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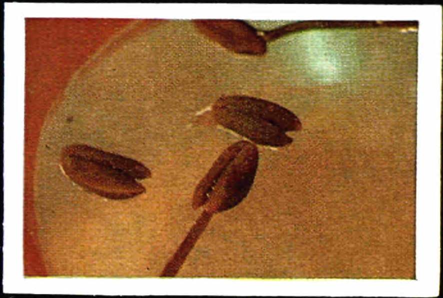

COVER :

New possibilities for the in vitro *cultivation of plant cells*
(see page 105).

CONTENTS

spectra

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Scientific and Technical Review of the European Communities (ex-Euratom-Review)

1970-4

Several times this year we have had occasion in this column to offer some reflections on science and technology in Europe, more especially on the problems of how to establish effective cooperation between the Community countries. Those reflections bore a certain tinge of pessimism.

Today, as 1970 runs out, it is again hard to avoid feeling somewhat depressed, particularly since, twelve months ago, the heads of state or of government reaffirmed at The Hague their resolve « to pursue Community action more intensely with the object of coordinating and encouraging industrial research and development in the principal leading sectors ».

What we now have is a bumper crop of groups whose job it is to prepare the groundwork for the Community's decisions — or lack of same — in this field and whose rules, terms of reference and composition are all different. And even so their studies and surveys by no means cover the whole of the member countries' scientific and technical activities. This is one of the chief points made in a memorandum by the Commission to the Council of Ministers in November.

This memorandum goes beyond diagnosis and proposes the steps for a new, comprehensive approach, the most notable of which is the idea to set up a European Research and Development Committee possessing decision-making powers, with a European Research and Development Agency as the executive body.

Let us hope that this memorandum will open the way to constructive discussions.

The public research effort in the European Community

In recent months the international arsenal of statistical data on the research and development effort has been suddenly and considerably enriched. What trends does this new information reveal?

JEAN PAUL ABRAHAM

Three new sources of statistical information

For several years now the international analyst has had to rely almost exclusively on the information obtained during the International Statistical Year organised by the *OECD*. This related to the years 1963-64 and thus could not reflect the intensification of the research effort which has taken place in several countries since then. In addition, it suffered from the technical weaknesses inherent in all pioneer work.

The state of information has appreciably improved as a result of three new developments. In the first place, in preparation for the conference of the ministers responsible for scientific policy in the European member states (22-27 June 1970), *UNESCO* conducted an enquiry into research and development activities in 1967. Twenty-five European countries, including all the Community countries except Luxembourg, took part in this enquiry. The distinctive feature was that it permitted a certain comparison to be made between the research efforts of the countries of Western and Eastern Europe.

In the second place the *OECD*, using the safe definitions employed in the International Statistical Year, undertook an enquiry into the research carried out in 1967. This covered 17 European and non-European members of the *OECD* and, when the full results have been published, will enable a fairly detailed comparison to be made between research activities in the Community countries and the major "reference" countries—the USA, the UK, Japan, Sweden, etc.

Finally, at Community level, a major effort has been made in a very short period of time by a team of statisticians drawn both from government departments and from the Statistical Office and several other departments of the Commission of the European Communities. In July 1969 the Working Group on Scientific and Technical Research Policy of the Medium-Term Economic Policy Committee instructed this team to build up a statistical basis for comparing the scientific budgets and programmes of the Community countries. The first report of this team has now been published[1]. The information which it contains has the following three distinctive features:

1. Since it is intended for use in comparing programmes and budgets, it concentrates on the *public* effort to promote research, viewed from the angle of *financing* and not of the research carried out. It is therefore technically based on *budgetary estimates* of public R&D funding and not directly on *inventories* of research carried out.
2. Again with a view to comparison, it comprises both *retrospective* data on the recent past and *short-term forecasts*. The first report thus deals with the period 1967-70 and presents figures for each of the years of this period.
3. Lastly, in the public field with which it deals, the information in this report is subjected to considerably more detailed analysis than was possible in the major international enquiries. To state a case in point, the data have been compiled and analysed on the basis of a *functional nomenclature*[2] specially drawn up for this purpose and distinguishing twelve major goals, each broken down into a variable number of groups and subgroups.

New trends in scientific policy

This increase in the amount of international statistical information available occurs at the precise moment when those responsible, at both the national and the international level, are endeavouring to reorient public research spending to satisfy new priorities. Scientific policy in Europe during the 'sixties was largely dominated by two well-known imperatives, namely:

(a) the need to increase the overall effort in order to close the gap separating Europe from the United States and the Soviet Union;

(b) the need to promote big technical operations in the nuclear and space fields and, for certain countries, in the field of military research.

