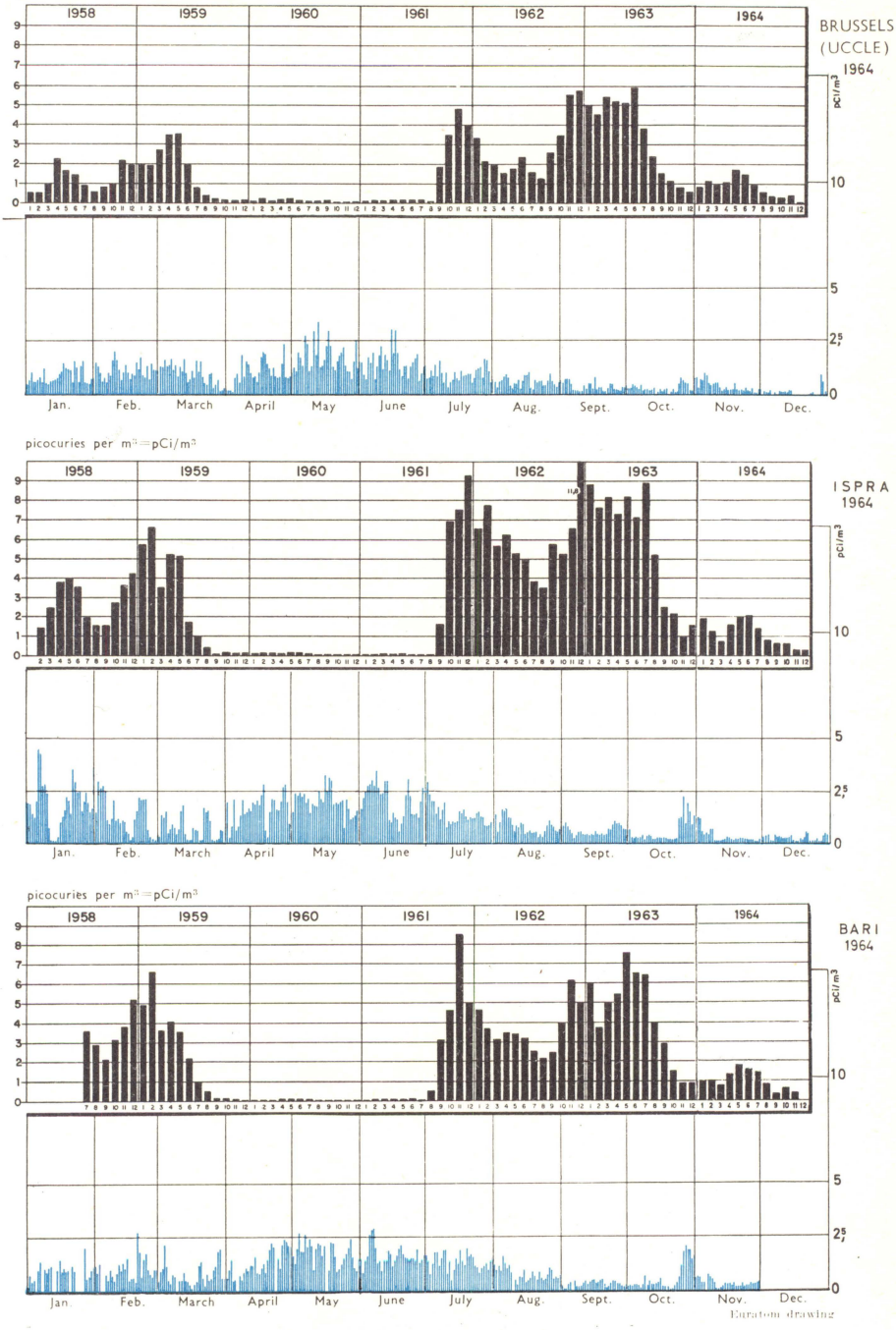
It will be seen that the caesium-137 and strontium-90 activity in milk rose after May 1963. The figures for strontium-90 in the Community, for instance, increased from 12.4 pCi/gCa in April to 34.4 pCi/gCa in July, stabilizing around 30 pCi/gCa for the remainder of the year. This increase was due to the heavy radioactive fall-out dating back to the early summer. Furthermore, it should be pointed out that, in certain mountainous regions marked by heavy precipitation, levels 2.5 or 3 times as high were recorded during the second half of the year. The annual mean concentration for the Community from January 1963 to December 1963 was 23.4 pCi/gCa, or 2.2 times that of the previous year.

The same trend is observed in the case of caesium-137. The figures for this nuclide rose approximately from 80 to 250 pCi/1 during the period April-July 1963. The mean concentration for 1963 was 167 pCi/1, against 64 pCi/1 for 1962.

Comparison of the values recorded in the Community and the readings taken in the US and Canada shows that the pattern for milk contamination was roughly the same, with variations in amplitude doubtless conditioned by geographical location and intensity of precipitations.

The radioactivity figures obtained for caesium represent only about 4 % of the maximum permissible concentration and for strontium about 10 %.

ARTIFICIAL BETA ACTIVITY IN AIR

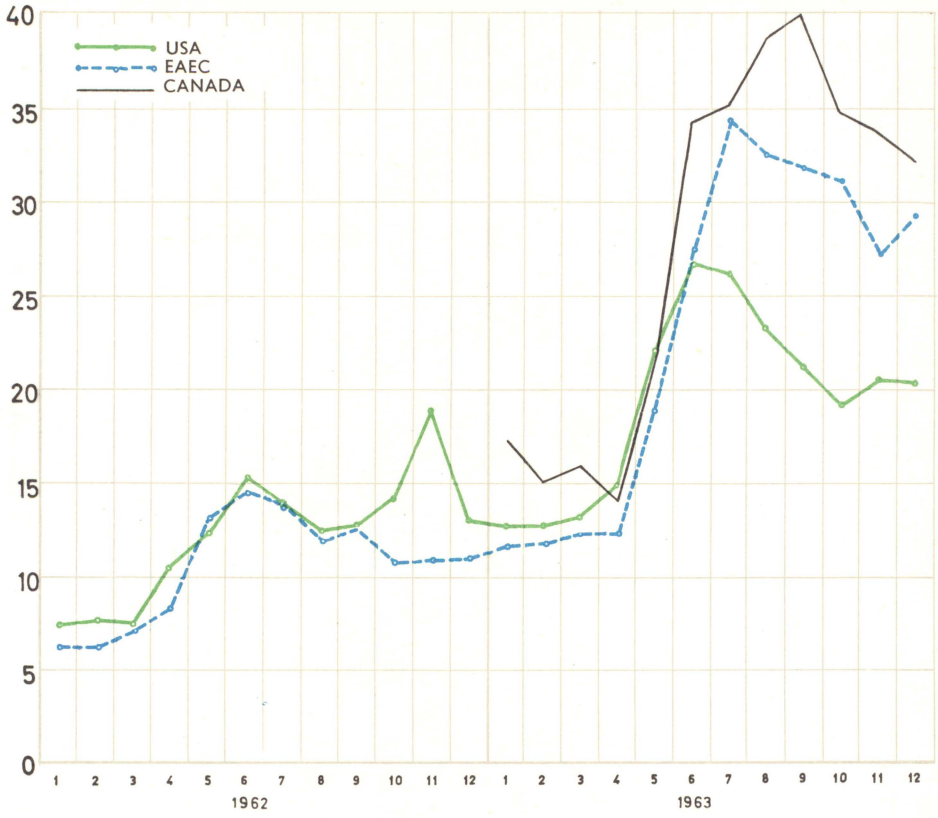


Exemple of artificial atmospheric beta radioactivity measurement in 1964 and from 1958 to 1964 at Brussels, Ispra and Bari.

^{90}Sr IN MILK

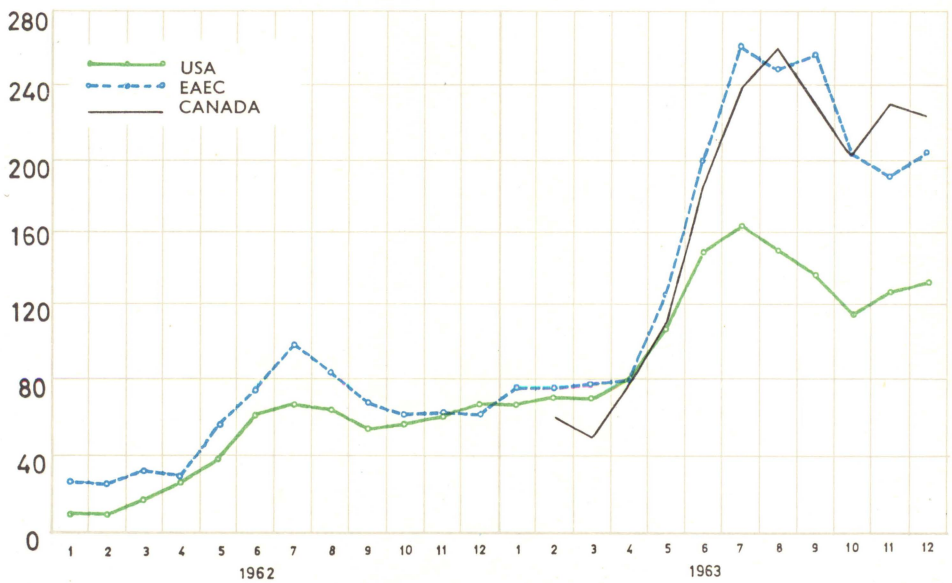
Euratom drawing

pCi/gCa = picocurie per gramme of calcium



^{137}Cs IN MILK

pCi/l = picocurie per litre



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

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 in clauses laid down in the basic contracts concluded with companies operating nuclear power plants accepted under the US/Euratom Cooperation Agreement. These studies are in fact the sequel to safety assessments prior to construction drawn up by the US/Euratom Joint Reactor Board. The Commission is thus formulating an opinion on safety aspects of the plants operated by SENN in Italy, KRB in Germany 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 vessel NS Savannah and to the Eurochemic reprocessing plant in Belgium.

Furthermore, the terms governing the implementation of the Commission's decision to accord joint enterprise facilities to the Kernkraftwerk Lingen GmbH and Kernkraftwerk Obrigheim plants stipulate that the Euratom Commission shall carry out a safety assessment for those installations.

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

1. *SENN*

Studies on the operational safety of the Garigliano power plant, performed in conjunction with the competent departments of the Italian Atomic Energy Commission (CNEN) and with the assistance of German experts and USAEC technical advisers, continued during 1964.

The enquiries, dealing mainly with start-up trials, made it possible to arrive at a more precise definition of the technical specifications to be incorporated in the final licence to operate at full power.

2. *SENA*

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

A start was made on an analysis of the safety aspect of boosting the plant's capacity to 260 MWe. This power increase should be obtained more especially by using chemical poisoning for reactor control. The Givet-Chooz plant, it must be remembered, was accepted in 1962 for inclusion in the US/Euratom Cooperation Agreement programme, with particular reference to the safety features, as a plant with a design capacity of 210 MWe.

3. *KRB*

An agreement has been signed with the appropriate Bavarian authorities for cooperation between the German specialist technical services and those of the Commission on safety studies for the Gundremmingen power plant. The procedure instituted is similar to that applied in respect of the Garigliano plant (SENN) in collaboration with the CNEN and of the Givet-Chooz plant (SENA) in collaboration with the CEA.

The study, launched jointly with the competent German technical authorities in 1964, will continue during initial plant operation.

4. *SEP*

The Dutch Government referred to the Commission for an expert opinion on the safety features of the projected SEP 50 MWe boiling-water-reactor plant.

The Commission has transmitted to the Netherlands Government an opinion and a safety assessment embodied in a report drafted with the assistance of experts drawn from Member States.

The purpose of the opinion and report was to enable the competent Dutch authorities to arrive at a decision on the granting of a construction licence and on the conditions governing such licence.

5. *AKB Project*

The Commission was approached by Kernkraftwerk für Atomkraft Bayern for an expert opinion on a Siemens-designed heavy-water-moderated carbon-dioxide-cooled power reactor with a capacity of about 100 MWe.

The expert report was drawn up with particular reference to the safety aspects.

6. *Marine-propulsion — NS "Savannah"*

As part of the operational safety assessment of the nuclear ship NS SAVANNAH, a fourth safety report was published in collaboration with two shipping classification offices in the Community, Germanischer Lloyd (Germany) and the Bureau Veritas (France).

The study was focussed on experience gained with the initial operation of the ship and with criteria and practical measures applied in the various ports of call. This study is obviously of great value with regard to the future commissioning of other nuclear-propelled vessels, especially those belonging to the Community. At the same time the Commission has continued to exchange views with the competent authorities in Member States, for the purpose of bringing about the smoothest possible coordination of administrative and technical provisions.

7. *EUROCHEMIC*

Euratom continued to participate in the work of the Eurochemic/Belgian Public Health Liaison Committee dealing with the safety aspects of the reprocessing plant at Mol.

The Belgian Government recently asked the Commission for an opinion on safety features of adapting the Eurochemic facilities for the reprocessing of fuels highly enriched with U-235.

8. *LINGEN and OBRIGHEIM*

The safety assessments on these power plants, for which joint enterprise status is sought, have just been initiated.

DOCUMENT No. 29

THE JOINT NUCLEAR RESEARCH CENTRE

The Joint Nuclear Research Centre comprises four establishments:

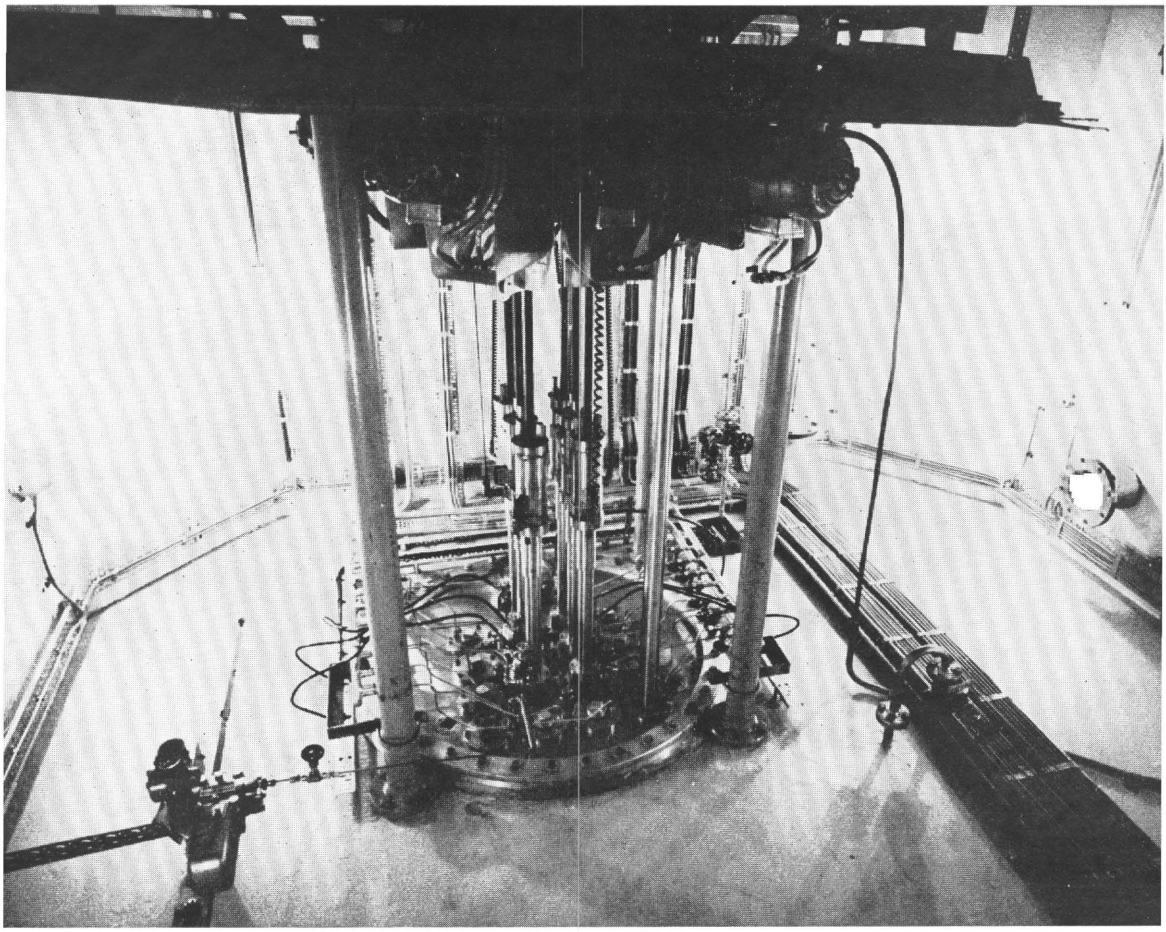
The Central Nuclear Measurements Bureau, at Geel in Belgium, is concerned with metrology.

The European Transuranium Institute, at Karlsruhe in Germany, concentrates on extending present knowledge of properties and technology of transuranium elements. In the forefront of these is plutonium, the prime choice as fuel for several types of power reactor.

On the other hand the general-purpose establishments at Ispra in Italy and Petten in the Netherlands may be assigned any job within the scope of Euratom's scientific and technical activities. Their equipment allows for the variety of activities which they may have to undertake over a period of time.

The activity of the Joint Centre is determined by the five-year programmes. A Central Programmes Committee allocates the work and supervises its performance. The Committee's deliverations enable the technical basis necessary for calculating preliminary draft annual budget estimates to be defined.

The Seventh General Report gave data on the history, staffing, research facilities, programmes and budgets of these establishments. Up-to-date details will be available when the present activities connected with the adjustment of the second five-year programme are completed.



PETTEN — CONTROL-ROD DRIVE MECHANISM
OF THE HIGH-FLUX REACTOR (HFR)

(See other side of page for caption)

The HFR is a materials-testing reactor, moderated and cooled by light water, which has been operating since 1962 at a power of 20 MW. The fuel elements are in the form of plates containing uranium with 99 % enrichment.

The reactor is controlled by 6 cadmium rods, each of which can be raised or lowered by means of a drive unit actuated by electric motors mounted on a platform under the reactor vessel. The photograph shows these drive mechanisms and the penetrations in the bottom head of the reactor. The mounting of these units underneath the reactor means that the space above the core is readily accessible for the installation of irradiation capsules or loops.

DOCUMENT No. 30

CONTRACTS AWARDED BY THE COMMISSION IN 1964 UNDER ITS RESEARCH PROGRAMME

Table 1

RESEARCH CONTRACTS AND SUPPLEMENTARY CONTRACTS (1)

Subject	Number	Total sum payable by the Commission during the overall period of the contracts (in EMA u.a.) (2)
Contracts relating to establishments of the Joint Research Centre :		
a) *Ispra*		
— Scientific data processing (CETIS)	3	114,000
— Direct conversion	7	329,000
— Other research	3	90,000
b) *Karlsruhe*		
— Transplutonium elements	2	207,000
— Transuranium elements	1	3,200,000
ORGEL Project	18	1,097,000
Fast reactors	1	150,000
Advanced gas-cooled reactors	1	150,000
Proven-type reactors	25	4,416,000
Technical and economic studies	2	164,000
Fuel reprocessing	2	3,740,000
Waste processing	2	261,000
New reactor types	3	1,234,000
Marine propulsion	1	20,000
Radioisotopes :		
— Research	11	291,000
— Industrial application (3)	51	224,000
Biology and health and safety	9	601,000
	142	16,288,000

(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.
(3) Including 38 contracts relating to the textile industry.

Table 2

CONTRACTS OF ASSOCIATION AND SUPPLEMENTARY CONTRACTS (1)

Subject	Number	Total sum payable by the Commission during the overall period of the contract (in EMA u.a.)
Physical determinations	1	1,950,000
Fast neutron reactors	3	8,703,000
Advanced gas-cooled reactors	1	10,000,000
Proven-type reactors	1	447,000
Marine propulsion	2	5,500,000
Biology and health protection	3	1,999,000
	11	28,599,000

(1) i.e. 4 contracts which raise the financial ceiling of previous contracts of association.

LIST OF NEW CONTRACTS AWARDED IN 1964

(excluding supplementary contracts)

I. *Contracts relating to establishments of the Joint Research Centre*

a) **Ispra**

— Scientific data processing

No. of contract	Contractor	Title
034-64-1 CETN	UNIVERSITY OF AMSTERDAM	Studies on the application of mathematical logic
035-64-3 CETI	PRAXIS	Participation in a monitor project for the integrated use of various nuclear codes, improvement of the APACHE system, and preliminary studies to determine the structure of a machine translator for the translation of one programming machine language into another
036-64-5 CETI	SOLARTRON	Study on a system for the dynamic coupling of analog and digital computors (second phase)

— Direct conversion

No. of contract	Contractor	Title
004-64-8 CODD	LEYBOLD HOCHVAKUUM ANLAGEN	Development, construction, testing, supply and installation of a device for research into a method of using caesium, for the construction of thermionic conversion cells
007-64-5 CODD	METALLGESELLSCHAFT	Study and development of materials used for thermionic converters, with a view to their employment in a reactor
008-64-12 CODU	MHD RESEARCH INC.	Study on the determination of electron density and temperature in a plasma by means of the new diagnostic technique with an He-Ne laser
009-64-5 CODI	SAES GETTERS S.A.	Research on the absorption properties of the materials employed in thermionic converters intended for in-pile use and for the development of a getter which can be used in converters
010-64-4 CODB	CEN	Research relating to the fabrication of fuel elements suitable for thermionic converters, and the supply of three such elements to the Community
011-64-6 CODF	CSF	Design and construction of thermionic converter measuring devices to be used for research on the operation of caesium plasma diodes
012-64-4 CODD	BROWN BOVERI & Co.	Research on the influence of polycrystalline structures and layers of extraneous matter on the thermal emission of electrons at the surface of emitting materials, and construction of an improved measuring device

— Other research

No. of contract	Contractor	Title
133-64-9 ISPI	UNIVERSITY OF PADUA	Measurement of macroscopic cross-sections
135-64-5 ISPI	CISE Segrate/Milan	Construction of the electrical equipment necessary for time and energy measurements with semi-conductors
140-64-4 ISPI	ARS Milan	Research on the relation between the differential collision cross-section and the macroscopic transport coefficients of the liquid in which diffraction appears

— Physical Determinations

No. of contract	Contractor	Title
002-63-11 MPAI (1)	CNEN (INFN) Rome	Research on low-energy nuclear phenomena and the interaction between ionizing radiations and photons and matter

b) **Karlsruhe**

— Transplutonium elements

No. of contract	Contractor	Title
011-64-6 TPUB	UNIVERSITY OF LIEGE Liège	Study on the chemical properties of transplutonium elements

— Transuranium elements

No. of contract	Contractor	Title
001-64-4 TRUB	BELGONUCLEAIRE CEN Brussels	Investigation of the conditions governing the use of plutonium in light-water reactors

(1) Contract of Association

II. *ORGEL Project*

No. of contract	Contractor	Title
091-64-4 ORGF	SEPR, Villejuif/Seine	Study on the internal pressure resistance of SAP tubes
130-63-11 ORGC	BATTELLE INSTITUTE, Frankfurt SERAI Brussels TNO The Hague	Implementation of a research programme aiming at the synthesis of pure polyphenyls to serve as reference materials, and preparation of labelled molecules (C^{14} and tritium)
131-64-4 ORGF	CEA, Paris, PROGIL, Paris	Study on the fouling of hot walls in the presence of terphenyls and under radiation
159-64-4 ORGI	ISTITUTO DINAMO-METRICO ITALIANO Turin	Development of special strain-gauges for use at high temperatures and under irradiation
161-64-9 ORGF	CEA, Paris	Study on petroleum fractions as substitutes for terphenyls in an ORGEL-type reactor
162-64-1 ORGF	CEA, Paris	Research on heat-exchange by means of organic coolants
163-64-4 ORGN	TNO, The Hague	Research on wear in SAP
165-64-5 ORGN	TNO, The Hague	Insulation by means of flame-sprayed ceramic material
166-64-6 ORGN	TNO, The Hague	Study of burn-out in terphenyl mixtures (extension of contract 097.ORGN)
167-64-5 ORGN	TNO, The Hague	Explosion-welding of SAP
169-64-7 ORGF	SOGREAH, GRENOBLE	Study on the use of powder for the thermal insulation of an ORGEL-type reactor channel

No. of contract	Contractor	Title
170-64-4 ORGI	MONTECATINI	Implementation of a programme for the fabrication of SAP products
176-64-8 ORGB	CEN	Electrochemical studies on the effect of halogenated ions on the passivation of oxide films
177-64-4 ORGI	UNIVERSITY OF BOLOGNA Bologne	Research on the pattern and mechanisms of plastic deformation in SAP powder
179-64-5 ORGN	LOK N.V. Aalsmeer	Basic study on the behaviour of closures of very high integrity when subjected to elevated pressure
180-64-5 ORGI	CISE	Study on Zircaloy/steel bonding process

III. *Proven-type reactors*

No. of contract	Contractor	Title
003-63-11 TEEI	FIAT, Turin	Development of nuclear calculation methods for water reactors
006-64-1 TEEF (RD)	CEA, Paris	Research programme on hydrodynamic instabilities limiting the power of boiling-water reactors
007-64-7 TEEF (RD)	INSTITUT DE SOUDURE Paris	Study on welded joints in heavy-gauge steel plates
011-64-1 TEEN	UNIVERSITY OF EINDHOVEN	Heat transfer in pressurized-water reactors

No. of contract	Contractor	Title
014-63-8 TEED	NUKEM Wolfgang bei Hanau	Improvement and testing of fuel elements for reactors moderated and cooled by light water
020-64-4 TEED	AEG, Berlin	Experimental and theoretical study on instabilities in boiling-water reactors
024-64-4 TEAL	CNEN, Rome	Research on heat transfer in organic liquids; irradiation tests in the CIRO loop; development of a rack-and-pinion drive mechanism for bottom-actuated « r »-type control rods; Chemical analysis of terphenylic organic liquids and their purification
025-64-7 TEEF	SOUDURE AUTOGENE FRANÇAISE (SAF) Paris	Manufacture of a welding and heat-treatment installation for heavy-gauge plates
026-64-2 TEEI	UNIVERSITY OF BOLOGNA	Research on hydrogen diffusion and precipitation mechanisms in zirconium and its alloys
028-64-1 TEED (RD)	HAHN-MEITNER INSTITUTE Berlin	Basic study on the fission-gas mechanism in ceramic fuels
029-64-3 TEED	METALLGESELLSCHAFT Frankfurt	Research on the use of ZrNb3Sn1 as cladding in water-cooled reactors; in particular the development of fabrication and inspection techniques for ZrNb3Sn1 clads
031-64-5 TEEF	IRSID St-Germain-en-Laye	Study of the base metal intended for a research project on brittle fracture in large welded assemblies of heavy-gauge steel for the construction of reactor vessels
033-64-9 TEEF (RD)	CAFL Paris	Study on the corrosion resistance of stainless steels in water or steam at high temperature and pressure

No. of contract	Contractor	Title
034-63-11 TEEC (RD)	THOMSON HOUSTON Paris AEG/Frankfurt ALSTHOM/Paris	Research on the improvement of the thermal potential of nuclear fuels by the use of the VAPOTRON process
038-64-3 TEGI	SNAM (AGIP) San Donato Milanese	Determination of the infinite multiplication constant of natural-uranium and graphite lattices by the PCTR method in the RBI critical assembly
045-65-3 TEGF	CITE Paris	Study and mock-up experiments on prestressed-concrete internal pressure vessels made according to the CITE-PATIN process
046-65-2 TEGF	MESSIER Paris	Development study on the machining of a very long monobloc clad
056-64-3 TEEB (RD)	CEN Brussels	Study on the basic physical properties of UO_2 single crystals and their irradiation behaviour
050-65-1 TEGI	ENEL Rome	Study on the reactivity curve of the Latina reactor
061-64-7 TEEF (RD)	SNECMA Paris	Elaboration of a study already carried out by the contractor on the improvement of heath transfer by turbulent flow in boiling-liquid nuclear reactors
063-64-12 TEGF	BERTIN Paris	Study on heat exchange by natural convection
065-64-7 TEOI	ISML	Improvement of SAP fabrication technique
101-63-11 RDI	SENN	Research on the Garigliano reactor

IV. *Technical and economic studies*

No. of contract	Contractor	Title
023-64-3 ECIF	M. SAVARY Paris	Preliminary study of the economic prospects for the use of nuclear energy in its various forms in the newly developing countries

V. *Fast reactors*

No. of contract	Contractor	Title
011-64-4 RAPC	BELGONUCLEAIRE Brussels SIEMENS Erlangen	*a*) Determination and compilation of the technical specifications for a fast reactor capable of pulsed or steady-state operation (SORA), by carrying out studies on certain component assemblies of that reactor; *b*) Working-out of the complete design and provision of all information necessary for the construction, start-up and operation of the reactor; detailed evaluation of the construction cost of the SORA complex

VI. *Advanced gas-cooled reactors*

No. of contract	Contractor	Title
003-63-1 RGAD	BROWN BOVERI KRUPP REAK- TORBAU Düsseldorf KFA Jülich	*a*) Research and development programme relating to a thermal reactor having a thorium/uranium fuel cycle and a high conversion factor, operating on a high-temperature gas-cooled reactor with a pebble-bed core and a secondary steam circuit (THTR reactor) and acquisition of operating know-how through participation in the operation of the AVR reactor now under construction and of its associated installations; *b*) Study on a prototype high-temperature gas-cooled thorium reactor (THTR)

No. of contract	Contractor	Title
004-64-9 RGZC	INDATOM Paris ENEL Rome	Study on the evaluation of reactors of the HTGR string

VII. *Fuel reprocessing*

No. of contract	Contractor	Title
001-64-11 RCII	CNEN Rome	Construction and operation of the EUREX plant and its use for research purposes
004-64-4 RCIB	CEN Brussels	Development of a reprocessing cycle for ceramic fuels, based on the volatilization method

VIII. *Radioactive waste processing*

No. of contract	Contractor	Title
003-65-3 WASF	Ets KUHLMANN Paris	Study on the processing of radioactive effluents by means of zeolitic silicates, and examination of the problems raised by the use of detergents
009-65-2 WASD	LEYBOLD HOCHVAKUUM ANLAGEN Cologne	Development of a method for the processing of highly radioactive effluents and of fission-product solutions by means of lyophilization

IX. *New reactor types*

No. of contract	Contractor	Title
006-64-4 NTRI	CISE Milan	Development of a heavy-water-moderated, fog-cooled reactor project

X. *Nuclear marine propulsion*

No. of contract	Contractor	Title
009-64-7 PNID (1)	GKSS Hamburg	Construction, development and operation of an experimental nuclear-propelled ship

XI. *Radioisotopes*

a) **Research**

No. of contract	Contractor	Title
040-63-9 RISB	IISN Brussels	Development of methods for the synthesis and storage of tritiated hormones with a high specific activity
046-64-1 RISI	UNIVERSITY OF MILAN Institute of Histological Pathology	Synthesis of 3 molecules uniformly labelled with C-14
053-63-10 RISI	SORIN Saluggia	Development of an electrochemical method for the preparation of iodine-labelled proteins
057-64-10 RISF	CECA Paris	Recovery of krypton from waste gases at low temperature
058-64-6 RISI	SORIN Saluggia	Development of an electrochemical method for the preparation of carrier-free sodium
062-64-7 RISF	UNIVERSITY OF PARIS Faculty of Science Prof. Josien Paris	Development of syntheses of deuterium-labelled organic compounds

(1) Contract of Association.

No. of contract	Contractor	Title
063-64-7 RISF	COLL. DE FRANCE Prof. Roche, Paris	Development of methods for the tritiation of thyroid hormones
064-64-11 RISD	KFA Jülich	Study of the physical and chemical properties of technetium and development of a recovery method
066-64-11 RISD	KFA Jülich	Development of a method for the preparation of chlorine-36 with high specific activity
073-64-9 RISI	INSTITUTE DONEGANI Milan	Preparation of phosphorus-32-labelled insecticides
095-64-11 RISB	UNIVERSITY OF LIEGE Liège	Preparation of tritium targets for neutron generators
021-64-9 IRAB	SERAI Brussels	Development of readily transportable automatic equipment for the radiochemical determination of chlorine ions and for oxygen determination

b) **Industrial application**

No. of contract	Contractor	Title
020-64-10 IRAF	HISPANO-SUIZA Bois-Colombes Seine	Study and development of thermo-elements and design of a low-energy radioisotope-powered thermo-electric generator
022-64-10 IRAB	COMASCI Brussels	Study on the application of short half-life radioactive tracers and of activable tracers to unit operations control in the textile industry

No. of contract	Contractor	Title
023-64-8 IRAL	ARBED Luxembourg	Study of the possibilities for the industrial use of activation analysis for the determination of oxygen, and possibly nitrogen and hydrogen, content of steel, as compared with the customary non-nuclear analysis methods
024-64-4 IRAF	SAMES Paris	Implementation of a research programme aimed at determining the experimental conditions for activation analysis with the aid of a 14 MeV neutron generator
025-64-10 IRAF	CENTRE DE RECH. DE LA SOIERIE ET DES INDUSTRIES TEXTILES Lyon	Study on the possibilities of using radioactive tracers for determining the distribution of the adjuvants employed for the softening, sizing and finishing of yarns
028-64-9 IRAB	UNIV. OF GHENT Ghent	Development of an automatic installation for the determination of oxygen and other elements which produce isotopes of very short half-life under fast-neutron bombardment
029-64-8 IRAF	L'ATOME INDUSTRIEL Paris	Bibliographical and theoretical study relating to the possibilities of using activable tracers in industry, and a fundamental study with a view to the development of certain applications
036-64-7 IRAN	TNO The Hague	Development of portable apparatus for analysis and thickness measurement by X-ray fluorescence
037-64-8 IRAL	ARBED Luxembourg	Use of radioactive isotopes in foundries
040-74-10 IRAD	FRIESEKE HOEPFNER Erlangen	Development of a radiometric apparatus for continuous analysis and determination by beta-ray absorption, suitable for use under ambient conditions in the chemical industry

No. of contract	Contractor	Title
048-64-11 IRAD	THYSSENHÜTTE Duisburg-Hamborn MAXIMILIANS-HÜTTE Sulzbach-Rosenberg	Systematic research relating to the labelling of the deoxidation process
049-65-1 IRAD	ISOTOPEN STUDIEN GESELLSCHAFT Frankfurt	Development and testing of a composite measuring apparatus for determining the speed and direction of the ground-water and the porosity of the formations in the vicinity of the boreholes

CONTRACTS WITH EXPERTS

(The undermentioned contracts all relate to research on the use of radioisotopes in the textile industry)

041-64-9 IRAD	P. CÜPPERS Mainz
042-64-8 IRAN	Dr. PLATZEK Delft
043-64-8 IRAN	TNO The Hague
044-64-9 IRAI	SORIN Saluggia
045-64-9 IRAI	SORIN
046-64-9 IRAI	SORIN
047-64-8 IRAB	CEN Brussels
050-64-9 IRAI	SORIN Saluggia

051-64-8 IRAI	SORIN
052-64-8 IRAI	SORIN
053-64-9 RIAD	BATTELLE INSTITUTE Frankfurt
054-64-9 RIAD	BATTELLE INSTITUTE Frankfurt
055-64-8 IRAD	Prof. BORN Munich
056-64-9 IRAD	Mr. LORENZEN
057-64-9 IRAD	Dr. SCHWARZ Oberlahnstein
058-64-8 IRAN	TNO The Hague
059-64-9 IRAS	INRESCOR
062-64-8 IRAB	CEN Brussels
063-64-10 IRAF	Centre de Recherche de la soierie et des industries textiles, Lyons
064-64-10 IRAB	Mr. VAN DER BORGHT Geel
065-64-12 IRAB	Mrs. DAVID Brussels
066-64-9 IRAD	Dr. PYCHLAU
067-64-10 IRAD	FRIESEKE/KOEPFNER Erlangen

068-64-8 IRAF	CEA (Mr. Puig) Paris
069-64-9 IRAF	CEA (M. Levêque) Paris
070-64-9 IRAF	ERSI
071-64-9 IRAD	Mr. R. HELM Bad Honnef
072-65-1 IRAB	MBLE Brussels
073-64-10 IRAI	BREDA
074-64-10 IRAI	BREDA
075-64-11 IRAF	CGE
076-64-10 IRAN	PHILIPS
077-64-11 IRAF	ATOME INDUSTRIEL
079-64-11 IRAF	CEA
081-64-11 IRAF	KUHLMANN
083-64-11 IRAF	SAMES
085-64-11 IRAB	CEN
086-64-12 IRAD	Mr. WENDT

XII. *Biology and health and safety*

No. of contract	Contractor	Title
031-64-1 BIAD (1)	GESELLSCHAFT FÜR STRAHLEN-FORSCHUNG Munich-Neuherberg	Research intended to facilitate understanding of the reactions of the human organism, and particularly of the haematopoietic organs, when exposed to ionizing radiations, and thereby to create the necessary bases for the discovery and development of methods of diagnosis and therapy in cases of irradiation
032-64-1 BIOF	ASSOCIATION CL. BERNARD Villejuif/Seine	Research on immunologically competent cells and the immunogenetics of grafts
035-64-5 BIOI	UNIVERSITY OF ROME (Institute of Radiology)	Study on the changes caused by radiations in man, by analysis of chromosome morphology
036-64-6 BIOI	UNIVERSITY OF ROME (Institute of Genetics)	Study on the mechanisms of chromosome damage caused by ionizing and non-ionizing radiations and on the various factors which influence the damage
039-64-10 BIOF	COLLEGE DE FRANCE Prof. Wolff Nogent-sur-Marne	In-vivo and in-vitro study on the effect of irradiations on the embryo and its organs
042-64-10 BIOF	INSTITUT G. ROUSSY Villejuif/Seine	Study on metabolic renewal and the existence of duplicative forms of DNA
046-64-3 BIOB	UNIVERSITY OF LIEGE IISN, Brussels ASBL, Brussels	Research on radio-protective substances
049-64-3 BIAF (1)	CEA Paris	Studies on the movement of certain important isotopes in animals and in men

(1) Contracts of association.

No. of contract	Contractor	Title
053-64-3 BIOB	CEN Brussels	Study on acute and chronic radiation effects, particularly with respect to the metabolism of nucleic acids and proteins
054-63-10 BIOF	UNIVERSITY OF STRASBOURG Strasbourg	Experimental study of the treatment of radiolesions by padutine and other therapeutic substances
055-64-10 BIOF	INSTITUTE G. ROUSSY Villejuif/Seine	Study of the recovery effect induced by nucleic acids after irradiation
052-64- BIAN	UNIVERSITY OF LEYDEN	Radiobiology of genetic and biochemical systems

DOCUMENT No. 31

ACTIVITIES OF THE INFORMATION AND DOCUMENTATION CENTRE (CID)

The Information and Documentation Centre (CID) in 1964 continued to expand its activities both in the field of documentation and of scientific and technical information.

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 to ensure a satisfactory division of labour so that optimum use may be made of the scientific and technical data available in the nuclear sphere.

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.

Lastly, in 1964 the CID was charged by the USAEC with the organization at Stresa, near Ispra, of the meeting of representatives of depository libraries for USAEC publications in Europe, Africa and Asia. The meeting afforded the occasion for a most valuable international comparison of notes on the methods applied in and the outlook for documentation.

I. Scientific and technical documentation

1. *Conventional documentary research*

While awaiting the launching of the semi-automatic documentation system developed by the CID, the "conventional documentation" unit is responsible for bibliographical research to meet the needs of the Joint Research Centre and the Commission's contractors and associates. This unit, sometimes with assistance from the specialist documentation services in the Community, carried out 271 bibliographical research operations in 1964.

2. *Semi-automatic documentation*

The mass of documentary information on nuclear science at present available in the shape of reports, articles in periodicals, books and so forth is estimated at 300,000 items. Due to the very extent of this wealth of material, much of it is inaccessible by conventional, i.e. essentially manual, methods of documentary research. In order to be equipped to meet the needs of interested parties—individuals, industrial firms, national centres—in the Member States, the Commission decided to set on foot a study of a semi-automatic documentation system which, armed with an electronic computer, will be able to supply the nuclear scientific and technical data needed more quickly, more accurately and more fully.

The computer was delivered in October 1963 and is used jointly by the CID, CETIS and the Statistics Office of the European Communities.

The "documentation analysis" unit of the CID had by 31 December 1964 fed into the computer more than 240,000 items of documentary information pre-coded according to a system of appropriate key-words devised by the CID.

These data derived for the most part from the American reference periodical Nuclear Science Abstracts. Others were communicated to Euratom in pursuance of two contracts entered into with the Excerpta Medica Foundation of Amsterdam (nuclear medicine) and the Brevatome Company of Paris (nuclear patents). A third contract has been concluded with the USAEC for the supply to the CID of bibliographical references pre-coded in the United States by USAEC experts according to the system developed by the CID. The contract should be a prelude to closer and more lasting cooperation between the USAEC and CID documentation services so that all nuclear literature may be stored by identical methods in parallel computers as and when it appears (50,000 to 60,000 fresh items of information a year).

The semi-automatic documentation system is due to become operational at the CID early in 1966.

3. *Bibliographical sources*

Nuclear technology proper frequently involves other fringe techniques and it is important for the CID to have precise information on documentation centres, libraries and periodicals which, while not belonging strictly to the nuclear field, are closely allied to it. A permanent survey has been instituted in these marginal sectors, enabling CID to draw up coded "profiles" of these secondary data sources for computer storage.

4. *Libraries*

The CID supervises the work of the Euratom Commission's five libraries, located at Brussels and the Ispra, Geel, Petten and Karlsruhe JRC establishments respectively. The Brussels library, where acquisitions for all except the Ispra library are centralized, is also responsible for meeting the needs of Euratom personnel engaged elsewhere than at Euratom institutions. Mechanization of the whole of the Euratom libraries' acquisition and accounting transaction, using a punched tape system, is on the point of completion.

II. Scientific and technical information

In reporting to the Council on 1 April 1963 the Commission defined the principles governing the dissemination of information obtained in the course of implementing the Community's research programme. Data are disseminated only when their publication cannot jeopardize the smooth progress of the research in hand. Information of industrial value is only communicated to individuals and undertakings in the Community whose direct interest in acquiring it can be duly substantiated, to Member States, and to others only when it serves the general interest of the Community. All information, in the realm of pure science or otherwise, of general humanitarian value is widely disseminated.

1. *Non-periodical publications and "communications" (Article 13 of the Treaty)*

Between 1 January and 31 December 1964 the Commission issued 528 technical and scientific reports which are listed in Document No. 33.

During the same period it circulated 329 communications, some consisting of a large number of voluminous documents and therefore only available on microfilm, to individuals, firms and Member States in the Community through "national correspondents" appointed in each of the member countries.

2. *Periodicals*

The three periodicals *Euratom Information, Transatom Bulletin* and *Euratom Bulletin* appeared regularly in 1964. The number of subscribers is increasing steadily.

Euratom Information gives abstracts, accompanied by the usual bibliographical references, of the research programme, of research contracts and contracts of association signed and, more especially of the Community's technical and scientific publications relating to its own research programme or to research under contract, as well as on registered patents and patterns. Since 1964 *Euratom Information* has been published monthly and has increased considerably in bulk owing to the inclusion of information on the Euratom/US research and development programme formerly contained in the *Quarterly Digest,* which has ceased publication.

The *Transatom Bulletin* also appears monthly. In 1964 it published 9832 bibliographical entries concerning translations from the lesser-known languages such as the Slavonic languages, completed or in hand, of scientific or technical documents on nuclear questions, and information on how to obtain them.

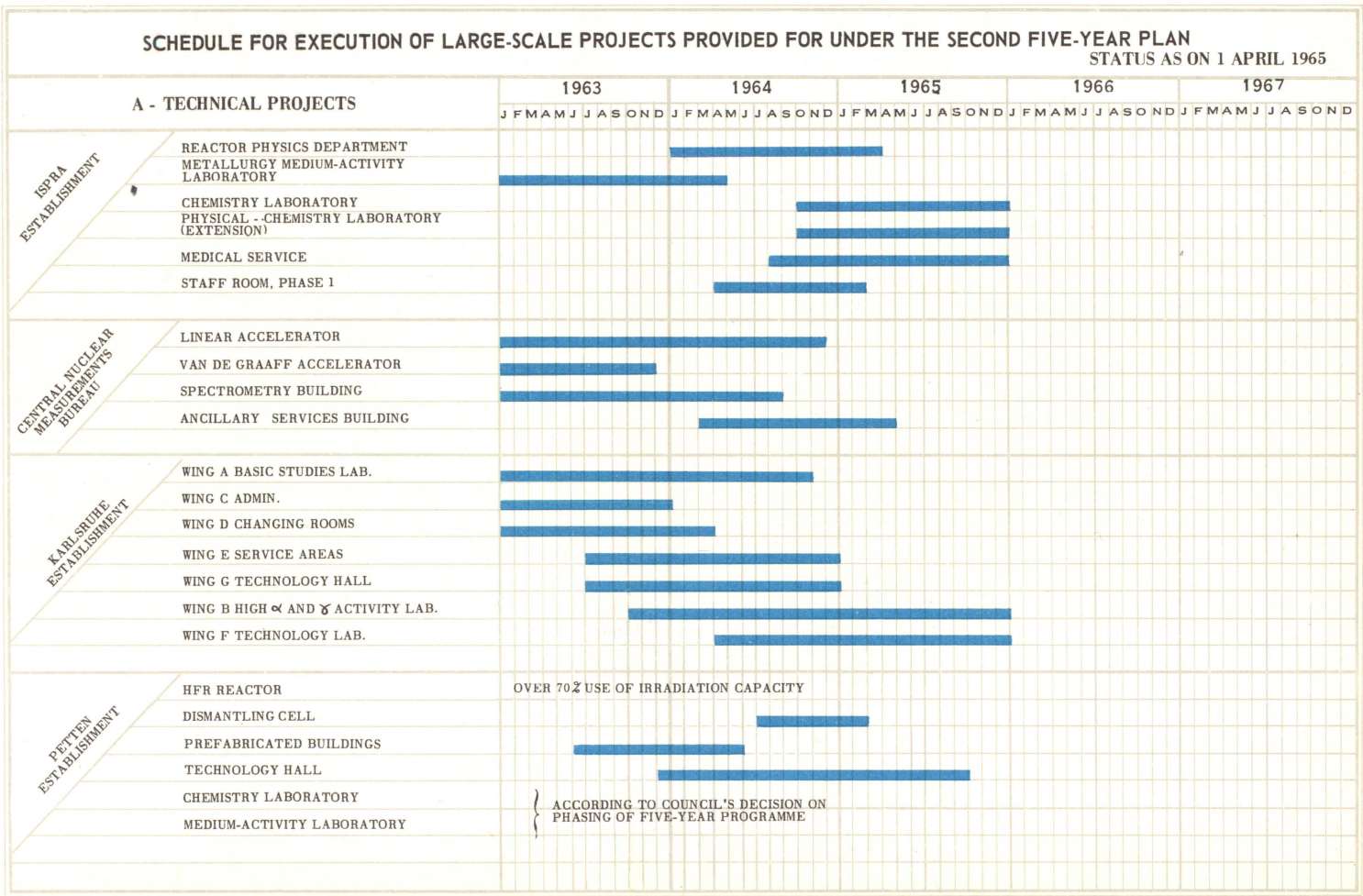
The *Euratom Bulletin* is a quarterly review printed in separate German, French, Italian, Dutch and English editions. It deals with matters connected with the peaceful uses of nuclear energy and the Commission's activities, in a form designed to be read by a very wide public.