These first-generation preoccupations are being progressively ousted by the

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[1] "The Public Financing of Research and Development in the Community Countries", published simultaneously in the series "Statistical Studies and Enquiries" of the Statistical Office of the European Communities (1970, No. 2) and in the "Research and Development" series of the Commission of the European Communities (R&D—1/EUR 4532 d, f, and e).

[2] European nomenclature for the analysis and comparison of the scientific programmes and budgets (*NASB*) adopted by the statistical experts on 9 October 1969.

second and even the third generation of objectives. The second-generation scientific policy aims primarily at *rationalising* the research effort, i.e. at fixing clear and precise objectives, choosing fields and projects on the basis of rigorous criteria, and increasing the efficiency of both the planning and the execution of research. The third generation prolongs the second by trying to dovetail the research effort into an *overall strategy of economic and social development*. It has two clear aims, namely:

- to steer the research effort towards more *immediate economic results*, markets to be conquered, products to be launched;
- to help to open up research to the needs of the *society of tomorrow*, the objectives of which will be to promote health, abolish pollution, forecast the weather, undertake town planning and provide housing and green belts.

While these two aims may compete with one another, they nevertheless have a common feature: that of altering and even reducing the relative importance of one of the major goals of the scientific policy of the 'sixties, namely, large-scale "off-the-market" technological operations, planned and usually executed by large public bodies at both national and international level.

In the light of these considerations it is not difficult to show that the research effort of the 'seventies is not being prepared in a vacuum, as the utopians imagine, nor in chaos, as the pessimists claim. It is not a question of *creating* a research policy where *none existed* before, but of *reorientating existing policies* in the light of the needs adjudged to be most urgent.

It is in this context that the new statistical information which has become available assumes its full importance. This information constitutes an international basis for comparing the effort being made by different countries at the present moment and indicates the manner in which this effort is divided between "the heritage of the past" and topics reflecting new preoccupations.

It is from this angle that the present article comments upon some key data in the *UNESCO* enquiry and in the report produced by the European Community's statisticians. At the moment of writing, the detailed results of the *OECD* enquiry are not yet available. Attention is focused mainly on the *public* effort.

Research potential and activity in 1967—The lessons of the UNESCO enquiry

The *UNESCO* data provide an overall picture of research potential and activity in 1967.

In this year the Community's research potential, expressed in terms of persons working full time on research, amounted to about 515,000, of whom nearly 160,000 were engineers and scientists. When compared—cautiously—with the strength recorded in 1963/64 by the *OECD*, these figures indicate an increase of about 20%[3].

Compared with the United States, the level attained within the Community is still modest. In this same year the number of scientists (i.e. not counting executive staff) in the United States was about as large as the total number engaged on research in the Community.

In addition, within the Community the differences between the Netherlands, France and West Germany on the one hand, and Belgium and above all Italy on the other, remain very marked. The group of the first three countries has a research strength of 3.5-4 persons per 1,000 inhabitants, whereas Italy falls short of one per thousand (Table I).

The fraction of staff directly employed by the government (outside higher education) does not exceed 15%

[3] The *OECD* census evaluated the number of personnel engaged on R&D in 1967 at 519,000, as against 427,000 in 1963-64.

Table I: *Research personnel in the Community in 1967.*

	Total personnel (equivalent full-time)			Engineers and scientists (equivalent full-time)		
	1,000 pers.[1]	per 10,000 inhabitants	proportion employed by public sector	1,000 pers.[1]	per 10,000 inhabitants	proportion employed by public sector
Germany	208.9	36.2	15.3%	63.1	10.9	16.3%
Belgium	21.0	21.9	6.2%	9.0	9.4	7.4%
France	184.5	37.2	14.4%	50.7	10.2	12.3%
Italy[2]	49.9	9.5	16.5%	19.7	3.8	13.7%
Netherlands[2]	50.2	39.8	12.1%	15.7	12.5	13.1%
Community[3]	514.6	28.3	14.4%	158.2	8.7	13.8%

Source: UNESCO—statistics on experimental development and research activities 1967.

[1] round figures, personnel of international organisations not included.

[2] social sciences not included.