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 1965



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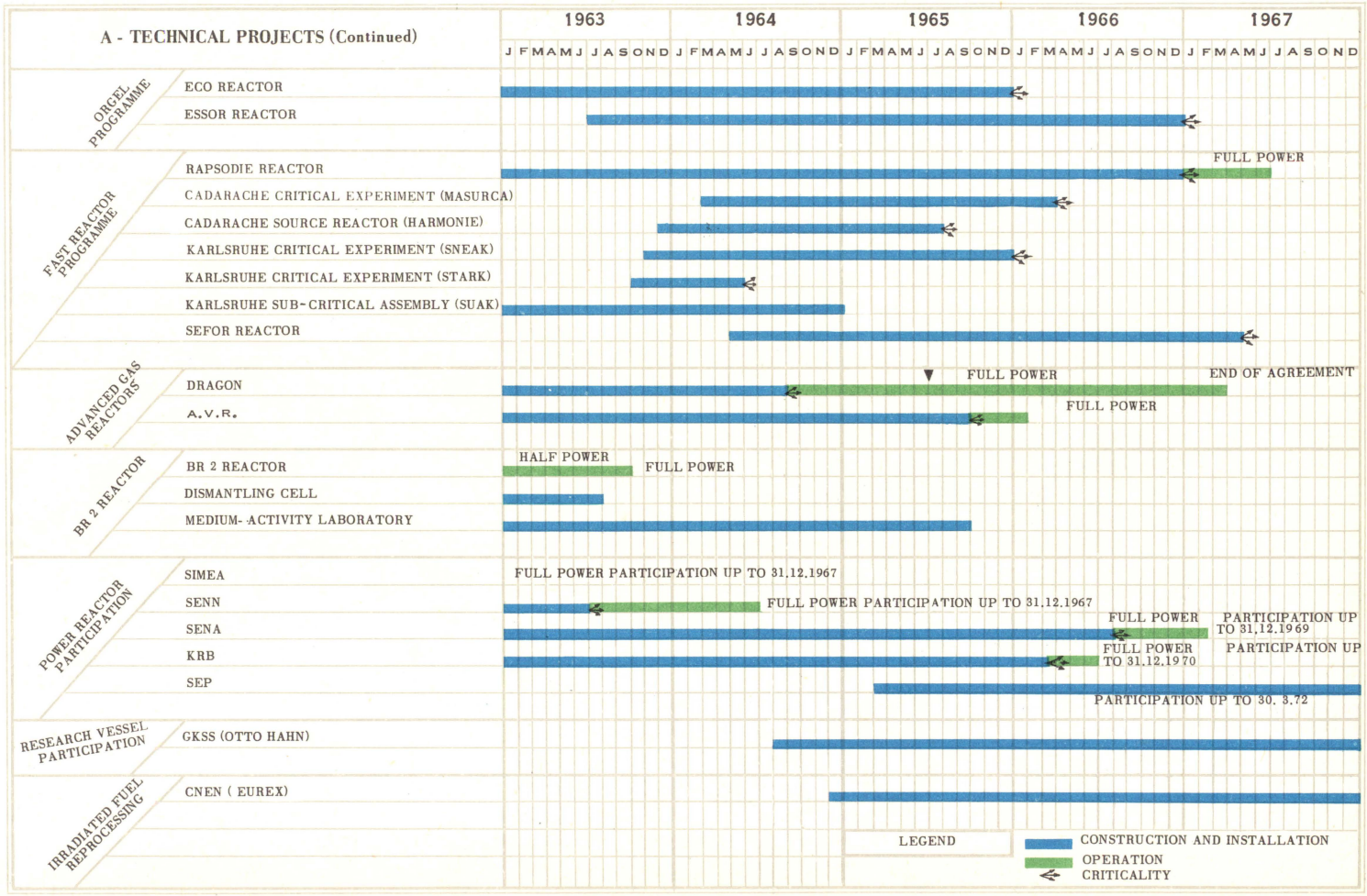

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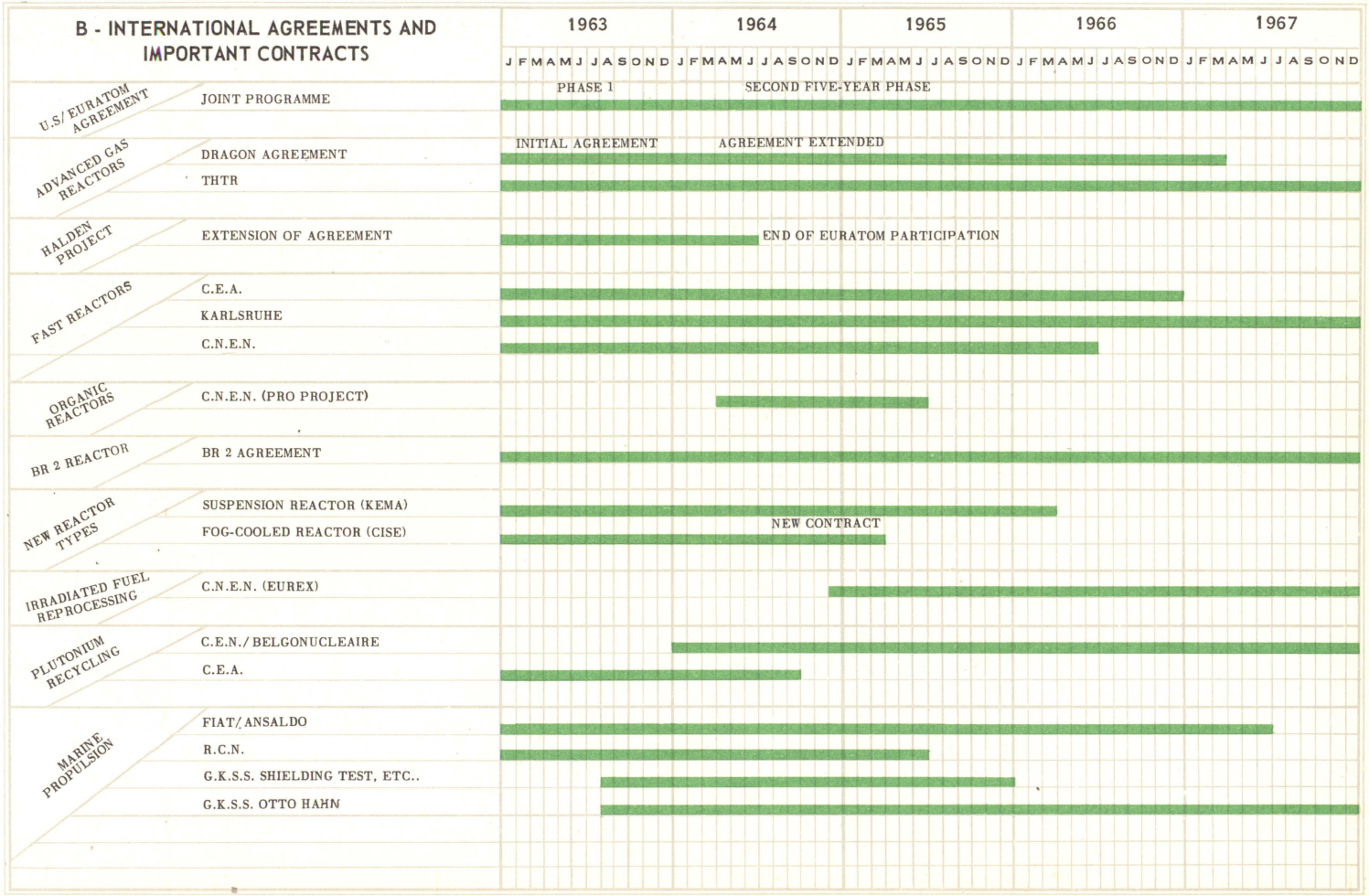

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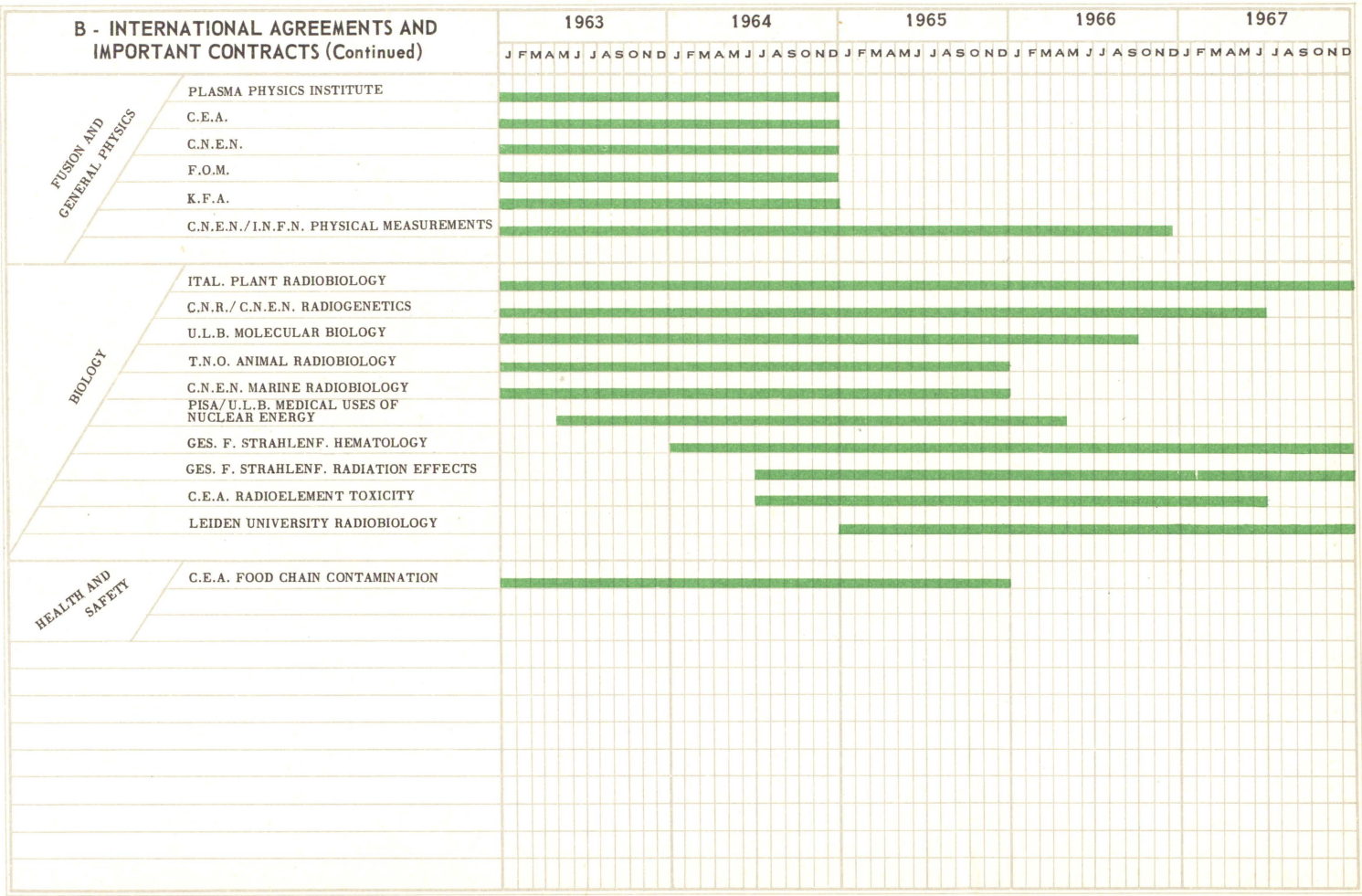

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DOCUMENT No. 33

SCIENTIFIC AND TECHNICAL REPORTS STEMMING FROM THE EURATOM RESEARCH PROGRAMME AND PUBLISHED BY THE COMMISSION (1)

(from 1 January to 31 December 1964)

(The authors of the publications listed are members either of Euratom research teams or of Enterprises to which Euratom has awarded contracts)

INDEX

1. BIOLOGY AND MEDICINE

a) Printed reports

APPLEYARD R.K. Euratom's Biology program 1961-1964 - Report and perspectives
Rapport Euratom n° EUR 1884 e

(1) Not included in this list : some 1,000 reports stemming from the research and development programme under the Agreement for Cooperation between the European Atomic Energy Community (EURATOM) and the United States of America.

BACQ Z.M.
ONKELINX C.
BARAC G.

Absence d'activité radioprotectrice du phénylsélénol chez la souris
Rapport Euratom n° EUR 563 f - Reprint

BALNER H.

Bone marrow transplantation after whole-body irradiation - an experimental study in the rat
Rapport Euratom n° EUR 484 e

BALTUS E.
BRACHET J.

Presence of deoxyribonucleic acid in the chloroplasts of acetabularia mediterranea
Rapport Euratom n° EUR 1677 e - Reprint

BARBE G.

Influence des ions manganèse sur la synthèse induite de cytochrome oxydase chez saccharomyces cervisae
Rapport Euratom n° EUR 1857 f - Reprint

BIELIAVSKY N.

Effets de la mitomycine sur l'incorporation de la thymidine tritiée dans les embryons d'amphibiens au stade Morula
Rapport Euratom n° EUR 559 f - Reprint

BILLAZ R.
GOFFEAU A.
BOVE J.M.

Action de la parachlorophényl 3 éthyl 5 oxazolidine dione 2.4. sur la phosphorylation photosynthétique
Rapport Euratom n° EUR 1700 f - Reprint

BOUDNITZKAYA E.V.
BRUNFAUT M.
ERRERA M.

Effects of x-rays on RNA and RNA metabolism in He-La Cells
Rapport Euratom n° EUR 1352 e - Reprint

BRACHET J.

Acides ribonnucléiques « messagers » et morphogénèse
Rapport Euratom n° EUR 817 f - Reprint

BRACHET J.
SIX N.
BOSSELER F.

Effet différentiel de la ribonucléase sur l'incorporation des acides aminés dans les protéines des pointes de racines d'oignons
Rapport Euratom n° EUR 1855 f - Reprint

BRACHET J.
FICQ A.
TENCER T.

Amino-acid incorporation into proteins of nucleate and anucleate fragments of sea urchin eggs: effect of parthenogenetic activation
Rapport Euratom n° EUR 1657 e - Reprint

BRACHET J.
QUERTIER J.

Cytochemical detection of cytoplasmic deoxyribonucleic acid (DNA) in amphibian ovocytes
Rapport Euratom n° EUR 1688 e - Reprint

BURNY A.
CHANTRENNE H.

Incorporation de ^{32}P dans les acides ribonucléiques de réticulocytes de lapin
Rapport Euratom n° EUR 562 f - Reprint

CHANTRENNE H.
LECLERCQ-CALINGAERT M.

Secondary effect of 8-Azaguanine on the induced or constitutive synthesis of penicillinase in bacillus cereus
Rapport Euratom n° EUR 509 e - Reprint

COLIN F.
MERCENIER P.
KORNITZE F.
CLEEMPOEL H.

Bases expérimentales d'une interprétation quantitative du rénogramme
Rapport Euratom n° EUR 1890 f

CULTRERA G.
RICOTTI V.
MAGLIULO E.

Il ruolo della transferrina nell'assorbimento intestinale di Fe^{59} del ratto normale e siderosico
Rapport Euratom n° EUR 1871 i - Reprint

DE BORTOLI M.
GAGLIONE P.
MALVICINI A.
VAN DER STRICHT E.

Misure di radioattività ambientale Ispra 1962
Rapport Euratom n° EUR 481 i

DEVREUX M.

Effets de l'irradiation gamma chronique sur l'embryogénèse de capsella bursa-pastoris moench
Rapport Euratom n° EUR 447 f - Reprint

DE VRIES M.J.

A systemic dermatosis of uncertain etiology (x-disease?) in monkeys
Rapport Euratom n° EUR 384 e - Reprint

DE VRIES M.J.

Pathology of secondary disease in primates
Rapport Euratom n° EUR 385 e - Reprint

DOMMERGUES P.
GILLOT J.

Comparaison des effets de différents agents mutagènes par l'étude de la mutagénèse de quelques plantes-types
Rapport Euratom n° EUR 1610 f

DOMMERGUES P.
GILLOT J.

Variation de la réaction des boutures d'œillet à l'irradiation gamma
Rapport Euratom n° EUR 1809 f

DOMMERGUES P.
GILLOT J.

Comparaison des effets de différents agents mutagènes par l'étude de la mutagénèse de quelques plantes-types (2^{me} année)
Rapport Euratom n° EUR 1829 f

DORIA G.

Iso-antigénicite des cellules embryonnaires
Rapport Euratom n° EUR 512 f - Reprint

DUMONT J.
RODESCH F.
ROCMANS P.

Stimulation of thyroidal radioiodine uptake by actinomycin and fluoruracil
Rapport Euratom n° EUR 808 e - Reprint

ERRERA M.
BRUNFAUT M.

Observations of mitotic figures in pulse labelled He-La cells
Rapport Euratom n° EUR 1658 e - Reprint

FABRY Cl.

Schéma anatomo-physiologique du tractus gastro-intestinal à prendre en considération pour le calcul des niveaux de contamination radioactive
Rapport Euratom n° EUR 489 f

FICQ A.

Nucleocytoplasmic relations in the oocyte
Rapport Euratom n° EUR 1836 e

FICQ A.
BRACHET J.

Métabolisme des acides nucléiques et des protéines chez les embryons normaux et les hybrides létaux entre échinodermes
Rapport Euratom n° EUR 569 f - Reprint

FEINENDEGEN L.E.
BOND V.P.
CRONKITE E.P.
HUGHES W.L.

Reutilization of DNA-thymine, and conversion of RNA-pyrimidines for DNA-thymine, in normal rat bone marrow. Studies with tritiated nucleosides
Rapport Euratom n° EUR 1814 e

FRACCARO M.

Problemi di citogenetica umana
Rapport Euratom n° EUR 514 i - Reprint

FRACCARO M.

Rapporto tecnico sulle attività del gruppo Euratom per le radiazioni e la citogenetica umana dell'università di Pavia dal 1-10-1963 al 29-2-1964
Rapport Euratom n° EUR 1893 i

GAVOSTO F.
GHEMI F.
PEGORARO L.
PILERI A.

Sintesi dell'ADN in cromosomi di leucemia acuta umana
Rapport Euratom n° EUR 1353 i - Reprint

GAVOSTO F.
PEGORARO L.
PILERI A.

Possibilité de marquer à l'aide de précurseurs tritiés les chromosomes de cellules leucémiques chez l'homme
Rapport Euratom n° EUR 1877 f - Reprint

GERBER G.B.
REMY-DEFRAIGNE J.

Studies on detoxication by the perfused liver - I. Hippuric acid synthesis after irradiation - II. Bilirubin conjugation and excretion after irradiation
Rapport Euratom n° EUR 564 e - Reprint

GERBER G.B.

Die Ursachen der strahlenbedingten Ausscheidung von β-Aminoisobuttersäure und Creatin
Rapport Euratom n° EUR 591 d

GILLET C.
LENNES G.
BACQ Z.M.

Action radioprotectrice de chlorures alcalino-terreux ($BeCl_2$, $SrCl_2$ et $BaCl_2$) sur la croissance de l'orge
Rapport Euratom n° EUR 1355 f - Reprint

GIRARDI F.
MERLINI M.

Studies on the distribution of trace elements in a mollusk from a freshwater environment, by activation analysis
Rapport Euratom n° EUR 474 e

GOFFEAU A.

Photosynthèse et multiplication virale chez brassica chinensis L
Rapport Euratom n° EUR 1648 f

GOFFEAU A.
BOVE J.M.

Réactions photosynthétiques chez brassica chinensis L - Réactions de Hill et photophosphorylations, importance du pH
Rapport Euratom n° EUR 1851 f - Reprint

GOTTSCHALK W.

Untersuchungen über die Abgrenzung von Pleiotropie und absoluter Koppelung
Rapport Euratom n° EUR 1689 d - Reprint

HERZOG A.

An effect of streptomycin on the dissociation of escherichia coli 70 S-ribosomes
Rapport Euratom n° EUR 1854 e - Reprint

HILL M.
MILLER-FAURES A.
ERRERA M.

Studies on rapidly labelled ribonucleic acid in He-La cells
Rapport Euratom n° EUR 570 e - Reprint

LATARJET R.

Interactions des radiations et des acides désoxyribonucléiques
Rapport Euratom n° EUR 1646 f

LIEBECQ C.
BACQ Z.M.
THOMOU A.

Effet de quelques radio-protecteurs sur le système enzymatique des microsomes hépatiques dégradant l'hexobarbital
Rapport Euratom n° EUR 1690 f - Reprint

MALVICINI A.

Le ricadute radioattive nella zona di Ispra dovute alle esplosioni nucleari durante il quinquennio 1958-1962
Rapport Euratom n° EUR 1651 i - Reprint

MALVICINI A.
DE BORTOLI M.
GAGLIONE P.
VAN DER STRICHT E.

Notevole incremento del manganese 54 nelle ricadute radioattive
Rapport Euratom n° EUR 1679 i - Reprint

MARBAIX G.

Synthèse d'azaguanosine triphosphate à partir d'azaguanine par les réticulocytes de lapin
Rapport Euratom n° EUR 1856 f - Reprint

MULDAL S.
GILBERT C.W.
LAJTHA L.G.
LINDSTEN J.
ROWLEY J.
FRACCARO M.

Tritiated thymidine incorporation in an isochromosome for the long arm of the x-chromosome in man
Rapport Euratom n° EUR 1402 e - Reprint

MYTTENAERE G.

Influence du rapport strontium-calcium sur la croissance et l'absorption du strontium et du calcium chez pisum sativum L
Rapport Euratom n° EUR 552 f - Reprint

NUNEZ J.
JAQUEMIN C.
BRUN D.
RAPPAPORT L.
ROCHE J.

Systèmes et mécanisme de désiodation in vitro des hormones thyroïdiennes
Rapport Euratom n° EUR 1680 f - Reprint

RAPPAPORT M.
LEONIS J.

Fractionnement des protéines solubles du jaune d'œuf de poule
Rapport Euratom n° EUR 1876 f - Reprint

RASIO E.
MALAISE W.
CONARD V.

Modes d'expression de la sensibilité à l'insuline de la graisse épididymaire et du diaphragme de rat in vitro
Rapport Euratom n° EUR 771 f - Reprint

RAVERA O.

Distribution of Mn^{54} from fall-out in population of fresh-water lamellibranchs (unio mancus elongatulus Pfeiffer)
Rapport Euratom n° EUR 1354 e - Reprint

RECHT P.

Irradiation consécutive aux retombées radioactives
Rapport Euratom n° EUR 457 f - Reprint

SRINIVASAN P.R.
BRUNFAUT M.
ERRERA M.

The role of sulfhydryl groupes in RNA metabolism
Rapport Euratom n° EUR 1875 e - Reprint

THOMAS R.

On the structure of the genetic segment controlling immunity in temperate bacteriophages
Rapport Euratom n° EUR 1675 e - Reprint

VAN DER WAAY D.
ZIMMERMANN W.M.T.

Problems in the sanitation of monkeys for wholebody irradiation experiments
Rapport Euratom n° EUR 383 e - Reprint

VAN PUTTEN L.M.

Bone marrow transplantation in the Rhesus monkey
Rapport Euratom n° EUR 382 e - Reprint

WINCKELMANS D.
HILL M.
ERRERA M.

Ribosomes from HeLa cells
Rapport Euratom n° EUR 571 e - Reprint

XXX

Application of atomic energy in agriculture (Annual report 1962)
Rapport Euratom n° EUR 1881 e

XXX

Application of atomic energy in agriculture (Annual report 1963)
Rapport Euratom n° EUR 1882 e

XXX

Bone marrow transplantation in irradiated animals - production and application of pathogen free animals in radiation experiment
Rapport Euratom n° EUR 1607 e

XXX

Etude des niveaux de contamination radioactive du milieu ambiant et de la chaîne alimentaire
Rapport Euratom n° EUR 1612 f

XXX

Mise au point et étude des effets de substances mutagènes chimiques, en comparaison avec les agents mutagènes physiques
Rapport Euratom n° EUR 1609 f

XXX

Studio della biologia dei pesci del Lago Maggiore, allo scopo di raccogliere quelle informazioni che permettano di prevedere le eventuali interazioni tra questi animali e la radioattività presente nelle acque del Lago (1962)
Rapport Euratom n° EUR 1825 i

XXX

Studio della biologia dei pesci del Lago Maggiore, allo scopo di raccogliere quelle informazioni che permettano di prevedere le eventuali interazioni tra questi animali e la radioattività presente nelle acque del Lago (1963)
Rapport Euratom n° EUR 1842 i

b) **Microfilmed reports**

BAGLIONI C.

The fusion of two genes in carriers of hemoglobin Lepore
Rapport Euratom n° EUR 1055 e (MF) - Reprint

BAGLIONI C.
WAETHERALL D.J.

Abnormal human hemoglobins
Rapport Euratom n° EUR 1176 e (MF) - Reprint

BALTUS E.
BRACHET J.

Le dosage de l'acide désoxyribonucléique dans les œufs de batraciens
Rapport Euratom n° EUR 573 f (MF) - Reprint

BELLION B.
BUECHI G.
CHIARLE S.
ORSELLO S.
ROSA U.
SOSI S.

Un nuovo radiocolloide marcato al ^{32}P : studio sul meccanismo di formazione e sul comportamento biologico
Rapport Euratom n° EUR 1901 i (MF) - Reprint

BENERECETTI A.S.
SALVATI A.M.

Some enzymic activities present in a chromatographic non-haemoglobin fraction of human haemolysates
Rapport Euratom n° EUR 1053 e (MF) - Reprint

BOND V.P.
FEINENDEGEN L.E.
HEINZE E.
COTTIER H.

Distribution of transfused tritiated cytidine labelled leukocytes and red cells in the bone marrow of normal and irradiated rats
Rapport Euratom n° EUR 1980 e (MF)

BRACHET J.

Nucleic acids in development
Rapport Euratom n° EUR 578 e (MF) - Reprint

BRACHET J.

Effects of puromycin on morphogenesis in amphibian eggs and acetabularia mediterranea
Rapport Euratom n° EUR 927 e (MF) - Reprint

BRACHET J.

Le rôle biochimique du noyau cellulaire
Rapport Euratom n° EUR 934 f (MF) - Reprint

CHANTRENNE H.

Aspects of the biosynthesis of enzymes
Rapport Euratom n° EUR 1128 e (MF) - Reprint

CHANTRENNE H.

On the mode of action of azaguanine on protein synthesis
Rapport Euratom n° EUR 1146 e (MF) - Reprint

CHANTRENNE H.

Information in biology
Rapport Euratom n° EUR 1147 e (MF) - Reprint

COTTIER H.
ODARTCHENKO N.
FEINENDEGEN L.E.
BOND V.P.

Possibilities and limitations in the use of tritiated thymidine for in vivo cytokinetic studies on lymphoreticular tissue
Rapport Euratom n° EUR 566 e (MF)

COTTIER H.
ODARTCHENKO N.
FEINENDEGEN L.E.
KEISER G.
BOND V.P.

Autoradiographische Untersuchungen über die Entkernung der Erythroblasten nach in vivo-Markierung mit Thymidin-^{3}H
Rapport Euratom n° EUR 1174 d (MF) - Reprint

DE BORTOLI M.
GAGLIONE P.
MALVICINI A.
VAN DER STRICHT E.

Strontium-90 and Caesium-137 in milk at Ispra, Italy, during 1960-62
Rapport Euratom n° EUR 1685 e (MF) - Reprint

DE CARLI L.
MAIO J.J.
NUZZO F.

Gene dosage and control of alkaline phosphatase in human cultured cells
Rapport Euratom n° EUR 673 e (MF)

DE CARLI L.
MAIO J.J.

Uso di reazioni cromatogene per la ricerca di marcatori enzimatici in popolazioni di cellule eteroploidi umane coltivate in vitro
Rapport Euratom n° EUR 1921 i (MF) - Reprint

DE CARLI L.
MAIO J.J.
NUZZO F.

Alkaline phosphatase activity and chromosome variation in human cells in culture
Rapport Euratom n° EUR 1963 e (MF) - Reprint

DECROLY M.
CAPE M.
BRACHET J.

Contribution à l'étude du métabolisme de l'acide ribonucléique au cours du développement embryonnaire
Rapport Euratom n° EUR 1865 f (MF) - Reprint

DI PRISCO G.
GIUDITTA A.

Effetto dei barbiturici sulla diaforasi-I di cervello di bue : relazione tra struttura e inibizione
Rapport Euratom n° EUR 727 i (MF) - Reprint

EDWARDS A.W.F.

Migrational selection
Rapport Euratom n° EUR 1666 e (MF) - Reprint

EDWARDS A.W.F.

The measure of association in a 2 × 2 table
Rapport Euratom n° EUR 1668 e (MF) - Reprint

EDWARDS A.W.F.

Natural selection and the sex ratio - the approach to equilibrium
Rapport Euratom n° EUR 1695 e (MF) - Reprint

EDWARDS A.W.F.

Human sex ratio and maternal immunity to male antigen
Rapport Euratom n° EUR 1696 e (MF) - Reprint

ERRERA M.
SRINIVASAN P.R.
BRUNFAUT M.

Essai de localisation cellulaire de la synthèse de l'acide ribonucléique de transfert
Rapport Euratom n° EUR 1665 f (MF) - Reprint

FEINENDEGEN L.E.
BOND V.P.

Observation on nuclear RNA during mitosis in human cancer cells in culture (HeLa-S_3), studied with tritiated cytidine
Rapport Euratom n° EUR 560 e (MF) - Reprint

FEINENDEGEN L.E.
BOND V.P.
CRONKITE E.P.
HUGHES W.L.

RNA turnover in normal rat bone marrow
Rapport Euratom n° EUR 1981 e (MF)

FICQ A.
AIELLO F.
SCARANO E.

Métabolisme des acides nucléiques dans l'œuf d'oursin en développement (étude autoradiographique)
Rapport Euratom n° EUR 574 f (MF) - Reprint

FICQ A.

Localisation d'un acide ribonucléique (RNA) de transfert dans les oocytes d'astéries
Rapport Euratom n° EUR 575 f (MF) - Reprint

FRANCESCHINI P.
CEPPELLINI R.
DE CARLI L.
SANTACHIARA-BENERECETTI S.

Propagazione in vitro di una linea cellulare umana portatrice di un marcatore cromosomico (delezione) preesistente in vivo
Rapport Euratom n° EUR 1396 i (MF)

FRANCESCHINI P.
VOLANTE G.
CEPPELLINI R.
DE CARLI L.
NUZZO F.
TORRICELLI C.

Mosaico cromosomico « traslocazione 21 su 13-15/normale » in un individuo mongoloide
Rapport Euratom n° EUR 1923 i (MF) - Reprint

GALAND P.

Effet de polynucléotides naturels et artificiels sur l'incorporation d'acides aminés marqués par des cellules de Landschütz (in vitro)
Rapport Euratom n° EUR 1035 f (MF) - Reprint

GERACI G.
DE PETROCELLIS B.
ROSSI M.
SCARANO E.

Anomala sensibilità della 2'-deossiribosil 4-amino-pirimidone-2 5'-fosfato aminoidrolasi da tessuti di animali a sangue caldo alla dialisi, al trattamento con resine a scambio ionico ed a filtrazione su sephadex
Rapport Euratom n° EUR 749 i (MF) - Reprint

GEUSKENS M.

Accumulation nucléolaire d'acide ribonucléique (RNA) dans l'oocyte d'astérie
Rapport Euratom n° EUR 580 f (MF) - Reprint

GIUDITTA A.
DI PRISCO D.

The inhibition of cerebral NAD(P)H : acceptor oxidoreductase by barbiturates and nervous depressants
Rapport Euratom n° EUR 1039 e (MF) - Reprint

GIUDITTA A.
STRECKER H.J.

NADH-tetrazolio riduttasi del cervello di bue
Rapport Euratom n° EUR 1028 i (MF) - Reprint

GIUDITTA A.
STRECKER H.J.

Brain NADH-tetraazolium reductase activity, lipoamide déhydrogenase and activating lipids
Rapport Euratom n° EUR 1365 e (MF) - Reprint

GRAZIOSI F.

La biofisica nelle sue relazioni con la ricerca d'insegnamento di fisica e biologia
Rapport Euratom n° EUR 1154 i (MF)

GRAZIOSI F.

Proprietà biologiche e molecolari di un nuovo tipo di particella fagica
Rapport Euratom n° EUR 1395 i (MF) - Reprint

GUERRINI F.
CALEF E.

Studi sul meccanismo di formazione dei fagi transduttori
Rapport Euratom n° EUR 720 i (MF)

HERZOG A.

L'action de la streptomycine sur les ribosomes de escherichia coli
Rapport Euratom n° EUR 677 f (MF) - Reprint

HUART R.
LEDOUX L.

The translocation of nucleic acids in germinating barley seeds
Rapport Euratom n° EUR 507 e (MF)

JANOWSKI M.

Incorporation de phosphore radio-actif dans les acides ribonucléiques de fragments nucléés et anucléés d'acetabularia mediterranea
Rapport Euratom n° EUR 579 f (MF) - Reprint

JEENER R.
VANSANTEN G.

On the structural alterations of phage proteins synthesized in the presence of pancreatic ribonuclease
Rapport Euratom n° EUR 1662 e (MF) - Reprint

KARAMATA D.
KELLENBERGER E.
KELLENBERGER G.
TERZI M.

Sur une particule accompagnant le développement du coliphage λ
Rapport Euratom n° EUR 1054 f (MF) - Reprint

MAGLIULO E.
VAN PUTTEN L.M.
DE VRIES M.J.

Risultati del trapianto di midollo osseo autologo in scimmie Rhesus irradiate
Rapport Euratom n° EUR 1967 i (MF) - Reprint

MAIO J.J.
DE CARLI L.

Induction and repression of alkaline phosphatase in human cultured cells by prednisolone, hydrocortisone and organic monophosphates
Rapport Euratom n° EUR 1669 e (MF) - Reprint

MODIANO G.
BENERECETTI-
SANTACHIARA A.S.
GONANO F.
CAPALDO A.
CAVALLI-SFORZA L.L.

Analisi della popolazione leccese per gruppi sanguini, G6PD, aptoglobine e transferrine
Rapport Euratom n° EUR 1922 i (MF) - Reprint

MORONI A.

Evoluzione della frequenza dei matrimoni consanguinei in Italia negli ultimi cinquant'anni
Rapport Euratom n° EUR 668 i (MF)

MYTTENAERE C.
KIRCHMANN R.

Influence de l'apport de strontium stable au sol sur la teneur en strontium des végétaux cultivés - emploi des techniques d'activation et de spectrométrie gamma
Rapport Euratom n° EUR 1143 f (MF) - Reprint

NUZZO F.
DE CARLI L.
BOMPIANI A.
MONETA E.

Valore adattivo in vitro di diversi cariotipi in un mosaico cromosomico umano
Rapport Euratom n° EUR 1038 i (MF) - Reprint

NUZZO F.
DE CARLI L.
RITA G.
RUSSI M.
FISCHER-FANTUZZI L.

Osservazioni su un caso di relativa stabilità del corredo cromosomico in un ceppo di rene di scimmia in coltura continua
Rapport Euratom n° EUR 1920 i (MF) - Reprint

ODARTCHENKO N.
BOND V.P.
FEINENDEGEN L.E.
COTTIER H.

Kinetics of erythrocytic precursor proliferation in dog
Rapport Euratom n° EUR 1366 e (MF) - Reprint

ODARTCHENKO N.
BOND V.P.
FEINENDEGEN L.E.
COTTIER H.

Kinetics of erythroblastic cell populations in the dog, studied with tritiated thymidine
Rapport Euratom n° EUR 1982 e (MF)

ODARTCHENKO N.
COTTIER H.
FEINENDEGEN L.E.
BOND V.P.

Mitotic delay in more mature erythroblasts of the dog, induced in vivo by sublethal doses of X-rays
Rapport Euratom n° EUR 1983 e (MF)

ODARTCHENKO N.
COTTIER H.
FEINENDEGEN L.E.
BOND V.P.

Evaluation of mitotic time in vivo, using tritiated thymidine as a cell marker : successive labelling with time of separate mitotic phases
Rapport Euratom n° EUR 1992 e (MF) - Reprint

PECHERE J.F.
ZANEN J.

Possible production of several exopenicillinases by bacillus cereus
Rapport Euratom n° EUR 1906 e (MF) - Reprint

RITOSSA F.M.
PULITZER J.F.

Aspects of structure of polytene chromosome puffs of drosophila busckii derived from experiments with antibiotics
Rapport Euratom n° EUR 1694 e (MF) - Reprint

RITOSSA F.

A new puffing pattern induced by temperature shock and DNP in Drosophila
Rapport Euratom n° EUR 1965 e (MF) - Reprint

ROLLER A.

Etude de DNA (teneur, localisation) des œufs de batraciens
Rapport Euratom n° EUR 1866 f (MF) - Reprint

RONDANELLI E.G.
GORINI P.
MAGLIULO E.
FIORI G.P.
PECORARI D.

Morfologia, dinamica e cronologia della mitosi nel megaloblasto dell'anemia perniciosa
Rapport Euratom n° EUR 1873 i (MF) - Reprint

SASSEN A.
KENNES F.
MAISIN J.R.

Electrophorèse en gélose des protéines tissulaires de la souris
Rapport Euratom n° EUR 1869 f (MF)

SCARANO E.
GERACI G.
POLZELLA A.
CAMPANILE E.

Probabile presenza di due siti attivi sulla 2'-deossiribosil 4-aminopirimidone-2 5'-fosfato aminoidrolasi
Rapport Euratom n° EUR 728 i (MF) - Reprint

SCARANO E.
BONADUCE L.
DE PETROCELLIS B.

The enzymatic aminohydrolysis of 4-aminopyrimidine deoxyribonucleotides - III. Purification and properties of 2'-deoxyribosyl 4-aminopyrimidone-2, 5'-phosphate aminohydrolase from monkey liver
Rapport Euratom n° EUR 1692 e (MF) - Reprint

SCARANO E.
GERACI G.
POLZELLA A.
CAMPANILE E.

The enzymatic aminohydrolysis of 4-aminopyrimidine deoxyribonucleotides - IV. On the possibility of the occurrence of an allosteric site on 2'-deoxyribosyl 4-amino-pyrimidone-2, 5'-phosphate aminohydrolase
Rapport Euratom n° EUR 1693 e (MF) - Reprint

SCHNEK A.G.
LEDOUX L.
LEONIS J.
RAPPAPORT M.
CHARLES P.

Protéines marquées de l'œuf de poule - biosynthèse et préparation
Rapport Euratom n° EUR 1867 f (MF)

SELS A.A.

Dosage des hémoprotéines chez la levure - 4) Cytochrome oxydase
Rapport Euratom n° EUR 1663 f (MF) - Reprint

SELS A.A.

Dosage des hémoprotéines chez la levure - 3) Chaînons de la succinoxydase
Rapport Euratom n° EUR 1667 f (MF) - Reprint

SMEETS J.G.P.M.

Een kwantitatieve en kwalitatieve vergelijking omtrent het voorkomen van splijtingsprodukten in de atmosfeer en in plantaardige en dierlijke produkten
Rapport Euratom n° EUR 1997 n (MF) - Reprint

SRINIVASAN P.R.
MILLER-FAURES A.
ERRERA M.

Isolation technique for HeLa-cell nuclei
Rapport Euratom n° EUR 1994 e (MF) - Reprint

STRECKER H.J.
DI PRISCO G.

Activation and inhibition of NaDH oxidation by brain mitochondrial fragments
Rapport Euratom n° EUR 1670 e (MF) - Reprint

THOMAS R.
LAMBERT L.

On the occurrence of bacterial mutations permitting lyzogenization by clear variants of temperate bacteriophages
Rapport Euratom n° EUR 576 e (MF) - Reprint

THOMAS R.

Le sort du prophage après l'infection d'une bactérie lysogène par un bactériophage non co-immun
Rapport Euratom n° EUR 577 f (MF) - Reprint

THOMAS R.
LAMBERT L.

Données sur le rôle du genotype bactérien dans l'établissement de la lysogénie
Rapport Euratom n° EUR 1630 f (MF) - Reprint

TOCCHINI-VALENTINI G.
STODOLSKY M.
AURISICCHIO A.
SARNAT M.
GRAZIOSI F.
WEISS S.B.
GEIDUSCHEK E.P.

On the asymmetry of RNA synthesis in vivo
Rapport Euratom n° EUR 1052 e (MF) - Reprint

TOCCO G.
ORENGO A.
SCARANO E.

Ribonucleic acids in the early embryonic development of the sea urchin
Rapport Euratom n° EUR 1177 e (MF) - Reprint

UTJAN L.

Sur les protéines basiques des réticulocytes de lapin
Rapport Euratom n° EUR 1664 f (MF) - Reprint

VAN BEKKUM D.W.
VAN PUTTEN L.M.
DE VRIES M.J.

Identification of causative factors of X-diseases in monkeys
Rapport Euratom n° EUR 672 e (MF) - Reprint

YAMAMOTO Y.L.
FEINENDEGEN L.E.
BOND V.P.

Effect of radiation on the RNA metabolism of the central nervous system
Rapport Euratom n° EUR 561 e (MF) - Reprint

ZAALBERG O.B.
WEYZEN W.W.H.
VOS O.

Influence of excess of antigen on immunological tolerance in radiation chimeras
Rapport Euratom n° EUR 1943 e (MF) - Reprint

XXX

Etude du mécanisme d'action des mutagènes chimiques (Rapport annuel 1963)
Rapport Euratom n° EUR 1156 f (MF)

XXX

Recherches en biologie fondamentale et en radiologie - Formation de jeunes chercheurs (Rapport annuel 1962)
Rapport Euratom n° EUR 1614 f (MF)

2. CHEMISTRY

a) **Printed reports**

ANZANI A.
BREDAEL I.
SCIUTO F.

Dispositif de mesures de la pureté nucléaire des matériaux par la méthode d'oscillation
Rapport Euratom n° EUR 523 f

BAUMGAERTNER F.
SCHOEN A.

Eine papierchromatographische Trennung der isomeren Dijodbenzole und ihr aktivierungsanalytischer Nachweis
Rapport Euratom n° EUR 1860 d - Reprint

BARBI G.B.

Thermodynamic functions and phase stability limits by electromotive force measurements on solid electrolytic cells
Rapport Euratom n° EUR 1874 e - Reprint

BERTHELOT C.A.
HERMANN S.
LAUER K.F.
MUZZARELLI R.A.A.

The chromatographic concentration and the spectrographic determination of traces of cadmium, yttrium, scandium and lanthanons in uranium metal
Rapport Euratom n° EUR 587 e

BRUECK A.
LAUER K.F.
LE DUIGO Y.

Détermination de la teneur en cobalt d'une solution par spectrophotométrie différentielle
Rapport Euratom n° EUR 581 f

BUIJS K.
CHOPPIN G.R.

Near infra-red studies of the structure of water: I. Pure water, II. Ionic solutions
Rapport Euratom n° EUR 554 e - Reprint

BUIJS K.
CHOPPIN G.R.
Assignment of the near-infra-red bands of water and ionic solutions
Rapport Euratom n° EUR 1197 e - Reprint

CERRAI E.
HAINSKI Z.
ROSSI G.
TRUCCO R.
Chemical separation and spectrographic determination of trace amounts of rare earths in SAP material (Part I)
Rapport Euratom n° EUR 1682 e - Reprint

DE GAUDEMARIS G.P.
DE GORSKI E.
GIULIANI P.
LELEU G.
Caloporteurs organiques d'origine pétrolière pour réacteurs nucléaires
Rapport Euratom n° EUR 496 f

DREZE P.
DUYCKAERTS G.
Extraction du plutonium (IV) par l'acide dibutylphosphorique
Rapport Euratom n° EUR 436 f

DUYCKAERTS G.
GOFFART J.
L'extraction liquide-liquide par les oxydes d'alkyphosphine
Rapport Euratom n° EUR 437 f

ELBERG S.
FRIZ G.
Physical properties of organic nuclear reactor coolants
Rapport Euratom n° EUR 400 e

FRANCINI M.
MARTINI S.
Oscillographic polarography in molten nitrates. I. The validity of the Randles-Sevcik equation
Rapport Euratom n° EUR 1908 e

FRIZ G.
Bestimmung der Zähigkeit von Polyphenylen mit Hilfe einer Methode für kleine Substanzmengen
Rapport Euratom n° EUR 594 d

FRIZ G.
REITER F.W.
NEHREN R.
A compilation of the newest values of the physical properties of OM_3 for heat transfer purposes
Rapport Euratom n° EUR 1619 e

GEISS F.
SCHLITT H.
RITTER F.J.
WEIMAR W.M.
Analyse von Polyphenylgemischen mit der Dünnschichtchromatographie - I. Qualitative Arbeiten
Rapport Euratom n° EUR 553 d - Reprint

GIRARDI F.
PIETRA R.
Determination of calcium, strontium and barium in single cristals of alkali halides by neutron activation
Rapport Euratom n° EUR 1656 e - Reprint

HAUBOLD W.
PEPPLER W.
Trennung von Terphenylgemischen durch Thermodiffusion
Rapport Euratom n° EUR 1895 d

HAUBOLD W.
Destillation von Terphenylgemischen mittels Dünnschichtverdampfer
Rapport Euratom n° EUR 1676 d - Reprint

HAUSSER K.H.
MONGINI L.
VAN STEENWINKEL R.
E.S.R. spectra of the terphenyl-anions
Rapport Euratom n° EUR 1344 e - Reprint

JUPPE G.
ALVARENGA A.
HANNAERT H.

The pyrolytic decomposition of terphenyls
Rapport Euratom n° EUR 1647 e

KARLSON P.
MAURER R.
WENZEN M.

Eine Mikromethode zur Markierung von Steroiden und von Ecdyson mit Tritium
Rapport Euratom n° EUR 510 d - Reprint

LATARJET R.
EKERT B.
DEMERSEMAN P.

Peroxydation of nucleic acids by radiation : biological implications
Rapport Euratom n° EUR 440 e - Reprint

LILJENZIN J.O.
REINHARDT H.
WIRRIES H.
LINDNER R.

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Rapport Euratom n° EUR 395 e (2) - Reprint

LILJENZIN J.O.
LINDNER R.
REINHARDT H.

Further studies on radiocolloids
Rapport Euratom n° EUR 458 e - Reprint

LINDNER R.
SCHMITZ F.

Diffusion of Pu in UO_2
Rapport Euratom n° EUR 501 e - Reprint

MANNONE F.
STOPPA C.

Estrazione del Torio da soluzioni acquose solforonitriche mediante Trilaurilammina
Rapport Euratom n° EUR 1911 i

MANNONE F.
STOPPA C.

Estrazione dell'Uranio esavalente da soluzioni acquose solforiconitriche mediante Trilaurilammina
Rapport Euratom n° EUR 1912 i

MANNONE F.
STOPPA C.
SANSO G.

Separazione con solventi dei prodotti di dissoluzione nietrica del carburo d'Uranio
Rapport Euratom n° EUR 1913 i

MUELLER W.
FUGER J.
DUYCKAERTS G.

Complex formation in tertiary amine extraction of trivalent metals
Rapport Euratom n° EUR 2169 e

NOUVERTNE W.
HEMPEL K.

Untersuchungen über die Lagerfähigkeit H-3-markierter Aminosäuren hoher spezifischer Aktivität
Rapport Euratom n° EUR 1828 d

OSINSKI P.

Recherches sur la préparation et la conservation des stéroïdes tritiés d'activité spécifique élevée
Rapport Euratom n° EUR 412 f

RABE J.G.
GUARINO A.
RABE B.

Auto-radiolysis of tritium-labelled cyclohexane and n-propanol under different conditions
Rapport Euratom n° EUR 1672 e - Reprint

REITER F.W.

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Rapport Euratom n° EUR 528 d

SCOPPA P.
GERBAULET K.

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Rapport Euratom n° EUR 2168 e

TOUSSAINT C.
VOS G.

Quelques applications analytiques de la diffusion cohérente et incohérente des rayons X
Rapport Euratom n° EUR 488 f

VENERONI R.
FRIESEN R.

Water determination in terphenyls using the Karl Fischer coulometric titration
Rapport Euratom n° EUR 2159 e

VERSINO B.
GEISS F.
BARBERO G.

Verwendung von Bentone-haltigen Trennsäulen für die Gaschromatographie von Polyphenylgemischen
Rapport Euratom n° EUR 1653 d - Reprint

VOS G.

Le dosage des traces minérales dans les polyphényles par spectrographie X
Rapport Euratom n° EUR 478 f

XXX

Activation analysis techniques at the Joint Research Laboratories at Ispra
Rapport Euratom n° EUR 1601 e

XXX

Bibliographie comparée de l'analyse par activation (rapport final)
Rapport Euratom n° EUR 1886 f

XXX

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Rapport Euratom n° EUR 1801 e

XXX

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Rapport Euratom n° EUR 1625 e

XXX

Propriétés thermiques des polyphényles (Parties I et II)
Rapport Euratom n° EUR 1635 f

XXX

Substituts aux terphényles
Rapport Euratom n° EUR 1604 f

XXX

Synthese von Kohlenstoff-14-, Tritium- und Deuterium-markierten Terphenylen
Rapport Euratom n° EUR 492 d

b) **Microfilmed reports**

BERLIN A.
MENES F.
FORCHERI S.
MONFRINI C.

Differences in the mobilities of like charge ions in molten systems
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EKERT B.

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Rapport Euratom n° EUR 565 e (MF) - Reprint

JOSIEN M.L.
Utilisation des molécules organiques marquées aux isotopes stables dans les études fondamentales de spectroscopie moléculaire et synthèse de plusieurs composés marqués au deutérium
Rapport Euratom n° EUR 675 f (MF) - Reprint

MAURER R.
WENZEL M.
KARLSON P.
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Rapport Euratom n° EUR 1991 e - Reprint (MF)

MILHAUD G.
AUBERT J.P.
Recherches sur l'obtention de bases puriques et pyrimidiques 14C de haute activité spécifique
Rapport Euratom n° EUR 1984 f (MF)

3. MACHINERY AND APPARATUS

a) Printed reports

AMELINCKX S.
DE CONINCK R.
DENAYER M.
GIJS A.
HEERSCHAP M.
NAGELS P.
VAN GOOL L.
Solid state neutron detector
Rapport Euratom n° EUR 431 e

BAUMIER J.
GOLLION H.J.
Pompes mécaniques pour métaux liquides
Rapport Euratom n° EUR 1826 f

BOBIN K.J.
MATHIEU F.
WANHAELEWIJN R.
Flow failure tests on BR-2
Rapport Euratom n° EUR 1681 e - Reprint

BONNET C.
MACKE E.
MORIN R.
Visualisation de l'ébullition nucléée de l'eau à pression atmosphérique et mesure simultanée des variations de température de surface
Rapport Euratom n° EUR 1622 f

BONNET P.
BORLOO E.
JANSEN J.
Tests non destructifs sur tubes de gaine Orgel
Rapport Euratom n° EUR 2109 f

CAPPELLANI F.
RESTELLI G.
Construction and performances of silicon surface barrier detectors
Rapport Euratom n° EUR 1683 e - Reprint

DE BLUST E.
MANDL V.
DE LOTTO I.
Tunnel diode low level discriminator
Rapport Euratom n° EUR 1037 e - Reprint

DEMANGE Ph.
DOUGUET E.
LEFRANC J.D.
Le vapotron nucléaire
Rapport Euratom n° EUR 1753 f - Reprint

DE LOTTO I.
STANCHI L.
Sensibilità e ritardo nei circuiti a scatto
Rapport Euratom n° EUR 430 i

FAURE J.

Détermination de la diffusivité thermique des isolants par la méthode du signal très bref
Rapport Euratom n° EUR 1822 f

FORTE M.

Nanosecond resolving time obtained with NaI (T2) detectors
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FRAYSSE G.
PROSDOCIMI A.
WINTER J.

Dispositifs d'électronique rapide utilisés dans des mesures de sections efficaces de fission
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GIULIANI S.
MUSTACCHI C.

Heat transfer in a fuel element gas gap
Rapport Euratom n° EUR 521 e

GUERRI L.

Numerical calculation of shock waves
Rapport Euratom n° EUR 1659 e - Reprint

HAINSKI Z.
ROSSI G.
TRUCCO R.

Quelques considérations sur la méthode « Copper Spark », influence de l'excitation
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HERZBERGER P.
BOULLET J.J.

Eine elektrische Waage für kleine Gewichte
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MEYER H.

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JASPERS J.H.

Bijzondere toepassingen van de argonarc lasmethode bij het Reactor Centrum Nederland in Petten
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MATTEOLI L.
LOGI P.
SALAMANNA S.

Autoradiografia quantitativa I. Preparazione degli standards radioattivi a concentrazione scalare di tracciante
Rapport Euratom n° 1883 i

MEYER H.
VERELST H.

Tunnel diodes as multivibrator for fast counting in time-of-flight coding and derandomising applications
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SPERNOL A.
DENECKE B.

Präzise Absolutmessung der Aktivität von Tritium
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PERSCHKE D.

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SCHROCK V.E.
VAN ERP J.P.
POSSA G.