[3] not including Luxembourg.

on the average within the Community, either for engineers and scientists or for personnel as a whole. The difficulties which have arisen in the course of the last few years as regards the status and allocation of research personnel in the public sector thus concern only a limited fraction of the Community's "research army".

In terms of *expenditure* (Table II), the research activity within the Community in 1967 ran at almost 6,000 million units of account (u.a.=$), or 1.7% of the GNP and a little more than 30 u.a. per head of the population. This expenditure has increased sharply since the first international census. Whereas personnel increased by about 20% between 1963-64 and 1967, expenditure in 1967 appears to have been more than 60% up on the figure for 1963-64. This is a general trend in Europe which not only reflects the increase in manpower and in the real and nominal level of salaries, but is also due to urgently needed spending on equipment and materials.

Table II: *Total expenditure on research and development in 1967—Share of the government in execution and financing.*

	Total expenditure[1]			Share of government in execution	Share of government and other public sources in financing		
	millions of u.a.	% of GNP	u.a. per inhabitant		State	Gov. agencies and misc.	State + government agencies
Germany	2,310	1.9	40.0	20.4	45.9	0.7	46.6
Belgium	182	0.9	19.0	7.2	23.2	13.8	37.0
France	2,369	2.2	47.8	23.2	48.5	16.3	64.8
Italy[2]	447	0.7	8.5	24.7	31.2	6.9	38.1
Netherlands[2]	514	2.3	40.8	9.4	40.3	0.6	40.9
Community	5,822	1.7	32.0	20.5	44.6	7.9	52.5
United Kingdom	2,472	2.3	45.2	22.0	50.2	2.8	53.0
United States	22,453	3.1	112.8	15.1	62.9	2.8	53.0

Source: see Table I, except for the United States, where the provisional *OECD* data have been used.

[1]round figures, not including research conducted by international organisations.
[2]human and social sciences excluded.

Despite this sharp rise, research expenditure in 1967 was less than a quarter of that in the United States. However, the gap has been reduced since 1963-64, when the Community's effort represented only 16.3% of the American figure. Moreover, the expenditure gap does not reflect the gap in real resources, since salaries are much higher in the United States.

Calculated as a percentage of the GNP, the differences are more appreciable *within* the Community than between the most advanced Community countries (Netherlands, France and Germany) and the United States.

Owing to the different methods used for defining the public sector in the international censuses, it is difficult to analyse the part played by this sector in the execution and funding of research. One factor in financing, for example, is the special funds, which, although classified as an independent source of finance, are completely or partially supplied from public sources. With the usual reservations, however, the phenomenon noted in the previous censuses is also revealed in the 1967 statistics. Within the Community the *state continued to play a more important part in research than in the United States, while financing less of it.*

While the various governments pick up the tab for the bulk of the research which they carry out themselves (91% at Community level), the fact remains that in Belgium and the Netherlands private enterprise provides about 10% of these funds. In the other countries the percentage is minimal and at all events does not foreshadow the work conducted under contract to private industry by certain government-run laboratories which is to be a feature of "third generation" scientific policy.

As for participation by the state in the financing of research in other sectors, the following three main points emerge:

1. It accounts for more than 90% of the funds earmarked for research in universities; in some countries

these funds come partly from special government agencies.

2. It provides large-scale backing for research carried out for the *production sector;* government aid in this field is particularly marked in France and the Netherlands.
3. It puts up only a very limited amount towards the cost of the research carried out by *private enterprise,* except in France; in 1967 state aid to this form of research consisted mainly in the backing given to the aircraft industry (Table III).

Table III: *Financing of research by the state and by government agencies in millions of u.a. and as a percentage of total research expenditure.*

	Private (millions of u.a.)	State (%)	Government agencies and miscellaneous (%)
Germany	1,401.3	15.9	0.1
Belgium	109.5	0.4	5.4
France	1,332.5	40.7	—
Italy	271.0	1.4	0.8
Netherlands	298.3	3.1	0.9
Community	3,412.6	22.8	0.3
United Kingdom	165.5	32.2	3.4

Source: *UNESCO,* as indicated in Table I.

Recent developments and general trends in publicly financed research

The data commented upon so far provide a *retrospective picture* of research potential and activity. Since they relate to research *actually carried out,* they assume that the machinery for the allocation and re-allocation of funds was fully operative.

The team of statisticians set up by the European Communities adopted a different approach, attempting to *forecast* the public effort, i.e. funds supplied by the central governments alone, on the basis of budget estimates.