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VAN AUDENHOVE J.
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Rapport Euratom n° EUR 1204 n - Reprint

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DE JONG A.
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WERZ R.
Messung der gemischten Strahlungsfelder im Reaktor BR-2 mit Hilfe von Kalorimetersonden
Rapport Euratom n° EUR 363 d - Reprint

XXX
Esone-Systeem voor nucleaire elektronica
Rapport Euratom n° EUR 1831 n

b) **Microfilmed reports**

XXX
Third symposium on engineering problems in thermonuclear research
Rapport Euratom n° EUR 1902 e (MF)

BERNARDET H.
GOURDON C.
Jauge de Penning à réponse rapide
Rapport Euratom n° EUR 1936 f (MF) - Reprint

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CHAVANEL H.
ELBERG S.
Dispositif pour la mesure des tensions de vapeur jusqu'à 20 kg/cm² et 500° c
Rapport Euratom n° EUR 567 f (MF) - Reprint

BESSOUAT R.
CHAVANEL H.
ELBERG S.
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Rapport Euratom n° EUR 568 f (MF) - Reprint

BESSOUAT R.
ELBERG S.
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Rapport Euratom n° EUR 1953 f (MF) - Reprint

BLED J.
BRESSON A.
PAPOULAR R.
WEGROWE J.G.
Nouvelles techniques d'utilisation des ondes millimétriques et submillimétriques
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BOESCHOTEN F.
GEISSLER K.
SILLER F.
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BONAZZOLA G.C.
A fast-neutron time-of-flight spectrometer
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Druckmessungen mit piezoelektrischen Sonden an einem linearen Z-Pinch
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CONRADS H.
HARTWIG H.
Eine getriggerte Gleitfunkenstrecke zur Erzeugung von Emissionsspektren im Gebiet der weichen Röntgenstrahlen
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DRAWIN H.W.
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FAUGERAS P.E.
LASRY J.
VERON D.
Physique des plasmas - canon coaxial
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FIGUERA A.S.
MILONE C.
A proton recoil fast neutron spectrometer with solid state detectors
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Magnetfeldmessungen mit Hilfe des Zeeman-Effektes
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MARTONE M.
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OSWALD B.
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PAPOULAR R.
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RUBBINO A.
Spectrometers for fast neutrons from nuclear reactions and from collimated beams
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POTENZA R.
RUBBINO A.
Fast neutron spectrometer
Rapport Euratom n° EUR 1934 e (MF) - Reprint

SPERNOL A.
VANINBROUKX R.
GROSSE G.
Thermal flux perturbation by cobalt detector
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WEISER G.
A rigid low-loss polarizing device for giant pulse lasers
Rapport Euratom n° EUR 1903 e (MF)

4. GEOLOGY, MINERALOGY AND METEOROLOGY

a) Printed reports

BOLLINI G.
GANDINO C.
SCAGLIANTI B.

5° Annuario meteorologico
Rapport Euratom n° EUR 1617 i

DEUTSCH S.
PASTEELS P.

Age measurements of Antarctic rocks (Queen Maud Land)
Rapport Euratom n° EUR 459 e - Reprint

GONFIANTINI R.
TOGLIATTI V.
TONGIORGI E.
DE BREUCK W.
PICCIOTTO E.

Snow stratigraphy and oxygen isotope variations in the glaciological pit of King Baudouin Station, Queen Maud Land, Antarctica
Rapport Euratom n° EUR 1673 e - Reprint

GANDINO C.

Il Föhn ad Ispra
Rapport Euratom n° EUR 769 i - Reprint

PICCIOTTO E.
WILGAIN S.

Fission products in Antarctic snow, a reference level for measuring accumulation
Rapport Euratom n° EUR 1674 e - Reprint

XXX

Messwerte der künstlichen Radioaktivität in den Ländern der Gemeinschaft (1958-1963)

Résultats des mesures de la radioactivité dans les pays de la Communauté (1958-1963)

Risultati delle misure della radioattività nei paesi della Comunità (1958-1963)

Resultaten van de metingen van de kunstmatige radioactiviteit in de landen van de Gemeenschap (1958-1963)
Rapport Euratom n° EUR 1820 d, f, i, n

b) Microfilmed reports

BLOCK W.

Allgemeine Untersuchung über die Radioaktivität des Rheineinzugsgebiets - Bericht über die Durchführung der Schlammprobenahme
Rapport Euratom n° EUR 536 d (MF)

BLASSEUR H.
HERMAN P.
HUBAUX A.

Apatites de l'est du Congo et du Ruanda
Rapport Euratom n° EUR 1661 f (MF) - Reprint

KIEFER H.
MAUSHART R.

Allgemeine Untersuchung über die Radioaktivität des Rheineinzugsgebiets - Bericht über die Durchgeführten Messungen zur Bestimmung der Radioaktivität des Schlamms
Rapport Euratom n° EUR 537 d (MF)

5. HEALTH AND SAFETY

a) Printed reports

FONTAINE G.
LAURENT R.
MALVICINI A.

Unité mobile d'intervention et de décontamination des solides
Rapport Euratom n° EUR 1821 f

WIEBE W.

Schiffbauliche und maschinelle Sicherheitsmaßnahmen auf nuklear angetriebenen Schiffen
Rapport Euratom n° EUR 453 d - Reprint

XXX

Technische Beurteilung der Sicherheit der N.S. Savannah (Vol. I und II)

Evaluation technique de la sécurité du N.S. Savannah (Vol. I et II)

Valutazione tecnica della sicurezza della N.S. Savannah (Vol. I e II)

Technische beoordeling van de veiligheid van het N.S. Savannah (Vol. I en II)

Technical safety evaluation of the N.S. Savannah (Vol. I and II)
Rapport Euratom n° EUR 1621 d, f, i, n, e

XXX

Recherches sur les effets multiples de certains radioprotecteurs chimiques (1962-1963)
Rapport Euratom n° EUR 1835 f

6. INDUSTRIAL APPLICATIONS OF ISOTOPES AND RADIATIONS

a) Printed reports

CHAUVIN J.L.
DANION J.

Mesure du débit solide des cours d'eau par charriage au moyen de traceurs
Rapport Euratom n° EUR 1837 f

SALES M.
BORELLI F.
BRUNA A.
CALDERA P.G.

L'emploi des isotopes radioactifs pour déceler les fuites de gaz
Rapport Euratom n° EUR 1645 f

7. ISOTOPE SEPARATION

a) Printed reports

BRESESTI M.
LANZ R.
DEL TURCO A.M.

Separazione di P-32 da solfati irraggiati in un reattore
Rapport Euratom n° EUR 766 i - Reprint

BRESESTI M.
DEL TURCO A.M.
OSTIDICH A.

Preparation of ^{18}F in a nuclear reactor
Rapport Euratom n° EUR 1655 e - Reprint

FASOLO G.B.
MALVANO R.
ROSA U.

Produzione di Mn^{54} carrier-free per irraggiamento di ferro in reattore
Rapport Euratom n° EUR 1641 i

FUSCHINI E.
MARONI C.
PORCEDDU C.
VERONESI P.

A new method for preparing radioactive sources
Rapport Euratom n° EUR 1878 e - Reprint

SPERNOL A.
DE ROOST E.
LERCH O.

High precision 4 $\pi\beta\gamma$ coincidence counting and the preparation of solid Co^{60} standard sources and solutions for an international comparison
Rapport Euratom n° EUR 477 e

8. MATHEMATICS AND COMPUTERS

a) **Printed reports**

AGAZZI A.
VINCENTI E.
MONTEROSSO R.

The code COSTANZA I
Rapport Euratom n° EUR 2104 e

ALBERTONI S.
BLAESSER G.
d'AMICO G.
CLERICI C.G.

HET - B2 : A heterogeneous method for reactor calculations
Rapport Euratom n° EUR 1839 e

ANNINO J.S.
SANGERMANO L.A.

GLEE : Generalized Library Editor and Executor
Rapport Euratom n° EUR 1843 e

BECKER W.
DE LOTTO I.

Pattern Display considerations for a programming aid machine linking a digital and an analogue computer
Rapport Euratom n° EUR 410 e

BORELLA A.
GUZZI G.

Computer program system for a quantitative analysis by neutron activation and gamma-ray spectrometry
Rapport Euratom n° EUR 531 e

BRAFFORT P.
HIRSCHBERG D.
MOMMENS J.

La programmation des problèmes non numériques
Rapport Euratom n° EUR 365 f

CAMION P.
VERBEEK L.

Efficient realization of Boolean functions by means of diode conjunction matrices and minimal cost assembling problems
Rapport Euratom n° EUR 600 e/f

CAMION P.

Minimisation du nombre de relais dans une commutatrice élémentaire
Rapport Euratom n° EUR 1626 f

CAMION P.

Matrices totalement unimodulaires et problèmes combinatoires
Rapport Euratom n° EUR 1632 f

CAMION P.
Nombre minimum d'inverseurs dans un schéma analogique
Rapport Euratom n° EUR 1918 f

COCCHI M.
DI COLA G.
Statistical study of the effects of measurement errors on the extrapolated radius and height calculation for a cylindrical reactor
Rapport Euratom n° EUR 1624 e

DE AMBROGIO W.
Un metodo per la selezione dei « Tests »
Rapport Euratom n° EUR 1824 i

DE BACKER W.
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Rapport Euratom n° EUR 590 e

DE HAAN W.
CAPRI A.B. - An I.B.M. 7090 thermal utilization factor calculation program on the ring method of Amouyal and Benoist
Rapport Euratom n° EUR 1606 e

DENOTH F.
GERACE G.B.
MAESTRINI P.
PELLEGRINI B.
Tecniche veloci di commutazione e organizzazione logica
Rapport Euratom n° EUR 2112 i

DI COLA G.
ROTA A.
Analysis and development of the series expansion methods in threshold detector activation data handling
Rapport Euratom n° EUR 588 e

GLODEN R.F.
Approximation des fonctions de Bessel - optimisation des programmes correspondants (Addendum)
Rapport Euratom n° EUR 282 f (2)

IHM P.
Methoden der Taxometrie
Rapport Euratom n° EUR 1671 d - Reprint

LAMBERT P.V.
Two theorems in the approximation of functions of two variables by polynomials of the Bernstein-type
Rapport Euratom n° EUR 505 e - Reprint

LECERF Y.
Logique mathématique (Parties I et II)
Rapport Euratom n° EUR 518 f - Reprint

MUELLER K.H.
Über Lösungsverfahren für die Boltzmann-Gleichung (Teil I)
Rapport Euratom n° EUR 217 d (1)

MUELLER K.H.
Über Lösungsverfahren für die Boltzmann-Gleichung (Teil II)
Rapport Euratom n° EUR 217 d (2)

MEYER H.
Studies for a data handling instrumentation system in the CBNM
Rapport Euratom n° EUR 2101 e

MONGINI-TAMAGNINI C.
AIREK-MOD : A modified version of the kinetic code AIREK II
Rapport Euratom n° EUR 1914 e

SCHELTEN-PETERSSEN B.
SCHULZE W.
Eichung magnetischer Durchflußmesser für Flüssigmetalle
Rapport Euratom n° EUR 1631 d

VAN WAUWE A.
The Sioux System
Rapport Euratom n° EUR 1917 e

VINCENTI E.
MONTEROSSO R.
AGAZZI A.
COSTANZA : A numerical code for the study of the reactor spatial dynamics in two groups
Rapport Euratom n° EUR 2103 e

b) **Microfilmed reports**

ENGELMANN F.
Solution of Milne's equation for general line profiles by power series expansion
Rapport Euratom n° EUR 1987 e (MF) - Reprint

GERACE G.B.
Microprogrammed control for computing systems
Rapport Euratom n° EUR 1155 e (MF) - Reprint

GORENFLO R.
Über Pseudozufallsgeneratoren und ihre statistischen Eigenschaften
Rapport Euratom n° EUR 616 d (MF)

LAVAL G.
PELLAT R.
COTSAFTIS M.
TROCHERIS M.
Marginal stability condition for stationary non-dissipative motions
Rapport Euratom n° EUR 1935 e (MF) - Reprint

ROBERTS F.
The development of special graphites for gas cooled, graphite moderated reactors - a review of the work carried out on the Harwell experimental graphite plant
Rapport Euratom n° EUR 1634 e (MF)

9. METALS, CERAMICS AND OTHER MATERIALS

a) **Printed reports**

AMELINCKX S.
DELAVIGNETTE P.
HEERSCHAP M.
Electron microscope study of inter-lamellar compounds of graphite with bromine, iodine monochloride and ferric chloride
Rapport Euratom n° EUR 542 e

AMELINCKX S.
RUEDL E.
Electron microscopic observation of dislocation networks and radiation damage in α-Uranium
Rapport Euratom n° EUR 1525 e - Reprint

BEGHI G.
PIATTI G.
QUATAERT D.
Evolution structurale de l'alumine dans le SAP fondu
Rapport Euratom n° EUR 589 e

BEGHI G.
PIATTI G.
QUATAERT D.

Analisi dilatometrica del SAP a differenti tenori in ossido
Rapport Euratom n° EUR 1613 i

BENEDICT J.
HUET J.J.

Untersuchungen in der Zirkoniumecke der Systeme Zirkonium-Niob-Chrom und Zirkonium-Niob-Vanadium
Rapport Euratom n° EUR 1317 d - Reprint

BROSSA F.
SCHLEICHER H.W.
THEISEN R.

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Rapport Euratom n° EUR 515 e - Reprint

DESLOIRE M.

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Rapport Euratom n° EUR 1846 f

DI COLA G.
MATZKE H.

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Rapport Euratom n° EUR 2157 e

DOUMERC J.
TROCCON G.
HAUSER R.

Etude théorique et technologique de combustibles nucléaires à base de pastilles réfractaires composites
Rapport Euratom n° EUR 1249 f

ESCHBACH H.L.

Herstellung von gleichmäßigen Aufdampfschichten auf Platten und Zylindern
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FRIGERIO G.
GEREVINI T.

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GUEGNAUD A.
ROQUES C.

Choix et mise en œuvre d'un acier austénitique pour la construction de la cuve du réacteur à neutrons rapides RAPSODIE
Rapport Euratom n° EUR 1642 f

GUYOT P.

Contribution à l'étude de la plasticité du SAP
Rapport Euratom n° EUR 550 f

GUYOT P.

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Rapport Euratom n° EUR 584 f

GUYOT P.

Activation energy and activation volume in SAP
Rapport Euratom n° EUR 1862 e - Reprint

HERENGUEL J.
LAMOTTE M.
MANSARD D.
ROUSSET P.
WHITWHAM D.

Etude de la mise en forme et de l'irradiation du monocarbure d'uranium
Rapport Euratom n° EUR 471 f

HESS E.G.

Contribution à l'étude des possibilités de fabrication de produits en aluminium fritté
Rapport Euratom n° EUR 1844 f

HOLTBECKER H.
MONTAGNANI M.

Saldatura e formatura del SAP con esplosivi
Rapport Euratom n° EUR 1818 i

LAGERWALL T.
SCHMELING P.

Interpretation and evaluation of non-ideal gas release in post-activation measurements
Rapport Euratom n° EUR 595 e

LEYENDECKER W.
SERRINI G.

Determinazione dell'alluminio nel SAP
Rapport Euratom n° EUR 585 i

MONTUELLE J.
CHAUDRON G.

Nouvelles propriétés structurales d'aciers inoxydables préparés à partir de métaux purifiés par zone fondue
Rapport Euratom n° EUR 1586 f - Reprint

PAGANELLI M.

Dimensioni dei sub-grani in estrusi di SAP 4, 7, 10 e 14 % Al_2O_3, ricotti a 600 e a 650°
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RAZ B.
SCHMIDT H.E.

A propos d'une anomalie de la résistance électrique d'UO_2 fritté
Rapport Euratom n° EUR 451 f - Reprint

RICHTER H.
TVERBERG J.C.

Über die Eigenschaften von Schweissnähten Niob-Haltiger Zirkonium-Legierung
Rapport Euratom n° EUR 1319 d - Reprint

RUEDL E.
STAROSTE E.

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Rapport Euratom n° EUR 1833 e

SCHLECHTER M.
KOOI R.
BILLIAU R.
CHARLIER R.A.
DUMONT G.L.

The preparation of UO_2 by fused salt electrolysis using UO_2 or UF_4 as starting materials
Rapport Euratom n° EUR 1896 e

SPILLER K.H.

Zur Kenntnis der physikalischen Stoffeigenschaften von Flüssigmetallen zwischen Schmelz- und Siedepunkt
Rapport Euratom n° EUR 599 d

THEISEN R.

Anwendung des Röntgenmikroanalysators zur Untersuchung des Zeilengefüges von kaltverformten Sinteraluminium
Rapport Euratom n° EUR 774 d - Reprint

VAN AUDENHOVE J.
ESCHBACH H.
MORET H.

Deposition by electron bombardment and weighing under vacuum of thin high purity boron layers
Rapport Euratom n° EUR 557 e - Reprint

VAN LANDUYT J.
AMELINCKX S.

Domain patterns in colombium (niobium)
Rapport Euratom n° EUR 1588 e - Reprint

WEISSGERBER P.

The investigation of passivating oxide layers on zirconium metal using small single shot anodic current pulses
Rapport Euratom n° EUR 1511 e - Reprint

b) **Microfilmed reports**

BEHRISCH R.
Festkörperzerstäubung durch Ionenbeschuß
Rapport Euratom n° EUR 1999 d (MF) - Reprint

MORANVILLE C.
Studi metallurgici sotto l'egida dell'Euratom
Rapport Euratom n° EUR 1962 i (MF) - Reprint

ROBERTS F.
LONGSTAFF B.
JENKINS T.R.
Some studies in the development of fine-grained graphites for nuclear applications
Rapport Euratom n° EUR 1633 e (MF)

10. PHYSICS

a) **Printed reports**

ALLEN J.E.
SEGRE S.E.
Strong ionizing front in a magnetic field
Rapport Euratom n° EUR 1879 e - Reprint

ANCARANI A.
FOSSOUL E.A.
Détermination de l'effet Doppler des éléments fissiles dans les réacteurs rapides
Rapport Euratom n° EUR 530 f

BEETS C.
CAMPAN J.L.
CAUMETTE P.
COLLE P.
DECKERS H.
DESPRETS A.
ZALESKI C.P.
Propagation des neutrons dans des massifs d'uranium naturel et d'uranium naturel-acier
Rapport Euratom n° EUR 1637 f

BERTOTTI B.
Stabilità di un plasma non uniforme senza collisioni
Rapport Euratom n° EUR 535 i

BONAZZOLA G.C.
BROVETTO P.
CHIAVASSA E.
SPINOGLIO R.
PASQUARELLI A.
The measurement by activation of cross sections for 14,7 MeV neutrons
Rapport Euratom n° EUR 1697 e - Reprint

BRESESTI M.
CAPPELLANI F.
DEL TURCO A.M.
ORVINI E.
The thermal neutron capture cross-section and the resonance capture integral of 124Xe
Rapport Euratom n° EUR 551 e - Reprint

BÜNEMANN D.
FENDLER H.G.
FIEBIG R.
FRISIUS F.
HOFFMANN O.
KOTSCHI H.
PATZELT H.
RICHTER G.
THURO G.
Shielding experiments and calculations at the research reactor Geesthacht, Germany
Rapport Euratom n° EUR 1636 e

DANERI AD.
DENERI ADR.
Il metodo di galerkin e la doppia P1 per il calcolo del flusso termico
Rapport Euratom n° EUR 533 i

DE BIEVRE P.
DEBUS G.
SPAEPEN G.
Thermal neutron absorption cross section of bore
Rapport Euratom n° EUR 454 e - Reprint

FUMELLI M.
Une décharge dans la vapeur de lithium
Rapport Euratom n° EUR 1627 f

FUSCHINI E.
GADJOKOV V.
MARONI C.
VERONESI P.
On the decay scheme of 47Ca
Rapport Euratom n° EUR 1678 a - Reprint

GIERTS G.
Spectrométrie des neutrons rapides au moyen de la réaction 6Li(n, t) 4He
Rapport Euratom n° EUR 441 f - Reprint

GIRARD J.P.
GOURDON C.
Injection longitudinale de particules chargées dans une configuration magnétique statique à miroirs
Rapport Euratom n° EUR 544 f

GUERRI L.
TARONI A.
Computation of the flow behind a converging detonation front in cylindrical or spherical geometry
Rapport Euratom n° EUR 1848 e

HAUSSER K.H.
Dynamic nuclear polarization in liquids at high magnetic fields
Rapport Euratom n° EUR 483 e

HUBERT P.
La première expérience CAPEL
Rapport Euratom n° EUR 545 f

KELLY R.
RUEDL E.
An attempt to correlate diffusion and electron microscopy in krypton-bombarded platinum foils
Rapport Euratom n° EUR 1834 e

KREBS K.
Dynamical model for lattice vibrations in metals
Rapport Euratom n° EUR 1343 e - Reprint

KUEPPER F.P.
Die zeitliche Änderung der radialen Elektronendichteverteilung beim Theta-Pinch
Rapport Euratom n° EUR 511 d - Reprint

LAVAL G.
PELLAT R.
REBUT P.H.
Les équilibres de bifurcation et la stabilité hydromagnétique
Rapport Euratom n° EUR 556 f - Reprint

LECOUSTEY P.
Transmission d'un jet de plasma à travers une barrière magnétique
Rapport Euratom n° EUR 1863 f - Reprint

LUNELLI M.
MAGGIONI G.
A multi-dimensional, multigroup, multiregion, neutron diffusion code (iterative-variational approach)
Rapport Euratom n° EUR 532 e

MAGISTRELLI F.
Esperienze sulle guaine di carica spaziale
Rapport Euratom n° EUR 495 i

MERCIER C.
Sur une représentation des surfaces toroïdales : applications aux équilibres magnétohydrodynamiques
Rapport Euratom n° EUR 555 f - Reprint

NEU H.
Electron heating in hall fields of MPD generators
Rapport Euratom n° EUR 506 e - Reprint

NEU H.
Die nukleare Cäsium-Zelle
Rapport Euratom n° EUR 1687 d - Reprint

PALUMBO D.
Das Euratom-Programm zur Fusions-Forschung
Rapport Euratom n° EUR 442 d - Reprint

LISKIEN H.
PAULSEN A.
Compilation of cross-sections for some neutron induced threshold reactions (second series) - Supplement n° 1
Rapport Euratom n° EUR 119 e

PETER G.
MÜLLER G.
RABBEN H.H.
Untersuchungen mit der HF-Plasma-Resonanzsonde an einem Caesium-Kontaktionisations-Plasma
Rapport Euratom n° EUR 1817 d

ROTTER W.
Verzögerte Photoneutronen im Beryllium-Reaktor BR-02
Rapport Euratom n° EUR 503 d - Reprint

RUBIN R.
KLEY W.
PERETTI J.
Inelastische Streuung kalter Neutronen an Vanadiumhydrid
Rapport Euratom n° EUR 522 d

SCHRAM P.
Kinetic equations for plasmas
Rapport Euratom n° EUR 1805 e

TAMAGNINI M.G.
PONTI C.
A comparison between the codes for the calculation of thermal spectra in homogeneous media
Rapport Euratom n° EUR 1605 e

VANINBROUKX R.
GROSSE G.
Standaardisatie van Cobalt-58
Rapport Euratom n° EUR 524 n

VOSLAMBER D.
Relaxation of electron and Ion temperatures in a strong magnetic field
Rapport Euratom n° EUR 1880 e - Reprint

WAGNER H.
HENSSEN H.
Rechnungen zur optimalen Auslegung der Primärabschirmung des OM-Schiffsreaktors
Rapport Euratom n° EUR 1888 d

WU J.C.
Effects of viscosity in magnetoplasmadynamic generators
Rapport Euratom n° EUR 520 e - Reprint

XXX
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Abschirmungsexperimente am Forschungsreaktor Geesthacht - Jahresbericht 1962
Rapport Euratom n° EUR 534 d (2)

XXX — Beschleuniger-Targets, bestimmt zur Herstellung von Neutronen - cibles pour accélérateurs destinées à la production de neutrons - accelerator targets designed for the production of neutrons
Rapport Euratom n° EUR 1815 d, f, e

b) **Microfilmed reports**

AGODI A.
GIORDANO R.
SCHIFFRER G.
GIANNINI M.
— Numerical methods for D.W.B.A. calculations on (n, p) reactions
Rapport Euratom n° EUR 895 e (MF) - Reprint

AGODI A.
SCHIFFRER G.
— Finite range and exchange effects in the reaction 28Si (n, p)28A1
Rapport Euratom n° EUR 1926 e (MF) - Reprint

AGODI A.
GIORDANO R.
SCHIFFRER G.
— Analysis of direct (n, p) reactions
Rapport Euratom n° EUR 1945 e (MF) - Reprint

ALLEN J.
TURRIN A.
— The collection of positive ions by a probe immersed in a plasma
Rapport Euratom n° EUR 1129 e (MF) - Reprint

ALLEN J.E.
GATTI G.
MARTONE M.U.
RUMI B.
— The implosion phase of a theta-pinch
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ALLEN J.E.
SEGRE S.E.
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— The disposition of an ionized gas in a gravitational field
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ANDREOLETTI J. — Physique des plasmas - sur la stabilité d'un plasma à pression finie
Rapport Euratom n° EUR 1937 f (MF) - Reprint

ANGER W. — Technische Probleme der Plasmaphysik
Rapport Euratom n° EUR 1970 d (MF) - Reprint

ANDREOLETTI J. — Etat stationnaire d'un plasma de faible pression en présence d'un champ électrique ambipolaire
Rapport Euratom n° EUR 1976 f (MF) - Reprint

BARTOLI C.
BOSCHI A.
GRATTON R.
— Study of an inductive system for the measurement of large impulse currents employed in Garridi experiment
Rapport Euratom n° EUR 1628 e (MF)

BECCHI C.
MANUZIE G.E.
MENEGHETTI L.
VITALE S.
— Photodisintegration of He3 by y-rays of energy between 10 and 30 MeV
Rapport Euratom n° EUR 1928 e (MF) - Reprint

BECHERER R.
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PREVOT F.