Thus the information in the report quoted above (see footnote 1) can be used to follow the recent trend of budgetary decisions on research and to analyse the functional breakdown of public appropriations. It also shows to what extent the new trends in scientific policy are already being reflected in budgetary decisions. Lastly it lists the contributions to international organisations, which often escape attention in the overall data on research actually carried out.

Since 1967 public appropriations have continued to increase rapidly, at a rate of nearly 9% a year at current prices, in all the countries of the Community[4] (Table IV).

The estimates for 1970, however, show a wide scatter; they include both a decrease in absolute terms in France and an increase of almost 40% in Italy. But these differences are reduced if it is borne in mind that in France the achievements of the year 1969 will no doubt fall short of the budgetary estimates. In Italy, on the other hand, the 1970 estimates include the launching of new programmes on which the final decisions had not yet been taken at the time the figures were compiled.

Combined analysis of Tables IV and V leads to interesting findings which can be summed up as follows:

1. The overall appropriations of the central governments for research in 1969 total about 4,200 million u.a., or 22 u.a. per inhabitant, and 1% of the Community's gross domestic product (GDP). Almost 80% of these appropriations were earmarked for civil research. The share of international contributions in these appropriations, which has been fall-

Table IV: *Research expenditure by central government bodies.*

	D	B	F	I	NL	Community
1. Expenditure (1969) in millions of u.a.						
— total	1,439	106	2,008	334	271	4,158
— civil	1,166	103	1,391	320	256	3,236
— contribution to international organisations	144	15	247	50	17	473
2. Annual mean variation in expenditure*						
1967-69 (%)	8.0	9.5	8.5	8.0	15.3	8.7
1969-70 (%)	13.0	16.8	—5.8	37.2	13.7	6.0

Source: "The public financing of research and development in Community countries" R&D—1/EUR 4532 d, f, e—Table I.

*NB. The annual rates of variation in expenditure per country shown in Tables IV to VII were calculated from values expressed in national currencies, i.e. without taking account of the parity changes introduced in 1969. The rates shown for the Community are averages of these rates per country, weighted by the expenditures for the initial years expressed in units of account and calculated at the exchange rates in force during those years.

[4] Except the Netherlands, where the rate of 15%, which is greatly influenced by research expenditure on higher education, inflates the actual increase.

Table V: *Functional breakdown of public expenditure on research in 1969 (% of total).*

	D	B	F	I	NL	Community
1. Nuclear	16.5	23.1	17.0	30.2	9.9	17.6
2. Space	6.4	6.7	6.3	5.0	3.9	6.1
3. Defence	19.0	2.4	30.8	4.1	5.4	22.2
Total major programmes (1—3)	41.9	32.2	54.1	39.3	19.2	45.9
4. The earth and its atmosphere	1.6	2.5	0.9	1.5	1.7	1.3
5. Health	2.0	3.5	2.1	2.8	4.2	2.3
6. Human environment	1.0	1.8	2.6	2.1	3.1	2.0
7. Agricultural productivity	2.0	5.6	4.6	3.6	9.4	4.0
8. Industrial productivity	5.1	10.7	10.1	5.0	6.7	7.8
9. Computer science, automation	2.1	0.1	1.4	0.7	0.4	1.4
10. Social and human sciences	1.7	0.8	1.1	1.2	3.7	1.4
Sub-total (1—10)	57.4	57.2	76.9	56.2	48.4	66.1
11. General promotion of knowledge—excluding higher education	8.3	10.8	8.8	11.4	5.2	8.7
12. Idem—higher education	34.3	32.0	14.1	32.4	46.4	25.1
Total general promotion of knowledge (11 & 12)	42.6	42.8	22.9	43.8	51.6	33.8
Not broken down	—	—	0.2	—	—	0.1
Total without defence (1—12 without 3)	81.0	97.6	69.1	95.9	94.6	78.8
Grand total (1—12)	100.0	100.0	100.0	100.0	100.0	100.0
in 1,000 million u.a.	1.44	0.11	2.01	0.33	0.27	4.16
as a % of the Community total	34.6	2.6	48.5	8.0	6.5	100.0
in u.a. per inhabitant	24.0	11.0	40.0	6.0	21.0	22.0
as a % of the Gross Domestic Product	1.0	0.5	1.4	0.4	1.0	1.0

Source: Op. cit. Tables 1 and 23.

ing off noticeably for some years, was 11%.