Décharge dans les gaz - la topographie du champ magnétique dans un duoplasmatron annulaire. Son influence sur la fixation de la décharge
Rapport Euratom n° EUR 1960 f (MF) - Reprint

BECHERER R.
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Rapport Euratom n° EUR 1961 f (MF) - Reprint

BERG H.
TONDELLO G.

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Rapport Euratom n° EUR 1966 e (MF)

BERTOTTI B.

Fine structure in current sheaths
Rapport Euratom n° EUR 1650 e (MF) - Reprint

BIGUET A.
BLANC P.
GRAVIER R.
LECOUSTEY P.
LUC H.
RENAUD C.
TACHON J.
VERON D.
ZANFAGNA B.

Temps de confinement d'un plasma chaud dans le puits magnétique de DECA II
Rapport Euratom n° EUR 1985 f (MF) - Reprint

BOESCHOTEN F.

Review of experiments on the diffusion of plasma across a magnetic field
Rapport Euratom n° EUR 1957 e (MF) - Reprint

BOGEN P.
HINTZ P.
SCHLUTER J.

Influence of impurities on a high temperature, high density deuterium plasma
Rapport Euratom n° EUR 1946 e (MF) - Reprint

BOLLINI D.
FOSSATI F.
PAOLILLO A.M.
ROVERA S.

Energy spectrum of protons from Cs and I with 17.6 MeV incident γ-rays
Rapport Euratom n° EUR 1933 e (MF) - Reprint

BRETON C.

Physique des plasmas - rôle de la dissociation dans les phénomènes d'ionisation de l'hydrogène dans une décharge pulsée
Rapport Euratom n° EUR 1131 f (MF) - Reprint

CARUSO A.
CAVALIERE A.

The low pressure discharge in the strong ionization regime
Rapport Euratom n° EUR 1986 e (MF) - Reprint

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GRATTON F.

Motion of a charge in changing magnetic fields with nonadiabatic intervals
Rapport Euratom n° EUR 1993 e (MF) - Reprint

CHODURA R.

Zum Zündmechanismus einer Theta-Pinch-Entladung
Rapport Euratom n° EUR 1949 d (MF) - Reprint

CORMACK G.D.

The contact surface in an electromagnetic shock tube
Rapport Euratom n° EUR 1975 e (MF) - Reprint

COSTA S.
FERRONI F.
FERRONI S.
MOLINO C.
MALVANO R.

Photoneutrons from medium elements up to 80 MeV photon energy
Rapport Euratom n° EUR 1998 e (MF) - Reprint

CUPERMAN S.
ENGELMANN F.
OXENIUS J.

Non-thermal impurity-radiation from a spherical plasma (Part II)
Rapport Euratom n° EUR 1938 e (MF) - Reprint

DEICAS R.
VALCKX F.P.G.

Source d'ions intense à faisceau plan
Rapport Euratom n° EUR 546 f (MF)

ENGELMANN F.
FICK E.

Quantentheorie der Zeitmessung (I und II)
Rapport Euratom n° EUR 1114 d (MF) - Reprint

ENGELMANN F.
FEIX M.
MINARDI E.

Connection between shielding and stability in a collisionless plasma
Rapport Euratom n° EUR 1864 e (MF) - Reprint

ETIEVANT C.

Les instabilités électrostatiques associées aux anisotropies de distributions de vitesses (comparaison - théorie - expérience)
Rapport Euratom n° EUR 1958 f (MF)

FASOLI U.
TONOLIO D.
ZAGO G.

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SILVERSTEIN E.A.
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The Li^6 (p, He^3) reaction in the energy range 3-5.6 MeV
Rapport Euratom n° EUR 1927 e (MF) - Reprint

FAUGERAS P.E.

Diffraction d'une onde électromagnétique plane par un cylindre de plasma inhomogène
Rapport Euratom n° 619 f (MF) - Reprint

FEIX M.

Excitation level of plasma oscillations
Rapport Euratom n° 762 e (MF) - Reprint

FIDONE I.
LAFLEUR Ch.
LAFLEUR S.

Mouvement stochastique d'une particule chargée dans un plasma
Rapport Euratom n° EUR 1602 f (MF)

FUSCHINI E.
GADJOKOV V.
MARONI C.
VERONESI P.

Time-reversal invariance in strong interactions IIβ $-\psi_1-\psi_2$ angular correlation in 106 Rh
Rapport Euratom n° EUR 948 e (MF) - Reprint

FUSCHINI E.
GADJOKOV V.
MARONI C.
VERONESI P.

Time-inversal invariance in strong interactions I β-$\gamma_1-\gamma_2$ angular correlation in 47 Ca
Rapport Euratom n° EUR 1931 e (MF) - Reprint

GADIOLO E.
MARCAZZAN G.M.
PAPPALARDO G.

Analysis of fluctuations on Al^{27} (d, a) Mg^{25} and Al^{27} (d, p) Al^{28} reactions
Rapport Euratom n° EUR 1942 e (MF) - Reprint

v. GIERKE G.
MÜLLER G.
PETER G.
RABBEN H.H.

On the influence of ion sheaths upon the resonance behaviour of a R.F. plasma probe
Rapport Euratom n° EUR 1990e (MF) - Reprint

HERRMANN W.

Über die Instabilität eines Elektronenstrahl-Plasmas (Erste Messungen an einem Strahl-Plasma)
Rapport Euratom n° EUR 674 d (MF)

HUBERT P.

Colloque international sur les configurations à miroirs magnétiques
Rapport Euratom n° EUR 1978 f (MF) - Reprint

HUBERT P.

Injection de particules chargées dans une bouteille magnétique statique ayant la symétrie de révolution
Rapport Euratom n° EUR 1979 f (MF) - Reprint

KALECK A.

Über den Bewegungsvorgang in einem linearen Plasmabeschleuniger
Rapport Euratom n° EUR 1968 d (MF)

KUNZE H.J.
FÜNFER E.
KRONAST B.
KEGEL W.H.

Measurement of the spectral distribution of light scattered by aθ - pinch plasma
Rapport Euratom n° EUR 1944 e (MF) - Reprint

LAVAL G.
PELLAT R.

Mouvement d'une spire de plasma dans une configuration magnétique à point de champ nul
Rapport Euratom n° EUR 1941 f (MF) - Reprint

LAVAL G.
PELLAT R.

Equations d'évolution de la fonction de distribution à une particule d'un plasma stable ou faiblement instable
Rapport Euratom n° EUR 1974 f (MF) - Reprint

MAHN C.
RINGLER H.
WIENECKE R.
WITKOWSKI S.
ZANKL G.

Experimente zur Erhöhung der Lichtbogentemperatur durch Reduktion der Wärmeleitfähigkeit in einem Magnetfeld
Rapport Euratom n° EUR 664 d (MF) - Reprint

MERCIER C.
TASSO H.

Influence de la forme de l'axe magnétique sur les plages de stabilité et leur variation
Rapport Euratom n° EUR 1603 f (MF)

MERCIER C.

Les effets toroïdaux sur l'équilibre et la stabilité magnéto-hydrodynamiques
Rapport Euratom n° EUR 1955 f (MF)

MERCIER C.

Les instabilités des plasmas
Rapport Euratom n° EUR 1956 f (MF)

MILONE C.

Energy spectra of photoneutrons from Al and neutron emission processes
Rapport Euratom n° EUR 891 e (MF) - Reprint

MINARDI E.

Microstability conditions for a plasma in a box
Rapport Euratom n° EUR 1969 e (MF)

MINARDI E.
Energy principle for electrostatic stability of a plasma
Rapport Euratom n° EUR 1977 e (MF)

SCHRADER W.J.
The influence of the relativistic increase of mass on particle energy gain and trapping near cyclotron resonance
Rapport Euratom n° EUR 628 e (MF)

TOSCHI R.
Convertitori magnetoplasmadinamici
Rapport Euratom n° EUR 1971 i (MF) - Reprint

TROCHERIS M.
Microinstabilités et phénomènes de transports anormaux dans les plasmas
Rapport Euratom n° EUR 1939 f (MF)

WIENECKE R.
Reaktionswärmeleitfähigkeit von Wasserstoff und einfach ionisiertem Helium in einer zylindersymmetrischen Entladung mit überlagertem axialem Magnetfeld
Rapport Euratom n° EUR 1950 d (MF) - Reprint

WIMMEL H.K.
Theory of the plasma resonance probe
Rapport Euratom n° EUR 1989 e (MF) - Reprint

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Participation des associations Euratom à la sixième conférence internationale sur les phénomènes d'ionisation dans les gaz (Paris, 1963)
Rapport Euratom n° EUR 1954 e, f (MF)-Reprint

11. REACTOR TECHNOLOGY

a) Printed reports

ACKERS J.G.
BUSTRAAN M.
COEHOORN J.
HEYBOER R.J.
LUIDINGA F.
MUYSKEN M.
NIJS W.W.
TAS A.
ZIJP W.L.
The critical facility KRITO
Rapport Euratom n° EUR 498 e

ALFILLE L.
VALENTIN G.
Essais exploratoires pour l'utilisation de gaines très minces pour crayon de combustible (gaines en acier inoxydable en sollicitation triaxiale)
Rapport Euratom n° EUR 1608 f

AMYOT L.
The fast neutron multiplication factor
Rapport Euratom n° EUR 1618 e

ARDENT V.
ROSSI G.
Fondamenti della teoria delle spettro dei neutroni termici in un reattore nucleare
Rapport Euratom EUR 2108 i

BARBASTE P.

Etude du contrôle de la puissance d'un réacteur par le débit du réfrigérant avec températures d'entrée et de sortie constantes
Rapport Euratom EUR 1652 f - Reprint

BLÄSSER G.
DIANA E.

On the parametric representation of fast reactor spectra
Rapport Euratom EUR 446 e - Reprint

BLÄSSER G.
MISENTA R.
RAIEVSKI V.

The kinetic theory of a fast reactor periodically pulsed by reactivity variations
Rapport Euratom n° EUR 493 e

BOSTRAAN M.
TAS A.

The subcritical facility puk
Rapport Euratom n° EUR 499 e - Reprint

BUSSAC J.
KANIA A.
MEYER-HEINE A.
VENDRYES G.
ZALESKI C.P.

Utilisation du plutonium dans les réacteurs à neutrons thermiques et dans les réacteurs à neutrons rapides
Rapport Euratom n° EUR 1841 f

BUSINARO U.L.
POZZI G.P.

A new approach on engineering hot channel and hot spot statistical analysis
Rapport Euratom n° EUR 1302 e

CASINI G.
KIND A.
ROSSI G.

Critical analysis of the progressive substitution method for material buckling measurements
Rapport Euratom n° EUR 789 e - Reprint

CANALI U.
ILSEMANN H.
PONTI C.
PREUSCH H.

Mac-Rad - A reactor shielding code
Rapport Euratom n° EUR 2152 e

CASINI G.
KIND A.
ROSSI G.

Spectrum effects on long term reactivity calculations for D_2O moderated-organic cooled reactors
Rapport Euratom n° EUR 1620 e

CLAUZON P.
KANIA A.
POMIE P.

Contribution à l'étude du cycle U^{233} -Th^{232} dans les réacteurs rapides
Rapport Euratom n° EUR 1885 f

GEIST J.J.

Capsule assembly vibration experiment in the high flux reactor (HFR)
Rapport Euratom n° EUR 1638 e

GELEE Y.
HOULLIER A.

Boucle en pile SR 1
Rapport Euratom n° EUR 1649 f

GODELLE M.

Arrêt d'un réacteur à eau lourde par variation brusque de réactivité
Rapport Euratom n° EUR 548 f

FORTE M.

The magnetic mirror neutron polarizer at the reactor ISPRA I
Rapport Euratom n° EUR 538 e

HENRY M.T.

Quelques caractéristiques de piles à neutrons rapides et piles assimilées
Rapport Euratom n° EUR 549 f

MARTIN R.	La manutention du combustible Rapport Euratom n° EUR 1179 f - Reprint
MASSIMO L.	Effects of a lower temperature on the nuclear properties of a Dragon type power reactor Rapport Euratom n° EUR 1899 e
MATTHES V.	The concept of « Neutron Importance » in reactor physics Rapport Euratom n° EUR 1897 e
MONTAGNANI M. WELTEVREDEN P.S.	Research on wear in reactor core materials Rapport Euratom n° EUR 1816 e
NIJSING R.	Diffusional and kinetic phenomena associated with fouling - considerations on the effect of hydrodynamic and thermal conditions Rapport Euratom n° EUR 543 e
RAIEVSKI V.	Reactor physics program at Euratom CCR Ispra Establishment Rapport Euratom n° EUR 592 e
SMIDT D.	Parameterstudien an gasgekühlten schnellen Reaktoren Rapport Euratom n° EUR 770 d - Reprint
SOLA A. SCOTT R. Jr. MC CARDELL R.K. FEINAUER E.	Reactor kinetic behavior and motion picture documentation of the destructive test Rapport Euratom n° EUR 497 e
STORRER F. STIEVENART M.	Contribution to the theory of the pulsed neutrons technique applied to fast multiplying systems Rapport Euratom n° EUR 593 e
STURM B.	Calculation of D_2O moderated lattices by basic methods Rapport Euratom n° EUR 597 e
VALETTE L.J.	Carbon transport Rapport Euratom n° EUR 516 e - Reprint
VAUTREY L.	Les métaux liquides et les piles rapides. Les installations thermiques de RAPSODIE Rapport Euratom n° EUR 1852 f - Reprint
WENT J.J. KERSTEN J.A.H. HERMANS M.E.A. WOLF H. VAN ZOLINGEN J.J. WIJKER H.	The aqueous homogeneous suspension reactor project Euratom-RCN-KEMA Rapport Euratom n° EUR 1611 e
WUNDT H.	Die Selbstregelfähigkeit von Leistungsreaktoren Rapport Euratom n° EUR 519 d - Reprint
WUSTNER R.	RAPSODIE, réacteur expérimental à neutrons rapides Rapport Euratom n° EUR 1699 f - Reprint

XXX — RAPSODIE : Point des études neutroniques, hydrauliques, thermiques et dynamiques et des études de stabilité au début de l'année 1963.
Rapport Euratom n° EUR 1807 f

XXX — Euratom's scientific activities - Orgel program (Vol. I, II, III)
Rapport Euratom n° EUR 1830 e

b) **Microfilmed reports**

DEGAIN R. — Les fluides organiques en tant que modérateurs et refroidisseurs dans l'industrie nucléaire
Rapport Euratom n° EUR 1133 f (MF) - Reprint

FRANZETTI F.
HOULLIER A. — Boucle de radiolyse pour l'étude des terphényles
Rapport Euratom n° EUR 1907 f (MF) - Reprint

LENY J.C. — Euratom's high hopes for the Orgel reactor
Rapport Euratom n° EUR 1859 e (MF) - Reprint

SELLERIO A.
GRECO G.
OLIVIERI E.
SINAGRA E.
SPITALE M.C. — Descrizione e funzionamento dell'oscillatore per il reattore AGN 201 dell'università di Palermo
Rapport Euratom n° EUR 1924 i (MF) - Reprint

VALLAURI M. — Neue Entwicklungen der Druckwasserreaktoren für Schiffsantriebe
Rapport Euratom n° EUR 1996 d (MF) - Reprint

12. RADIOACTIVE WASTE PROCESSING AND STORAGE

a) **Printed reports**

DEJONGHE P.
LOPES CARDOZO R. — Decontamination of synthetic effluent by flotation
Rapport Euratom n° EUR 502 e - Reprint

13. LAW, ECONOMY AND INDUSTRY

a) **Printed reports**

DAMBRINE C.
ROZENHOLC M. — L'industrie française et les réacteurs rapides
Rapport Euratom n° EUR 768 f - Reprint

ILLIES K.
LEGRAND J. — Die Bau- und Betriebskosten einer Kernenergie-Antriebsanlage für Handelsschiffe im Vergleich zu denen herkömmlicher Handelsschiffe unter Voraussetzung gleicher Benutzung mit dem Ziel gleicher Wirtschaftlichkeit
Rapport Euratom n° EUR 586 d

MICHAELIS H.

Situation et perspectives de l'énergie nucléaire dans la Communauté européenne de l'énergie atomique

Situation and trends of nuclear energy in the European atomic energy Community
Rapport Euratom n° EUR 1887 f e

XXX

Etude comparative des polices d'assurance en usage dans les Etats membres de la Communauté européenne de l'énergie atomique et couvrant la responsabilité civile afférente aux installations nucléaires

Vergleichende Untersuchungen der in den Mitgliedstaaten der Europäischen Atomgemeinschaft bestehenden Versicherungspolicen für die Deckung des Haftpflichtrisikos aus Atomanlagen
Rapport Euratom n° EUR 598 f d

XXX

Verzekeringsvraagstukken betrekking hebbend op het vervoer van bestraalde en onbestraalde splijtstoffen over zee

Certaines questions d'assurance portant sur le transport par mer de combustibles nucléaires irradiés et non irradiés
Rapport Euratom n° EUR 1639 f

b) **Microfilmed reports**

REGGIO G.

Analyzation of nuclearship competitiveness on the basis of the recent economic studies
Rapport Euratom n° EUR 1995 e (MF) - Reprint

14. DOCUMENTATION

a) **Printed reports**

BERNSTEIN H.H.
PETRI H.

Ein mechanisches Verfahren zur Herstellung selektiver Listen mit Hilfe der Lochstreifentechnik
Rapport Euratom n° EUR 1686 d - Reprint

BERNARD-GEORGES A.
LAURENT G.
LEVENBACH D.

Analyse morphologique du verbe allemand
Rapport Euratom n° EUR 539 f

BREE R.

Regional cooperation in the field of scientific and technical information within the European Community
Rapport Euratom n° EUR 494 e

BOEHM E.

Le fichier des périodiques de résumés utilisé par le Centre d'information et de documentation (CID) de la Commission d'Euratom
Rapport Euratom n° EUR 529 f

BUNTROCK H.

Zur Kompilation von Thesauri
Rapport Euratom n° EUR 558 d - Reprint

XXX — Etudes de documentation automatique
Tome I : Analyse et comparaison des langages documentaires
Rapport Euratom n° EUR 409 f

XXX — Euratom-Thesaurus - Keywords used within Euratom's nuclear energy documentation project (first edition)
Rapport Euratom n° EUR 500 e

b) **Microfilmed reports**

LECERF Y.
LEROY A. — Autoamorçage d'un ensemble d'analyse automatique utilisant un diagramme général comme organe de contrôle sémantique
Rapport Euratom n° EUR 1988 f (MF)

LYNCH I.
HIRSCHBERG L. — Discussions on the theory of projectivity (Parts I and II)
Discussions sur l'hypothèse de projectivité (Parties I et II)
Rapport Euratom n° EUR 335 e, f (MF)

ROLLING L. — Euratom's plans and realizations in the field of information retrieval
Rapport Euratom n° EUR 508 e (MF)

15. GENERAL

a) **Printed reports**

DE STORDEUR A. — The European Community activities in the fast reactor field
Rapport Euratom n° EUR 1630 e

HAUNSCHILD H.H. — Euratom-Forschung: ein Überblick ein Jahr nach Festsetzung des 2. Fünfjahresprogramms
Rapport Euratom n° EUR 1691 d - Reprint

KRUYS P.
MORIN R.
BERGE PH.
SEBILLE J.
FERNET P. — Research carried out under the Euratom/United States Agreement
Rapport Euratom n° EUR 1840 e

ULKEN D. — Probleme des Kernenergie-Schiffsantriebes
Rapport Euratom n° EUR 1872 d - Reprint

WOISIN G. — Über die Größe der Torsionsmomente im Seegang
Rapport Euratom n° EUR 504 d - Reprint

XXX — Centrale elettronucleare del Garigliano - Relazione annuale 1963
Rapport Euratom n° EUR 1803 i

XXX — Centrale électronucléaire de Chooz - Rapport annuel 1963
Rapport Euratom n° EUR 1804 f

XXX — Centrale elettronucleare di Latina - Relazione annuale 1963
Rapport Euratom n° EUR 1810 i

XXX — Euratom participation in five nuclear power stations in the European Community
Rapport Euratom n° EUR 420 e

XXX — Euratom : Scientific and technical activities. Activités scientifiques et techniques
Rapport Euratom n° EUR 1850 e, f

XXX — Euratom's scientific activities at the Joint Nuclear Research Centre's Ispra Establishment
Rapport Euratom n° EUR 1643 e

XXX — Kernenergiecentrale naamloze vennootschap samenwerkende electriciteits-productiebedrijven (N.V. SEP) Jaarverslag 1963
Rapport Euratom n° EUR 1811 n

XXX — Kernkraftzentrale Gundremmingen (KRB) - Jahresbericht 1963
Rapport Euratom n° EUR 1802 d

XXX — List of Euratom scientific and technical reports up to December 31, 1963 (numerical index and price list)
Rapport Euratom n° EUR 225 e

XXX — Unionlist of non-« United States Atomic Energy Commission » - Project reports (NP-reports) available in Europe
Rapport Euratom n° EUR 1892 e

b) **Microfilmed reports**

BUZZATI-TRAVERSO A.A. — La pianificazione della ricerca scientifica
Rapport Euratom n° EUR 1959 i (MF) - Reprint

DOCUMENT No. 34 **PATENT APPLICATIONS**

PATENT APPLICATIONS FILED BY THE COMMISSION AND ITS CONTRACTORS TO SAFEGUARD INVENTIONS DEVELOPED UNDER THE EURATOM RESEARCH PROGRAMMES

(from 1 January to 31 December 1964)

File No.	Title of Patent	Inventor	Holder	Origin
I/229	Perfectionnements à la fermeture des extrémités de crayons d'éléments combustibles nucléaires à gaine d'épaisseur très faible	Alfillé (EUR) Bocquet (SEIV) (1) Chaignon (SEIV) Pramaggiore (SEIV) Valentin (SEIV)	Euratom	Orgel
I/269	Inrichting voor het met elektronen bombarderen van een voorwerp	Groeseneken (CEN) Henuset (CEN) Meulemans (CEN)	CEN	CEN 023 ORGB
I/275	Dispositif électromécanique générateur de trains d'impulsions modulés en fréquences	Bredael (EUR) Sciuto (EUR)	Euratom	Ispra (DRAGON Project)
I/293	Durchführung für schmierbedürftige Elemente in abgeschlossene druck- und temperaturmäßig hoch beanspruchte Räume oder Behälter	Schupp (EUR)	Euratom	Ispra
I/299	Dispositif étanche télécommandé de transfert magnétique	Basso-Bert (St-Gobain) Removille (EUR)	Euratom	St-Gobain 019 PETF
I/318	Verfahren und Vorrichtung zur Wärmeisolierung von Reaktorkanälen	Ohlmer (EUR)	Euratom	Ispra

(1) SEIV — Société d'Études Industrielles de Villejuif

File No.	Title of Patent	Inventor	Holder	Origin
I/319	Cellule de mémoire analogique pneumatique	Genet (EUR) Neisse (EUR)	Euratom	Ispra
I/325	Mécanisme de transformation d'un mouvement de rotation continue en un mouvement de rotation alternative	Van Saene (EUR)	Euratom	BCMN Geel
I/326	Umhüllung von zu bestrahlenden Probekörpern	Bodnarescu (EUR)	Euratom	CEN Mol GEX BR2
I/328	Procédé et installation pour le chargement et le déchargement d'un réacteur nucléaire	Charles (EUR) Guiducci (EUR)	Euratom	Orgel
I/330	Appareil de métallisation sous vide, particulièrement pour la métallisation de corps de forme allongée, notamment cylindriques ou parallélipipédiques	Ceresoli (EUR)	Euratom	Ispra
I/331	Générateur d'impulsions pneumatiques à auto-entretien	Genet (EUR) Neisse (EUR)	Euratom	Ispra
I/332	Reactivity Pulsing Device for Nuclear Reactors	Raievski (EUR)	Euratom	Ispra
I/335	Procédé pour le formage de gorges profondes sur des pièces en matériaux conducteurs, particulièrement tubes métalliques ou en matériaux céramique-métal, à l'aide d'un appareil de formage magnétique, et dispositif pour la mise en œuvre de ce procédé	Marchal (CEN) Veaux (EUR)	Euratom	Ispra
I/336	Pulsierungseinrichtung für eine als schneller Reaktor ausgebildete gepulste Neutronenquelle	Kistner (EUR) Meister (EUR)	Euratom	Ispra
I/339	Reactivity Pulsing Device for Pulsed Fast Reactors	Riccobono (EUR)	Euratom	Ispra
I/345	Verfahren zur Eliminierung von Ionen und Radioaktivitäten aus Wasser und anderen Flüssigkeiten durch Verwendung von Kunststoff und anderen Dielektrikagemischen	Schumacher (EUR)	Euratom	Euratom