2. The differences in the *public* effort of the various countries (expressed as a percentage of the GNP) are appreciable. Apart from France, where the share of public financing in the total is considerably higher than elsewhere, these gaps between countries are not due, for the most part, to different breakdowns between public and private financing but to the fact that *overall* spending on research was at a higher or lower level (see Table V).

3. With the exception of France, where the proportion is only 23%, the Community countries devote 40-50% (and even more in the Netherlands) of their public research budgets to the general promotion of knowledge.

It will also be noted that these appropriations:

(a) for the most part go to universities;

(b) are very often the subject of decentralised distribution and allocation procedures (sometimes by way of special government agencies);

(c) expand in accordance with the rate of university expansion rather than for specific reasons;

(d) are at present increasing more rapidly than the other categories of research appropriations.

4. Even in countries which are not making any major military effort,

the concentration of public money on ambitious programmes of "off-the-market" advanced technology remains striking. Italy devotes 33% of its public research funds to nuclear and space programmes, Belgium 30% and Germany 23%. Only the Netherlands are more modest, with 14%.

5. In financial terms, public funding of research for industry (Table V, item 8), agriculture (item 7) and "social" ends in the wide sense of the word (items 4, 5, 6 and 10) is still of secondary importance.

If this is the existing structure, do these data not provide a clearer picture of the trends resulting from the new preoccupations of scientific policy? When the rates of increase of the various categories of appropriation shown in Table VI are arranged in decreasing order, the situation for the Community as a whole is that shown in Table VII.

The spectacular increase in public spending on *data-processing* is mainly due to the establishment of plans to promote the development of the computer industry in France and Germany. Next among the categories enjoying a sustained increase will be noted the majority of the appropriations for *broad social ends* (with exceptions in 1970).

Public expenditure on *industry and agriculture* is also expanding rapidly, but will be slowed down in 1970, particularly because of budget cutbacks in France.

Lastly, the amounts earmarked for *nuclear research* and *defence* are marking time.

With the exception of appropriations for universities, all the categories now undergoing rapid expansion represent separately only a small fraction of overall public spending (maximum 7% in 1967). On the other hand, the appropriations for nuclear research and defence—the two stagnant headings—accounted respectively for 21 and 15% of the total in 1967.

Final remarks

In view of the situation which we have just outlined, it is clear that a reorientation of scientific policy in terms of new objectives will manifest itself only slowly in the public research budgets. In most countries these budgets are reminders of the fact that, historically, government participation has developed around two focal points, namely:

(a) the financing of a human and material infrastructure for basic research, above all in universities;

(b) the financing, and often also the execution, of large technological operations of a civil or military nature which do not ensure an immediate commercial return.

The first of these points will continue to develop, particularly under the influence of the university expansion which is occurring in all the Community countries. It is, moreover, a striking fact that even those countries where

Table VI: *Trend of public research appropriations in the Community as a whole.*

	Amounts 1969 in millions of u.a.	Percentage of total	Annual increase 1967-69	Provisional increase 1969-70
1. Nuclear	730.7	17.6	0.1	3.5
2. Space	253.3	6.1	8.5	8.1
3. Defence	922.1	22.2	3.2	—3.5
4. The earth and its atmosphere	53.6	1.3	11.7	12.8
5. Health	95.0	2.3	16.4	10.0
6. Human environment	85.2	22.0	13.5	5.7
7. Agricultural productivity	165.0	4.0	11.6	1.5
8. Industrial productivity	324.0	7.8	13.1	1.5
9. Computer science—automation	61.3	1.4	43.7	43.5
10. Social and human sciences	60.6	1.4	8.7	3.9
11. General promotion of knowledge excluding higher education	360.4	3.7	15.3	11.3
12. Idem—higher education	1,043.5	25.1	14.5	9.2
Not broken down	3.3	0.1	—	—
General total	4,158.0	100.0	8.7	6.0

Source: Op. cit. Tables 5-19 and 23.

the public effort to promote knowledge is already very considerable—the Netherlands and Germany—still show very high annual growth rates.

On the other hand, all the documents indicating these new trends, and in particular the report on the options outlined in the Sixth French Plan, indicate that there will be a relative drop in the emphasis placed on the second point, namely, major technological projects.

However, expenditure on this type of action is so great that the proposed changes will only lead to a very gradual alteration in the structure of the public research budgets.

These considerations could raise doubts as to the real extent and impact of the changes announced in the scientific policies of all our countries.