File No.	Title of Patent	Inventor	Holder	Origin
I/350	Crayon de combustible à joint thermique perfectionné pour réacteurs nucléaires	Biondi (Montecatini) Gualandi (ISML) Klersy (EUR) Detiffe (EUR)	Euratom	Montecatini 118 ORGI
I/360	Instrument pour la détermination de la valeur du coefficient angulaire en un point d'une courbe (see I/635 - add. patent)	Terzaghi (EUR)	Euratom	Euratom
I/369	Dispositif étanche pour la réalisation d'un mouvement de balayage circulaire	Van Saene (EUR)	Euratom	BCMN Geel
I/375	Verfahren zur Wiederaufbereitung von Kernreaktorbrennstoffen (see add. patent I/497)	Wurm (EUR)	Euratom	Ispra
I/388	Verfahren zur Herstellung trägerfreier jodmarkierter Verbindungen	Schön (TH) Baumgärtner (TH)	Euratom	TH Munich 031 RISD
I/389	Détecteur de particules liquides entraînées par un gaz en circulation	Delisle (CEA) Lions (CEA)	CEA	CEA 006 RAAF
I/390	Lichtleiterkörper	Strub (EUR)	Euratom	Ispra
I/391	Composé céramique de creuset à base de BeO et de La203 pour la fusion des métaux et alliages fissiles et procédé de préparation de ce composé	Wurm (EUR) Lanaspeze (Battelle) Auriol (Battelle)	Euratom	Ispra (Battelle Geneva) 007 ISPS)
I/393	Verfahren zur Fortleitung gesundheitsschädlicher flüchtiger Stoffe in höhere Luftschichten, und Vorrichtung zur Durchführung des Verfahrens	Ritter (EUR)	Euratom	Ispra
I/394	Procedimento per ottenere un rivestimento metallico su leghe di zirconio	Volta (EUR) Sesini (CISE) Di Pietro (CISE)	Euratom	Ispra (CISE)
I/395	Appareillage pour la purification d'une atmosphère inerte enfermée	Portal (EUR)	Euratom	Ispra

File No.	Title of Patent	Inventor	Holder	Origin
I/396	Apparatur zur Durchführung spektralphotometrischer Titrationen	Brück (EUR) Le Duigou (EUR)	Euratom	Ispra
I/397	Improvements in or Relating to Nuclear Fuel Materials — Hollow Fuel Particles	Jaques (UKAEA) Sturge (UKAEA)	UKAEA	DRAGON Project
I/398	Ureum Precipitatie	Hermans (KEMA) Van der Plas (KEMA)	RCN	KEMA (RCN) 001 SUAN
I/400	Improvements in or Relating to the Pyrolytic Deposition of Carbon	Bickerdike (RAE) Hughes (RAE)	Royal Aircraft Est.	DRAGON Project
I/402	Selbsttätige Kupplungs- und Entkupplungseinrichtung	Riemenschneider (EUR)	Euratom	CEN Mol GEX BR2
I/404	Gerät zum kontinuierlichen Messen des Flüssigkeitsstands elektrisch leitfähiger Flüssigkeiten	Cuyvers (CEN) Soenen (CEN)	Euratom	CEN Mol GEX BR2
I/405	Zusammengesetzter Wärmeaustauscher sowie mit einem solchen Wärmeaustauscher ausgerüstete Reaktoranlage (add. patent to I/261)	Bonsel (RCN) Van Haarst (RCN) Weevers (RCN)	RCN	RCN 007 PNIN
I/406	Perfectionnement aux crayons de combustible à gaine mince souple pour réacteurs nucléaires	Alfillé (EUR) Charrault (EUR) Lafontaine (EUR)	Euratom	ORGEL
I/407	Ringmanschette zur mechanischen Verbindung achsial flüchtender Rohr der Stangenstücke	Fiebelmann (EUR)	Euratom	Ispra
I/408	Machine outil pour effectuer le tronçonnage d'un assemblage de tubes coaxiaux, particulièrement de canaux d'un réacteur nucléaire à tubes de force	Di Piazza (EUR) Leroy (EUR) Monzani (EUR)	Euratom	Ispra
I/409	Elektronische Schaltung zum ziffernmäßigen Vergleich zweier Binärzahlen (see add. patent I/455)	Becker (EUR)	Euratom	Ispra

File No.	Title of Patent	Inventor	Holder	Origin
I/410	Erzeugung von rechteckigen Einzelimpulsen durch Entladen einer Leitung	Kobus (EUR)	Euratom	Ispra
I/411	Dispositif de manutention et de transport de matériaux radioactifs	Baudiffier (EUR) Bazzoni (EUR) Cauwe (EUR) Lecoq (EUR)	Euratom	Ispra
I/413	Verfahren zur Oberflächenbehandlung von Metallen zum Zwecke der späteren Aufbringung von Überzügen	Brossa (EUR) Ferrari (EUR) Schleicher (EUR)	Euratom	Ispra
I/417	Niveaumessgerät für hochtemperierte flüssige Medien, insbesondere Flüssigmetalle (add. patent to I/218)	Schelten-Peterssen (EUR) Schulze (EUR)	Euratom	Ispra
I/418	Crayon de combustible tubulaire à gaine mince souple pour réacteurs nucléaires	Alfillé (EUR) Charrault (EUR) Lafontaine (EUR)	Euratom	ORGEL
I/419	Verfahren und Anordnung zur Erzeugung kurzer Neutronenimpulse hoher Flächenstromdichte	Hora (IfP) Kronast (IfP)	Inst. f. Plasmaphysik	Inst. f. Plasmaphysik 003 FUAD
I/420	Élément combustible pour réacteur nucléaire et procédé de fabrication dudit élément (see add. patent I/424)		CEA	CEA 006 RAAF
I/421	Détecteur de vibrations	Loupere (Veritas)	CEA	006 RAAF
I/422	Appareil pour l'ouverture de tubes	Menissier (SICN)	CEA	006 RAAF
I/423	Procédé de mesure continue de la température de saturation en oxyde d'un métal liquide et dispositif pour la mise en œuvre de ce procédé	Delisle (CEA)	CEA	006 RAAF
I/424	Élément combustible pour réacteur nucléaire et procédé de fabrication dudit élément (add. patent to I/420)	Mercier (CEA)	CEA	006 RAAF
I/425	Procédé d'identification de pièces mécaniques et dispositif pour la mise en œuvre de ce procédé	Rideau (CEA)	CEA	006 RAAF

File No.	Title of Patent	Inventor	Holder	Origin
I/426	Pince de télémanipulateur	Mas (CEA) Escavis (CEA)	CEA	CEA 006 RAAF
I/427	Pince mécanique de manipulation	Mas (CEA) Escavis (CEA)	CEA	CEA 006 RAAF
I/428	Mécanisme basculeur automatique, notamment pour objets radioactifs	Mas (CEA) Escavis (CEA) Gerard (CEA)	CEA	CEA 006 RAAF
I/429	Banc de démontage pour éléments combustibles de réacteur nucléaire	Escavis (CEA) Mas (CEA)	CEA	006 RAAF
I/430	Porte étanche	Escavis (CEA) Mas (CEA)	CEA	006 RAAF
I/431	Dispositif de raccordement électrique à embrochage automatique	Loriot (CEA) Mas (CEA)	CEA	006 RAAF
I/434	Dispositif de commande automatique pour appareil photographique (add. patent to I/163)	Mahe (CEA)	Euratom	CEA 001 FUAF
I/435	Verfahren und Vorrichtung zum Schmelzen von Urandioxyd	Hoppe (NUKEM) Müller(NUKEM) In der Schmitten (NUKEM)	Euratom	Nukem 013 TEED
I/436	Procédé pour la préparation de dioxydes à partir de fluorure d'éléments radioactifs	Billiau (CEN) Lamotte (TLH) Schlechter (EUR) Schmets (CEN) Speeckaert (CEN) Zamorani (EUR)	CEN and Belgo-nucléaire	CEN 098 RDB
I/437	Werkwijze ter bereiding van een minerale ionenwisselaar en minerale ionenwisselaar bereid volgens deze werkwijze	Huys (CEN) Baetsle (CEN)	CEN	CEN 028 RISB
I/438	Process for the Analysis of Isotopes and the Apparatus for this Purpose	Lugnair (Ö.St.A) Rüdenauer (Ö.St.A.) Viedler (Ö.St.A) Viehböck (Ö.St.A)	Österr. Studienges. f. Atomenergie	DRAGON Project
I/439	Vorrichtung zum Schmelzen von Metallen und Verbindungen mit hohem Schmelzpunkt	Himmelstein Kühn Wille (NUKEM)	Nukem	Nukem 088 RDD

File No.	Title of Patent	Inventor	Holder	Origin
I/440	Improvements in or Relating to Fuel Bearing Components for Nuclear Reactors-Making Fuelled Tubes with Inner Unfuelled Layer	Redding (UKAEA)	UKAEA	DRAGON Project
I/441	Kernreaktorbrennelement	Heiers (EUR) Leipold (EUR)	Euratom	Petten
I/442	Splijtstofelement voorzien van verdwijnend gif	Coehoorn (RCN) Bogaardt (RCN)	RCN	RCN 007 PNIN
I/445	Vorrichtung zur Erzeugung eines Ionen enthaltenden Gasstromes	Platzek (TNO)	Euratom	TNO 002 IRAN
I/446	Perfectionnement aux réacteurs nucléaires (add. patent to I/264)	Foure(SNECMA) Moussez (SNECMA)	SNECMA	SNECMA 058 RDF
I/447	Inrichting voor het filtreren, classeren of agiteren van een uit minstens twee fasen van verschillend s.g. bestaand vloeibaar mengsel	Spruyt (RCN) Matteman (RCN) Bottinga (RCN)	RCN	KEMA (RCN) 001 SUAN 002 NTAN
I/448	Optisches Gerät zu Kontrolle der Symmetrie und der Obenflächenbeschaffenheit des Inneren von Rohren	Krischer (EUR)	Euratom	Ispra
I/449	Vakuumdichte und druckfeste Hochspannungsdurchführung	Junger (EUR) Cordani (EUR) Spelta (EUR)	Euratom	Ispra
I/452	Verfahren zur Optimierung der Wärmeleitung und Wärmeübertragung bei hohen Temperaturen	Merz (EUR)	Euratom	Petten
I/454	Gasdurchströmtes, im Proportionalbereich arbeitendes $4\pi\beta$-Zählrohr zur Radioaktivitätsmessung	Adam (EUR) Bertolini (EUR) Fantechi (EUR)	Euratom	Ispra
I/455	Elektronische Schaltung zum ziffernmässigen Vergleich zweier Binärzahlen (add. patent to I/409)	Becker (EUR)	Euratom	Ispra

File No.	Title of Patent	Inventor	Holder	Origin
I/456	Elektrische Schaltung zur Füllstandsüberwachung, zur Feststellung des Siedens und zur Verwendung bei Benetzungsuntersuchungen in Metallbehältern mit Flüssigmetall	Spiller (EUR) Perschke (EUR)	Euratom	Ispra
I/458	Prüfapparatur zum Messen der Empfindlichkeitsverteilung von Sekundäremissionsvervielfachern in Abhängigkeit vom Ort auf der Kathode	Strub (EUR)	Euratom	Ispra
I/459	Capteur pneumatique pour mesures de niveau ou de pression dans les liquides	Genet (EUR) Milliot (EUR)	Euratom	Ispra
I/462	Widerstandsmatrix zur Dekodierung binärer Kodes	Becker (EUR)	Euratom	Ispra
I/463	A Process for Welding Composite Metal-Oxide Materials such as Sintered Aluminium Powder (S.A.P.)	Beghi (EUR) Musso (EUR)	Euratom	Ispra
I/469	Hochvakuum-Hochdruck-Ventil	Munten (EUR) Bruch (EUR) Sebastian (I.f.P.) (EUR)	Inst. f. Plasmaphysik	Inst. f. Plasmaphysik 003 FUAD
I/471	Aus Glasfasern aufgebauter Lichtleiter mit mindestens einem spaltförmigen Ende	Glock (I.f.P.) Chiapetti (I.f.P.)	Inst. f. Plasmaphysik	Inst. f. Plasmaphysik 003 FUAD
I/472	Linearer Strömungswiderstand für Strömungsmessgeräte	Ahlborn (I.f.P.) Salvat (I.f.P.)	Inst. f. Plasmaphysik	003 FUAD
I/473	Anordnung zum Herstellen zweidimensionaler Bilder eines Infrarotstrahlers	Hora (I.f.P.)	Inst. f. Plasmaphysik	003 FUAD
I/474	Verfahren zur Korrektur eines optischen Systems	Hora (I.f.P.)	Inst. f. Plasmaphysik	003 FUAD
I/475	Elektrische Einrichtung mit einer Wicklung aus hohlen, von einem Kühlmittel durchströmten Leitern	Oswald (I.f.P.)	Inst. f. Plasmaphysik	003 FUAD
I/476	Verfahren und Einrichtung zur Darstellung einer sich schnell ändernden Energieverteilung	Steinhausen (I.f.P.)	Inst. f. Plasmaphysik	003 FUAD

File No.	Title of Patent	Inventor	Holder	Origin
I/477	Mit elektrischen Feldern arbeitendes Massenspektrometer	Blauth (I.f.P.) Melzner (I.f.P.) Meyer (I.f.P.)	Inst. f. Plasmaphysik/ Max-Planck Gesellschaft	003 FUAD
I/478	Flugzeit-Massenspektrometer	Blauth (I.f.P.) Melzner (I.f.P.) Meyer (I.f.P.)	Inst. f. Plasmaphysik/ Max-Planck Gesellschaft	003 FUAD
I/479	Massenspektrometer	Blauth (I.f.P.) Melzner (I.f.P.) Meyer (I.f.P.)	Inst. f. Plasmaphysik/ Max-Planck Gesellschaft	003 FUAD
I/480	Verfahren und Einrichtung zur Erzeugung von elektrischen Schwingungen deren Frequenz von einer Spannung und dem Verhältnis von Ladung zu Masse von Gasionen abhängt	Blauth (I.f.P.) Melzner (I.f.P.) Meyer (I.f.P.)	Inst. f. Plasmaphysik/ Max-Planck Gesellschaft	003 FUAD
I/481	Massenspektrometer	Blauth (I.f.P.) Melzner (I.f.P.) Meyer (I.f.P.) Behrisch (I.f.P.)	Inst. f. Plasmaphysik/ Max-Planck Gesellschaft	003 FUAD
I/483	Reactorinstallatie voorzien van automatische regeling	Speelman (RCN)	Inst. f. Plasmaphysik/ Max-Planck Gesellschaft	RCN 007 PNIN
I/484	Procédé pour déterminer la valeur des fuites des boîtes à gants ou des enceintes	Gandolfo (EUR)	Euratom	Euratom (Mol)
I/486	Vernicklung von Zirkonium, Uran, Aluminium, ihren Legierungen und A1-A1203 — Sinterprodukten	Airola (EUR) Brossa (EUR) Ferrari (EUR)	Euratom	Ispra
I/487	Matériau composite du type cermet, et procédé de fabrication du composite sous forme compactée	Portal (EUR)	Euratom	Ispra
I/488	Dispositif expansible pour radiographie-rotative et outil relatif de commande (add. patent to I/288)	Jansen (EUR)	Euratom	Ispra

File No.	Title of Patent	Inventor	Holder	Origin
I/489	Appareil pour la radiographie de tubes et particulièrement de tubes à ailettes pour applications nucléaires	Jansen (EUR) Mandrier (EUR)	Euratom	Ispra
I/490	Procedimento per ottenere uno strato superficiale di miscela ossidocarburo su zirconio o lega di zirconio	Camona (CISE) Volta (EUR)	Euratom	Ispra (CISE)
I/491	Dispositif pour mesurer le niveau d'un liquide transparent	Bonnaure (EUR) Bredael (EUR) Sciuto (EUR)	Euratom	Ispra
I/492	Hybrid Control Device for Analog Computers	Van Wauwe (EUR) De Backer (EUR)	Euratom	Ispra
I/493	Procédé de soudage	Perona (CISE) Volta (EUR)	Euratom CISE	Ispra (CISE 180 ORGI)
I/496	Vorrichtung zum Positionieren eines Körpers	Bodnarescu (EUR)	Euratom	CEN Mol GEX BR2
I/497	Verfahren zur Wiederaufbereitung von Kernreaktorbrennstoffen (add. patent to I/375)	Avogadro (EUR) Wurm (EUR)	Euratom	Ispra
I/498	Strahlenabschirmung eines Lochs durch die Decke einer Experimentierzelle für radioaktive Präparate	Patané (EUR)	Euratom	CEN Mol GEX BR2
I/499	Kernreaktorinstallatie voorzien van een noodkoelsysteem voor de afvoer van vervalwarmte	Van den Bergh (RCN)	RCN	RCN 007 PNIN
I/500	Improved Uranium Mononitride Fuel and Method of Making	Endebrock (Battelle, Ohio)	USAEC	USAEC/ Battelle Memorial Inst., Ohio (R & D)
I/501	Soudeuse télécommandée	Babule (EUR) Sayag (EUR) Lemaire (Siers.) Mettetal (Siers.)	Siersatom	Cde Petten
I/503	Sicherheitselement für Kernreaktoren	Köhler (G.f.K.)	Ges. f. Kernforschung	Ges. f. Kernforschung 009 RAAD

File No.	Title of Patent	Inventor	Holder	Origin
I/504	Brennelement-Schleuse	Benndorf (G.f.K.) Franze (G.f.K.)	Ges. f. Kernforschung	009 RAAD
I/505	Einrichtung zum Beladen von Kernreaktoren	De Temple (G.f.K.)	Ges. f. Kernforschung	009 RAAD
I/506	Vorrichtung zum Beladen von Kernreaktoren	Benndorf (G.f.K.)	Ges. f. Kernforschung	009 RAAD
I/507	Einrichtung zum Beladen von Kernreaktoren	De Temple (G.f.K.) Benndorf (G.f.K.)	Ges. f. Kernforschung	009 RAAD
I/508	Wärmeaustauscher, insbesondere für Hochdruckreaktoren	De Temple (G.f.K.)	Ges. f. Kernforschung	009 RAAD
I/509	Abstandshalter für Brennelemente (see add. patent I/578)	Keiper (G.f.K.) Sommer (G.f.K.) De Temple (G.f.K.)	Ges. f. Kernforschung	009 RAAD
I/510	Kernreaktor	Schmidt (G.f.K.)	Ges. f. Kernforschung	009 RAAD
I/511	Schieberventil	De Temple (G.f.K.)	Ges. f. Kernforschung	009 RAAD
I/512	Improvements in or Relating to a Process for the Preparation of Spherical or Spheroidal Particles	Huddle (UKAEA) Horsley (UKAEA)	CEN	DRAGON Project
I/513	Dispositif de sécurité et de contrôle pour réacteur nucléaire	Lebey (CEA)	CEA	CEA 002 TEGF
I/514	Greifervorrichtung, insbesondere für Brennelemente	Wolter (G.f.K.)	Ges. f. Kernforschung	Ges. f. Kernforschung 009 RAAD
I/515	Kernreaktor	Schmidt (G.f.K.)	Ges. f. Kernforschung	009 RAAD
I/516	Brennelement für Kernreaktoren	Spies (G.f.K.)	Ges. f. Kernforschung	009 RAAD
I/517	Stossdämpfer für Reaktor-Sicherheitsstäbe	Marten (G.f.K.)	Ges. f. Kernforschung	009 RAAD
I/518	Haltevorrichtung für Spaltstoffelemente in Kernspaltzonen	Wolter (G.f.K.)	Ges. f. Kernforschung	009 RAAD

File No.	Title of Patent	Inventor	Holder	Origin
I/519	Verfahren zum Bestimmen der Temperaturleitfähigkeit durch Messen der Phasendifferenzen von Temperaturwellen in Werkstoffproben	Spies (G.f.K.)	Ges. f. Kernforschung	009 RAAD
I/521	Perfezionamenti ai metodi di ricerca di fughe di gas mediante l'uso di traccianti radioattivi		SORIN	SORIN 003 IRAI -GAS
I/522	Verfahren zum Schmelzen von Metallen und Verbindungen mit hohem Schmelzpunkt	Himmelstein (NUKEM) Kühn (NUKEM) Wille (NUKEM)	Euratom	Nukem 088 RDD
I/523	Zirkonium-Legierung		Metallges.	Metallges. 019 TEED/ RD
I/526	Werkwijze voor de bereiding van kernbrandstofcarbiden	Beucherie (EUR) Wurm (EUR) Payrissat (EUR)	Euratom	Ispra
I/527	Afblaastank	van den Bergh (RCN) Luyten (RCN)	RCN	RCN 007 PINN
I/528	Ondersteuningsconstructie voor een kernreaktor	Bonsel (RCN)	RCN	007 PINN
I/529	Improvements in or Relating to Fluidised Bed Apparatus	Gough (UKAEA) Kern (UKAEA) Batchelor (UKAEA)	UKAEA	DRAGON Project
I/530	Improvements in or Relating to Retarding Mechanisms	Lockett (UKAEA) Coast (UKAEA)	UKAEA	DRAGON Project
I/531	Improvements in or Relating to Fuel for Nuclear Reactors	Huddle (UKAEA) Kern (UKAEA)	UKAEA	DRAGON Project
I/532	Improvements in or Relating to Charge / Discharge Machines for Nuclear Reactors	Lockett (UKAEA) Pugh (UKAEA)	UKAEA	DRAGON Project
I/533	Process for the Preparation of Sintered A1-A1203 Material (add. patent to I/372)	Piatti (EUR) Beghi (EUR)	Euratom	Ispra

File No.	Title of Patent	Inventor	Holder	Origin
I/535	Anlage zur quantitativen Bestimmung der Konzentration von Dämpfen in einem Trägergas, insbesondere in Verbindung mit der Überwachung der Leckverluste aus einem Flüssigkeitsstrom	Verheyden (EUR) Klein (EUR)	Euratom	Ispra
I/537	Verfahren und Gerät zum Abmanteln von Thermokoaxialkabeln	Geiger (EUR)	Euratom	Ispra
I/543	Kollektoranlage	Schlüter (I.f.P.) Knoblock (I.f.P.) Andelfinger (I.f.P.) Schmitter (I.f.P.) Breit (I.f.P.) Kunze (I.f.P.)	Inst. f. Plasmaphysik	Inst. f. Plasmaphysik 003 FUAD
I/544	Kontakte für Stossstromanlagen	Knoblock (I.f.P.) Wulff (I.f.P.)	Inst. f. Plasmaphysik	003 FUAD
I/545	Improvements in or Relating to High Temperature Processes and Furnaces	Jaques (UKAEA) Kingdon (UKAEA)	UKAEA	DRAGON Project
I/546	Arrangements for Closing Penetrations in the Walls of Pressure Containing Structures	Lockett (UKAEA) Coast (UKAEA) Coudray (UKAEA) Vitry (Indatom) Torielli (SNAM)	UKAEA	DRAGON Project
I/554	Carbide Fuel Manufacture	Huddle (UKAEA) Horsley (UKAEA)	UKAEA	DRAGON Project
I/557	Base Support Grid for Nuclear Reactors	Coudray (UKAEA) Vitry (Indatom)	Indatom	DRAGON-Project
I/558	Servicing Machine for a Nuclear Reactor	Coudray (UKAEA) Neybourger (Indatom)	Indatom	DRAGON Project

File No.	Title of Patent	Inventor	Holder	Origin
I/559	Device for the Handling of Elements Inside Active Circuits of Nuclear Reactors and Particularly for the Loading and Unloading of Fuel Elements	Torielli (SNAM) Rocca (SNAM)	SNAM	DRAGON Project
I/560	Device for Temporary Closure of Pressure Vessels to Allow Removal of Equipment Contained therein	Torielli (SNAM) Rocca (SNAM)	SNAM	DRAGON Project
I/561	Device for the Rapid Exchange of Fuel Elements in Nuclear Reactors with Disencapsulation of Unirradiated Elements and Encapsulation of Irradiated Elements	Torielli (SNAM) Rocca (SNAM)	SNAM	DRAGON Project
I/562	Ausbildung einer ultrahochvakuumdicht hartzuverlötenden Oberfläche eines Keramikteiles	Berberich (I.f.P.)	Inst. f. Plasmaphysik	I.f.P. 003 FUAD
I/565	Wärmeröhre	Bohdansky (EUR) Caron (EUR) Strub (EUR)	Euratom	Ispra
I/566	Kühlsystem für Kernreaktoren	Bohdansky (EUR) Busse (EUR) Grover (EUR)	Euratom	Ispra
I/567	Thermionischer Konverter	Busse (EUR) Grover (EUR) Caron (EUR)	Euratom	Ispra
I/569	Procédé de protection du magnésium ou de ses alliages contre la corrosion dans les liquides organiques	De Beni (EUR)	Euratom	Ispra
I/570	Process for the manufacturing of Fuel Elements	Gautsch (EUR) Mustacchi (EUR) Wahl (EUR)	Euratom	Ispra
I/573	Verfahren zur Messung von hohen Temperaturen	Meier (EUR)	Euratom	CEN Mol GEX BR2
I/574	Splijtstofelement voorzien van verdwijnend neutronengif	Engel (RCN) Versteeg (RCN)	RCN	RCN 007 PNIN