Although these spectacular declarations of intent must thus be cut down to size, we are nonetheless not inclined to share in any sweeping scepticism, for the changes announced cannot be measured exactly in financial terms, for the following reasons.

In the first place, the *unit cost* of research in the fields to be developed is often lower than in large-scale technological operations. A reorientation of the goals pursued by the public authorities need not necessarily lead to strictly proportional shifts in the allocation of funds.

In the second place certain technological operations have reached such a stage that their *internal reorientation* towards the aim of immediate or early commercial exploitation is both possible and necessary. Public expenditure on proven and advanced reactors is obviously a typical case in point.

Lastly, and on a more general plane, the role of the government authorities in tomorrow's scientific policy should be measured less and less in solely financial terms. In the promotion of research on town and country planning, the planning of education and the fight against pollution, or when it is a question of urging private enterprise to undertake "competitive" research, the problems of organisation, concertation and coordination are just as important —and sometimes more important— than those of finance. Alongside its financial role, the state will have to inform, stimulate and select. The orientation of research towards short-term economic and social results, and the reformulation of a basic research policy with this in mind, are infinitely more complex tasks than the restructuring of a scientific budget.

The success of these changes cannot therefore be measured in terms of the overall appropriations but must be evaluated on the basis of more variegated and qualitative criteria. The discussion of the efficiency of the research effort has only just begun.

EUSPA 9-13

Table VII: *Increase in various categories of research appropriations within the Community.*

	1967-69	1970 (estimated)
Large increase (> 1 point above average 1967-69)	— Computer science — Health — Promotion of knowledge excluding higher education — Prom. knowl. higher educ. — Human environment — Industrial productivity — The earth and its atmosphere — Agricultural productivity	— Computer science — Terrestrial environment — Promotion of knowledge — Health
Moderate increase (max. 1 point above/below average 1967-69)	— Social and human sciences — Space	— Promotion of knowledge higher education — Space
Small increase (> 1 point below average 1967-69)	— Defence — Nuclear	— Human environment — Social and human sciences — Nuclear — Industrial and agricultural productivity — Defence

New possibilities for the in vitro *cultivation of plant cells*

In the case of the higher plants, in vitro *cultures have been successfully used to make the male gamete "forget" its function and produce an entire plant on its own. Furthermore, it has been possible to achieve isogenicity, i.e. absolute genetic purity.*

MARCEL DEVREUX

AT CERTAIN particular stages of the cell division process a variable quantity of chromosomes can be seen in the cell nucleus; there is a fixed number for each species and they carry the hereditary characteristics. These chromosomes are always present in even numbers in every cell of an organism because half of them originate from the male gamete and the other half from the female gamete. It is therefore clear that when the gametes are being formed two particular divisions must occur—called reduction divisions—whose function is to reduce the chromosome number of the species by half.

The normal cells of an organism are called diploid, as opposed to gametes, which are haploid. In man, for instance, all the body cells are diploid with 46 chromosomes, while the gametes are haploid, with 23 chromosomes.

In the great majority of cases a new plant is produced by sexual reproduction, i.e. by the union of a male gamete with a female gamete. The fusion of these two gametes produces a special cell—a zygote—which is the first cell of the new organism. With plants the zygote develops in the ovule; an embryo is created which gradually differentiates the main organs of the new plantule: root, stem, leaf, etc. This differentiation is the result of the hereditary factors carried by the chromosomes in the nuclei.

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Differentiation of a plant starting from any cell

For a long time it was thought that the particular conditions in which the zygote develops were indispensable to smooth differentiation of the embryo. The theory was later put forward that it must be possible to differentiate a plant from any cell whatsoever, since all the genetic potentiality of an adult organism must be present in every one of its nuclei.

This was verified experimentally a few years ago (F.C. Steward). The first tests were carried out using *in vitro* cultures of tissue discs taken from carrots; these tissues, after proliferation on a solid culture medium, were put in a liquid medium in rotary shakers: the cells were thus separated and a true cell suspension was obtained. It was then noted that the cells isolated in this fashion underwent multiplication and differentiated embryoids, i.e. structures which were very similar to the embryo in the seed. These embryoids in time yielded new adult plants which corresponded perfectly to a plant grown from seed. They also genetically resembled the plant from which the cells had come, just as in any vegetative propagation method—cuttings, grafting, etc. The demonstration was thus a complete success; the totipotency of the nucleus was once again proved but it was also apparent that differentiation of a normal plant could be achieved using any cell at all and not solely the zygote in the ovule.

This result was quite amazing, so much so that carrot cells were imagined as having some mysterious specific power! Fairly quickly, however, other research showed that the phenomenon was quite general among plants and the same result could be obtained from cells taken from a vast number of different tissues and from different species.

Differentiation of a haploid plant from a gamete cell

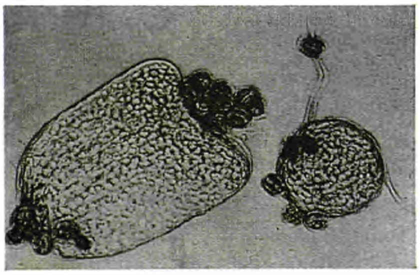
It was normal at this stage to ask whether it would be possible to regenerate a whole plant, not by starting with a somatic cell but this time by differentiating an adult plant from a single gamete. A haploid plant could thus be obtained. Several laboratories carried out these fascinating experiments, with varying degrees of success.

Some haploid plants had already been obtained under "natural" conditions, either spontaneously or as the result of artificial hybridisation or various types of treatment, but the number of these plants was always very limited and they originated almost accidentally. If it were possible to produce them as and when required and in large quantities, this would be extremely useful for new basic research and also for improving cultivated plants.

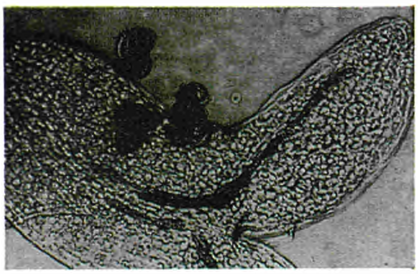
Embryo formations were first obtained from cultures of *Datura* anthers in Delhi in 1964 by S. Guha and S.C. Maheswari. In a second article, in 1966, the same authors showed quite clearly the haploid nature of the plantule they developed from anther cultures.

Then in 1967 at the *CNRS* laboratory at Gif-sur-Yvette, near Paris, J.P. Nitsch and his fellow research workers obtained haploid plants from tobacco anthers. Practically at the same time two Japanese teams in 1968 published the positive results obtained from rice (H. Niizeki and K. Oono)

The cultured anthers gradually turn brown.

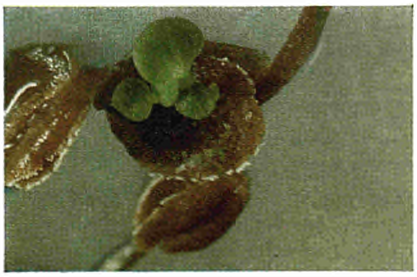


Inside the anthers certain of the microspores divide, form small spheres, then young embryoids....



..... and finally embryoids which perfectly resemble the embryo in the seed.

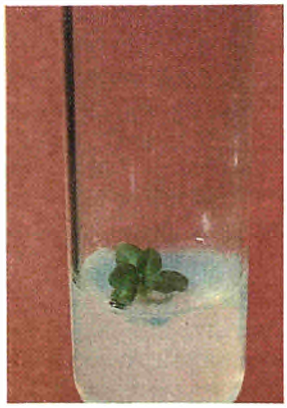
The anthers open and a variable number of plantules appear.



The first two leaves are like two cotyledons, then the real leaves develop at the same time as the first roots.

Very rarely, an "albino" plantule may be produced.

The plantules are then transferred to a "minimum" medium....



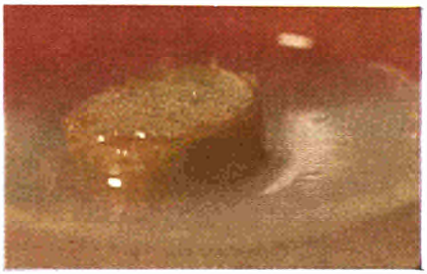
... which encourages abundant root growth.

Finally they are transplanted to soil where they continue their normal vegetative cycle.

The flowers of the haploid plants are always very abundant and sterile.

The induced mutations can be identified directly because of haploidy (here, a light green plant with somatic instability which is shown by darker patches and results from pronounced chromosome aberrations).

Culturing a tissue disc taken from a stem internode of the haploid plant.



It gradually develops a meristematic callus,.....

.....then new plants are differentiated from the callus and, as the result of spontaneous endopolyploidy, these new plants are diploid and fertile.

A considerable number of new plantules can be produced from a single disc of stem tissue.