File No.	Title of Patent	Inventor	Holder	Origin
I/575	Impianto nucleare a ciclo chiuso per generazione di vapore d'acqua		FIAT	FIAT 008 PNII
I/576	Haltekopf für Brennelemente	Händel (G.f.K.) Warchold (G.f.K.)	Ges. f. Kernforschung	Ges. f. Kernforschung 009 RAAD
I/577	Verschlusskopf für Brennelemente	Händel (G.f.K.)	Ges. f. Kernforschung	009 RAAD
I/578	Abstandshalter (see I/509 GF and I/642 GF)	Sommer (G.f.K.)	Ges. f. Kernforschung	009 RAAD
I/579	Verfahren zum Einstellen der Leistungsdichteverteilung in einem Kernreaktor	Köhler (G.f.K.)	Ges. f. Kernforschung	Ges. f. Kernforschung 009 RAAD
I/580	Kernreaktor	Müller (G.f.K.)	Ges. f. Kernforschung	009 RAAD
I/581	Einrichtung zum Be- und Entladen von Elementen für Kernspaltzonen	Simon (G.f.K.)	Ges. f. Kernforschung	009 RAAD
I/582	Verfahren zum Trennen von Kernbrennstoffen	Vogg (G.f.K.) Bähr (G.f.K.) Ochsenfeld (G.f.K.)	Ges. f. Kernforschung	009 RAAD
I/583	Verfahren zur Vordekontamination von aufzubereitenden Kernbrennstoffen	Vogg (G.f.K.) Bähr (G.f.K.)	Ges. f. Kernforschung	009 RAAD
I/584	Verfahren zum Aufbereiten von Kernbrennstoffen	Vogg (G.f.K.) Bähr (G.f.K.)	Ges. f. Kernforschung	009 RAAD
I/585	Kernreaktor	Ritz (G.f.K.)	Ges. f. Kernforschung	009 RAAD
I/586	Brennelement-Schleuse	Engelmann (G.f.K.) Wittek (G.f.K)	Ges. f. Kernforschung	009 RAAD
I/588	Procédé et dispositif et méthode pour mesurer de très haute température	Berthelot (G.f.K.)	Euratom	BCMN Geel
I/589	Druckbehälter	Benzler (EUR)	Euratom	Euratom

File No.	Title of Patent	Inventor	Holder	Origin
I/590	Werkwijze voor de rechtstreekse bereiding van korrels van een ammoniumhoudend uranylsulfaat van nagenoeg ronde vorm en bepaalde deeltjesgrootte	Hermans (KEMA) Kocken (KEMA)	RCN	KEMA Contract 002 SUAN KEMA/ SUAN 001 SUAN
I/591	Improvements in or relating to grinding devices	van Lierde(CEN)	Euratom	CEN 010 TEEB
I/592	Improvements in or relating to processes for the preparation of particulate material — The addition of carbon to particles produced by the sol / gel process	van der Plas (KEMA) Hermans (KEMA) Noothout (UKAEA)	UKAEA	DRAGON Project
I/593	Improvements in or relating to processes for the preparation of particulate material — Internal gelation of sol particles	van der Plas (KEMA) Hermans (KEMA) Noothout (UKAEA)	UKAEA	DRAGON Project
I/594	Perfectionnements apportés aux échangeurs d'ions et à leurs procédés de fabrication	Lefèvre (CEA) Prospert (CEA) Raggenbass (CEA)	CEA	CEA Contract 025 RISF
I/596	Dispositif et réglage de la puissance d'un réacteur nucléaire (see I/596 and I/598)	Costes (CEA) Lebey (CEA)	CEA	CEA Contract 002 TEGF
I/597	Dispositif de réglage de la puissance d'un réacteur nucléaire (see I/596 and I/598)	Costes (CEA) Lebey (CEA)	CEA	CEA Contract 002 TEGF
I/598	Dispositif de réglage de la puissance d'un réacteur nucléaire (see I/596 and I/597)	Costes (CEA) Lebey (CEA) Martin (CEA)	CEA	CEA Contract 002 TEGF
I/602	Procédé de préparation du phosphotungstate d'ammonium et produit obtenu	Hubertin (CEA) Lefèvre (CEA) Poupard (CEA) Raggenbass (CEA)	CEA	CEA Contract 025-RISF
I/605	Werkwijze voor het afscheiden van hoogkokende bestanddelen uit organische koel- en moderatorvloeistoffen	Lopes Cardozo (EUR) van Velzen (EUR)	Euratom	Ispra

File No.	Title of Patent	Inventor	Holder	Origin
I/607	Jauge pneumatique de niveau pour liquides	Elbaz (EUR) Metivier (EUR) Morbello (EUR) Neisse (EUR)	Euratom	Ispra
I/615	Methods of Forming Nuclear Fuel Bodies	Redding (UKAEA) Lamb (UKAEA)	UKAEA	DRAGON Project
I/617	Sicherungsschaltvorrichtung für Kernreaktoren		BROWN-BOVERI/ KRUPP (BBK)	BBK Contract 003 RGAD
I/618	Hohlkörperförmiges, vorzugsweise hohlkugelförmiges Brennstoffelement und Verfahren zu dessen Herstellung		BBK	Contract 003 RGAD
I/619	Sicherungsvorrichtung für Drucksysteme		BBK	Contract 003 RGAD
I/620	Anordnung zur gas- und druckdichten Drehdurchführung		BBK	Contract 003 RGAD
I/621	Hochtemperatur-Kernreaktor		BBK	Contract 003 RGAD
I/622	Anordnung zum fernbetätigten Aus- und Einbau einer Armatur		BBK	Contract 003 RGAD
I/623	Kompensationseinrichtung an Doppelrohren		BBK	Contract 003 RGAD
I/624	Verfahren zur Herstellung von aktivierten Präparaten		BBK	Contract 003 RGAD
I/625	Stopfen oder Kappen zum Verschliessen von Rohrleitungen		BBK	Contract 003 RGAD
I/626	Vorrichtung zum reinigen eines Gasstromes von CO_2		BBK	Contract 003 RGAD
I/627	Verfahren zur Herstellung von CO_2-Absorptionsfiltern aus CaO		BBK	Contract 003 RGAD
I/628	Vorrichtung zum Aussortieren von Kugeln mit beschädigter Oberfläche bzw. mit verändertem Durchmesser		BBK	Contract 003 RGAD

File No.	Title of Patent	Inventor	Holder	Origin
I/629	Anordnung zur Überdrucksicherung insbesondere für Druckgefässe		BBK	Contract 003 RGAD
I/630	Wärmeaustauscher		BBK	Contract 003 RGAD
I/631	Vorrichtung zum Dosieren einer Gasmenge		BBK	Contract 003 RGAD
I/632	Kernreaktor-Core		BBK	BBK Contract 003 RGAD
I/633	Verfahren zum Absperren einer koaxialen Rohrleitung		BBK	Contract 003 RGAD
I/634	Sicherheits bzw. Überströmventil		BBK	Contract 003 RGAD
I/635	Perfectionnements aux instruments pour la détermination de la valeur du coefficient angulaire en un point d'une courbe (add. patent to I/360)	Terzaghi (EUR)	Euratom	Euratom
I/637	Zirconium base nuclear reactor alloy	Klepter (GE)	USAEC	General Electric/ USAEC R & D
I/639	Caméra de télévision		CEA	CEA Contract 002 TEGF
I/640	Barrière thermique	Vitry (Indatom)	Indatom	Indatom 016 TEGC Indatom/ DBW
I/642	Abstandshalter für Brennelemente (add. patent to I/578 GF)	Müller (G.f.K.)	Ges. f. Kernforschung	Ges. f. Kernforschung Contract 009 RAAD
I/643	Verfahren zum Kühlen von Kernreaktoren	Franze (G.f.K.)	Ges. f. Kernforschung	Contract 009 RAAD
I/644	Verfahren und Einrichtung zum Umladen von Kernreaktoren	Müller (G.f.K.)	Ges. f. Kernforschung	Contract 009 RAAD
I/645	Dampferzeuger	Bukau (G.f.K.)	Ges. f. Kernforschung	Contract 009 RAAD

File No.	Title of Patent	Inventor	Holder	Origin
I/646	Brennelement für Kernreaktoren	Schmidt (G.f.K.)	Ges. f. Kernforschung	Contract 009 RAAD
I/647	Brennelement für Kernreaktoren (add. patent to I/357 GF)	Schmidt (G.f.K.)	Ges. f. Kernforschung	Contract 009 RAAD
I/648	Kernreaktor	Ritz (G.f.K.)	Ges. f. Kernforschung	Contract 009 RAAD
I/649	Regel- und Abschaltvorrichtung für Kernreaktoren	Mühlhäuser (G.f.K.)	Ges. f. Kernforschung	Contract 009 RAAD
I/650	Kernreaktor-Brennelement	Schmidt (G.f.K.)	Ges. f. Kernforschung	Contract 009 RAAD
I/651	Verfahren zur Vordekontamination von aufzubereitenden Kernbrennstoffen	Vogg (G.f.K.)	Ges. f. Kernforschung	Contract 009 RAAD
I/652	Einrichtung zum Be- und Entladen der Spaltzone von Kernreaktoren	De Temple (G.f.K.)	Ges. f. Kernforschung	Contract 009 RAAD
I/653	Einrichtung zum Abführen von Spaltgassen aus Kernreaktor-Brennelementen	De Temple (G.f.K.)	Ges. f. Kernforschung	Contract 009 RAAD
I/654	Verfahren und Vorrichtung zum Überwachen von Anordnungen ibs. von Sicherheitsschalteinrichtungen für Kernreaktoren	Oehmann (G.f.K.)	Ges. f. Kernforschung	Contract 009 RAAD
I/659	Process for the preparation of samples for measurements of isotopes by means of mass spectrometers	Edl (Ö.St.A.) Lugmair (Ö.St.A.), Rüdenauer (Ö.St.A.) Viehböck (Ö.St.A.)	Österr. Studiengesellsch. f. Atomenergie m.b.H.	DRAGON Project
I/660	Improvement in or Relating to nuclear reactors seed and blanket H.T.R. continually movable fuel	Acciarri (UKAEA) Lockett (UKAEA) Rennie (UKAEA)	UKAEA	DRAGON Project
I/667	Dispositif de contrôle (see I/668 Fr)	Aubert (CEA) Fortin (CEA) Gugenberger (CEA) Martin (CEA) Rouge (CEA)	CEA	CEA 002 TEGF

File No.	Title of Patent	Inventor	Holder	Origin
I/668	Dispositif de contrôle (see I/667 Fr)	Aubert (CEA) Fortin (CEA) Gugenberger (CEA) Martin (CEA) Rouge (CEA)	CEA	CEA 002 TEGF
I/669	Dispositif de supportage pour installations soumises à des vibrations (see I/670 Fr)	Andrieux (FP)	CEA (prev. FIVES-PENHOET SA)	CEA 006 RAAF
I/670	Dispositif de supportage pour installations soumises à des vibrations (see I/669 Fr)	Andrieux (FP)	CEA (prev. FIVES-PENHOET SA)	CEA 006 RAAF
I/671	Cloche d'extraction étanche, notamment pour un organe d'obturation d'un récipient renfermant un élément radio-actif	Escavis (GAAA) Gerard (GAAA) Mas (CEA)	CEA	CEA 006 RAAF
I/672	Dispositif de transmission de mouvement de rotation	Loriot (BEP) (1) Mas (CEA)	CEA	CEA 006 RAAF
I/673	Perfectionnements aux dispositifs de manutention desservant des enceintes actives	Loriot (BEP) Mas (CEA)	CEA	CEA 006 RAAF
I/674	Réacteur nucléaire	Vendryes (CEA) Zaleski (CEA)	CEA	CEA 006 RAAF
I/675	Réacteur nucléaire refroidi par circulation de métal liquide	Chalot (CEA) Gollion (CEA) Kania (CEA)	CEA	CEA 006 RAAF
I/676	Assemblage combustible pour réacteur nucléaire	Leduc (CEA) Mulot (CEA) Normand (CEA)	CEA	CEA 006 RAAF
I/677	Dispositif d'irradiation	Leduc (CEA) Marmonier (CEA)	CEA	CEA 006 RAAF
I/678	Perfectionnements aux dispositifs de positionnement à distance	Loriot (BEP) Mas (CEA)	CEA	CEA 006 RAAF
I/679	Support pour installation thermique, par exemple pour cave de réacteur nucléaire	Andrieux (FP)	CEA (prev. FIVES-PENHOET	CEA 006 RAAF

(1) BEP — Bureau d'Etudes PEETERS.

DOCUMENT No. 35 **IMPLEMENTATION OF BUDGETS**

I. Research and investment budget

The Commission had at its disposal for the financial year 1964 the following fixed appropriations:

Millions of EMA u.a.

1964 research and investment budget adopted by the Council on 18 December 1963	94.720
Budgetary commitments carried forward from previous financial years pursuant to Article 4, para. 1 b of the Financial Regulation governing the establishment and implementation of the research budget	30.564
Total:	125.284

The budgetary commitments entered in the books at 31 December 1964 amounted to 97.197 million EMA u.a., the breakdown being as follows:

Heading	Chapter	Description	Budgetary Commitments : credits available in 1964	Amount entered in books at 31.12.64
			(millions of u.a.)	
I		*Staff expenditure*	14.800	14.560
II		*Operating expenditure*	6.052	5.810
III		*Joint Nuclear Research Centre*		
	30	Apparatus and equipment	9.161	7.953
	31	Real property investments	9.859	6.736
Total under Heading III			19.020	14.689

Heading	Chapter	Description	Budgetary Commitments: credits available in 1964	Amount entered in books at 31.12.64
			(millions of u.a.)	
IV		*Reactor development and construction*		
	40	Gas reactors	9.200	9.200
	41	Light water reactors	1.607	0.805
	42	Heavy water reactors	0.056	0.056
	43	Organic reactors	14.644	11.047
	44	Homogeneous reactors	0.674	0.606
	45	Fast reactors	23.375	17.995
	47	Nuclear marine propulsion	0.978	0.964
	48	Research and applied technology relating to proven-type reactor development and construction	8.035	4.159
	49	Power reactors	0.455	0.022
Total under Heading IV			59.024	44.854
V		*Other scientific and technical activities*		
	50	High-flux irradiation	3.276	3.271
	51	Fusion — plasma studies	6.481	6.405
	52	Biology	4.033	2.423
	53	Radioisotopes	1.606	1.049
	53a	Miscellaneous research	4.881	1.380
	54	General documentation	1.187	1.146
	55	Training and instruction	0.674	0.557
	56	Reprocessing of irradiated fuels	2.850	1.009
	57	Processing of active effluents	1.400	0.044
Total under Heading V			26.388	17.284
Grand total			125.284	97.197

The payment authorizations covered by the 1964 budget amounted to 85 million u.a., while a total of 75.190 million u.a. had been paid out at 31 December 1964.

Of the payment authorizations of 15.994 million u.a. brought forward from 1963 to 1964, 15.214 million u.a. have been paid out.

II. Operating budget

For the financial year 1964, the sum of 8,606,750 u.a. was available to the Commission under the operating budget (Section III).

Expenditure commitments during the financial year totalled 7,804,640 u.a. At 31 December 1964, actual expenditure in respect of these commitments amounted to 7,223,714 u.a.

DOCUMENT No. 36

STAFF BREAKDOWN UNDER THE RESEARCH AND INVESTMENT BUDGET ACCORDING TO PAYROLL (1)
(Posts filled as at 28.2.1965)

	A	B	C	D	Establishment personnel	Total
Ispra and ORGEL	436	457	159	—	372	1,424
Transuranium Institute	37	44	27	—	19	127
CNMB	47	50	20	1	26	144
Petten	49	46	20	—	5	120
Fast reactors	38	10	3	—	—	51
Advanced gas reactors	26	1	3	—	—	30
BR2	18	19	11	—	—	48
Proven-type reactors	25	2	5	—	—	32
Irradiated fuel reprocessing	3	—	—	—	—	3
Waste	1	—	1	—	—	2
New type reactors	2	1	—	—	—	3
Marine propulsion	5	—	—	—	—	5
Radioisotopes	5	—	4	—	—	9
Fusion	59	20	11	—	2	92
Health and safety	7	3	—	—	—	10
Biology	46	7	6	—	3	62
Training	1	1	3	—	—	5
General administration of research and of programmes	7	—	2	—	—	9
Dissemination of information	26	21	41	4	—	92
Total	838	682	316	5	427	2,268

(1) The discrepancies between the figures fiven 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 UNDER RESEARCH AND INVESTMENT BUDGET (as at 28 February 1965)

I. In the Community

		Number of personnel
1.	*Belgium*	
	Brussels	186
	CNMB Establishment, Geel	119
	Ghent	1
	Liège	2
	Mol	60
	Total:	368
2.	*Germany*	
	Transuranium Institute, Karlsruhe	108
	Bonn	1
	Frankfurt	1
	Freiburg	2
	Hamburg	1
	Jülich	4
	Mannheim	3
	Munich	14
	Total:	134
3.	*France*	
	Cadarache	23
	Chooz	1
	Fontenay-aux-Roses	53
	Genlis	1
	Grenoble	3
	Paris	2
	Saclay	9
	Strasbourg	1
	Total:	93

		Number of personnel
4.	*Italy*	
	Ispra Establishment	1,070
	Bologna	2
	Casaccia	3
	Fiascherino	1
	Garigliano	1
	Latina	1
	Milan	2
	Pallanza	1
	Pavia	1
	Rome and Frascati	18
	Turin	2
	Total:	1,102
5.	*Netherlands*	
	Petten Establishment	92
	Amsterdam	3
	Arnhem	2
	Jutphaas	2
	The Hague	3
	Rijswijk	2
	Wageningen	5
	Total:	109
	Total in the Community:	1,806

II. Outside the Community

		Number of personnel
1.	*Great Britain*	
	Culham	1
	Harwell	1
	Winfrith	14
	Total:	16
2.	*United States*	
	Argonne	1
	Baltimore	1
	Berkeley	1
	Boulder	1
	Detroit	1
	Idaho Falls	1
	Livermore	1
	Oak Ridge	4
	Princeton	1
	Raleigh	1
	San José	1
	Upton	1
	Vallecitos	1
	Total:	16
3.	*Canada*	
	Chalk River	1
	Total outside Community:	33
	Grand Total (1):	1,839

(1) Add to this total:

Establishment staff working at Ispra	380
» » » » Karlsruhe	19
» » » » Geel	26
» » » » Fontenay	1
» » » » Munich	1
Total	427

DOCUMENT No. 38 **GRANTS AWARDED IN 1964**

Category	*Subject*	*Where working*
Sp.	Etudes dans le domaine de la physique de basse énergie et, en particulier, dans les applications de l'effet Mössbauer aux propriétés des niveaux excités des noyaux	CCR ISPRA
Th.	Interpretation of neutron scattering — I.R. absorption and Raman scattering in order to form a theory of ferro-electricity and melting	CCR ISPRA
Sp.	Regelungstechnik: Servomechanismen für Reaktoren	CCR ISPRA
Th.	Lösung der zeitabhängigen Boltzmanngleichung, mit Hilfe der Monte-Carlo-Methode	CCR ISPRA
Sp.	Tecniche radioisotopiche applicata alla biochimica	CCR ISPRA
Sp.	Studio di reticoli ad acqua leggera e confronto con i risultati sperimentali	CCR ISPRA
Sp.	Studio e realizzazione, tramite metodi di sintesi, di circuiti logici per l'automatizzazione dei sistemi di misura di variabili fisiche	CCR ISPRA
Sp.	Potenziali elettrocinetici di pareti e di particelle in liquidi debolmente polarizzati	CCR ISPRA
J.P.	Verifica ed ampliamento del metodo « semplificato » di calcolo dei reattori ad acqua pesante	CCR ISPRA
Th.	Diffusion des neutrons rapides	CCR ISPRA
Sp.	La trasmissione anormale dei raggi X nei struttura del diamante	CCR ISPRA
Th.	Chemie des Urans und der Spaltprodukte in geschmolzenem System KC1-A1C1$_3$	CCR ISPRA
Sp.	Ricerca nel campo della sicurezza di reattori a tubi in pressione con particolare riguardo al trasferimento dell'energia liberata in caso di incidente alla struttura del reattore	CCR ISPRA
Sp.	Preparazione di leghe in fase dispersa e studio delle loro proprietà	CCR ISPRA

(Th = thesis grant; Sp = specialist's grant; J.P. = courses for young university teachers at nuclear research centres).

Category	*Subject*	*Where working*
Th.	Untersuchungen über die atomaren Beweglichkeiten der Kationen in Uran-Plutonium Mischkörpern	CCR ISPRA
Sp.	Studio e messa a punto di codici nucleari, concernenti in particolare la preparazione di libreria di dati nucleari	CCR ISPRA
Sp.	Travaux de spécialisation dans le domaine de la physique nucléaire	CCR ISPRA
Th.	Untersuchung der Verteilung von Spaltprodukten zwischen flüssigen Uranmetallen (Uranlegierungen) und Halogenidschmelzen	CCR ISPRA
Th.	Abschreck- und Verformungsversuche an Urancarbid	CCR ISPRA
Sp.	Fisica-matematica applicata alla trattazione numerica di problemi di fluidodinamica e magneto-fluidodinamica	CCR ISPRA
Th.	Auslaugung von Spaltprodukten aus bestrahlten Keramischen Kernbrennstoffen (UO_2, U_3O_8 und ThO_2) mittels einer Alkalihalogenidschmelze und Aufklärung des Reaktionsmechanismusses an der Phasengrenze fest-flüssig	CCR ISPRA
Sp.	Chimica delle Alte Temperature : Cinetica di elettrodi in sali fusi e forze elettromotrici di catene galvaniche solide	CCR ISPRA
Th.	Het berekenen en uitvoeren van warmtetechnische constructies op het gebied van de directe conversie van warmte in elektriciteit	CCR ISPRA
Sp.	Specialisatie op het gebied van de programmering en de numerieke analyse	CCR ISPRA
Sp.	Meccanica delle deformazioni rapide	CCR ISPRA
Sp.	Processi di trasporto alle Alte Temperature	CCR ISPRA
Sp.	Problemi impiantistici relativi alla costruzione ed alla compatibilità di materiali nei reattori nucleari	CCR PETTEN
Sp.	Elektronische Verarbeitung von Daten aus kernphysikalischen Experimenten	BCMN GEEL
Sp.	Spezialisierung auf dem Gebiet der Programmierung und elektronischen Datenverarbeitung in Zusammenhang mit kernphysikalischen Problemen	BCMN GEEL
Sp.	Diffrazione ai neutroni	RCN PETTEN
Sp.	Effet des radiations sur l'absorption et le sort des acides nucléiques marqués (homologues ou hétérologues) injectés dans *Arabidopsis*	CEN MOL
Sp.	Studio dei difetti cristallini nei minerali e nei metalli, in particolare per mezzo della microscopia Elettronica	CEN MOL
Sp.	Propulsione Navale Nucleare — Ingegneria del reattore — Integrazione del reattore alla nave	CADARACHE

Category	*Subject*	*Where working*
Sp.	Théorie de la physique des plasmas — travail concernant la particule « test »	CEN FONTENAY-AUX-ROSES
Th.	Studien über Niob in Uranspaltprodukten	CEN GRENOBLE
Th.	Kondensation von Dampfblasen in ruhendem Wasser bei Temperaturen wenig unterhalb der Sättigungstemperatur	CEN GRENOBLE
Th.	Recherche de l'influence du rayonnement neutronique rapide sur les caractéristiques magnétiques d'un monocristal Fe-Ni	CEN GRENOBLE
Th.	Untersuchung des Einflußes von Neutronen und Gamma-Strahlen auf Halbleiter durch Messung der thermischen Leitfähigkeit bei sehr tiefen Temperaturen	CEN GRENOBLE
Th.	Arbeiten auf dem Gebiet der Wärmeübertragung	CEN GRENOBLE
Th.	Reazione fra sodio e soda nel sodio fuso	CEN SACLAY
Th.	Recherches portant sur les phénomènes de transport des ions dans les sels fondus	CEN SACLAY
Sp.	Spécialisation dans le domaine neutronique	CEN SACLAY
Th.	Studio sulla purificazione del Plutonio e in particolare : comportamento dello Zirconio-Niobio e del Rutenio nell'estrazione del Plutonio mediante Trilaurilammina	CEN FONTENAY-AUX-ROSES
Sp.	Bau einer Entladungskammer für ein vollständig ionisiertes Wasserstoffplasma hoher Dichte	Laboratorio Gas Ionizzati - FRASCATI
Th.	Recherches concernant l'influence d'agents chelateurs sur l'activité d'enzymes et sur leur comportement sous radiation	Institut für experimentelle Kernphysik KARLSRUHE
Th.	Technique des cavités résonnantes en régime de supraconduction, appliquées à la construction d'un accélérateur linéaire	Institut für experimentelle Kernphysik KARLSRUHE
Sp.	Ricerche riguardanti le oscillazioni longitudinali in plasmi relativistici e le loro instabilità	Instituut voor Plasma-fysica (FOM) JUTPHAAS
Sp.	Physique des plasmas — phénomènes sur l'interaction « Ondes-particules » dans un plasma	Institut für Plasmaphysik - MUNICH
Sp.	Diffusion of trapped Reversed Magnetic field in a Theta Pinch in the presence of a probe	Culham Laboratory CULHAM
Th.	Travaux de recherches en physique des plasmas	Institut de Physique théorique de la Faculté des Sciences BRUXELLES
Sp.	Le problème des complexes d'addition par transfert de charge	Institut de Biologie physico-chimique PARIS

Category	*Subject*	*Where working*
Sp.	Biophysikalische Bestrahlungsexperimente	Institut d'Astrophysique LIEGE
Sp.	Etudes : 1) sur la ribonucléase acide de la rate 2) sur la phosphodiesterase de la rate	Centre de Recherches sur les Macromolécules STRASBOURG
Sp.	« Enzymologie — Protein — Biochemie »	Centre de Recherches sur les Macromolécules STRASBOURG

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