After being separated these plants develop in the "minimum" medium and are then planted out in soil; their descendants will be perfectly uniform, because the plants are absolutely pure from the genetic point of view.

and tobacco (K. Nakata and M. Tanaka). The technique then spread rapidly to other laboratories, but up to the time of writing only tobacco, rice and *Datura* have produced haploid plants by the anther culture method. It is considered desirable to be able to produce a large number of haploid plants at will from many different species, and particularly from cultivated species. The reasons for this will become apparent later. But first let us take a detailed look at how these haploid plants develop in *in vitro* cultures, taking tobacco as an example (see figure 1).

We shall start by considering the various stages of development of a normal plant, under normal conditions.

During the development of the male gametes two reduction divisions occur in the anther in certain particular somatic cells—called microsporocytes—each producing four new cells, or microspores. The latter have a reduced number of chromosomes; in the case of tobacco the reduction is from 48 chromosomes to 24.

In each anther of the flower a large number of microsporocytes thus produce four times as many microspores. The four microspores individuate, then their nucleus prepares for the first haploid mitosis: deoxyribonucleic acid (DNA), the principal constituent of the nucleus and the chromosomes, is synthesised, and the nucleus then undergoes mitosis to produce the binucleate gametophyte; these two nuclei quickly differentiate: one, the vegetative nucleus, becomes very large and diffuse; the other, the generative nucleus, is highly condensed. These two nuclei synthesise DNA, while in the cytoplasm of the vegetative nucleus reserve starch-type substances accumulate by synthesis. At the same time the highly resistant outer wall of the pollen grain —the exine—is formed.

In the case of tobacco the pollen is dispersed in this binucleate form when the flower opens. After coming into contact with the stigma papillae, the pollen germinates, then the generative nucleus divides once in the developing pollen tube to produce the two spermatic nuclei, or male gametes, which ensure double fertilisation in the ovule; one nucleus fuses with the female gamete to give a diploid zygote which will develop into an embryo, and the other fuses with the two polar nuclei to form the triploid endosperm.

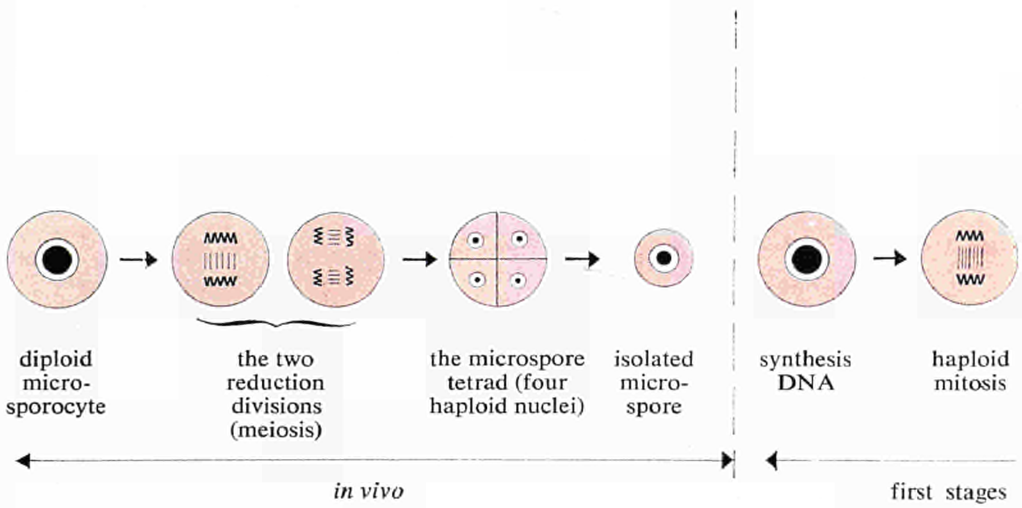
It was observed that to obtain haploid plants from *in vitro* anther cultures it is necessary to start at a definite stage of development which is very near to the first haploid division of the gametophyte.

It appears that this stage makes it possible for the "dedifferentiation" of certain microspores to occur. By cellular multiplication these then form a small meristematic sphere and then an embryoid. There would thus seem to be two successive phenomena caused by *in vitro* culturing: the first is the "dedifferentiation" of the microspore, which virtually "forgets" that it ought to form a pollen grain; the second is the new differentiation of the microspore into an embryoid which will develop into an entire haploid plant.

Where exactly does the haploid plant come from?

It is known that in tobacco the male gametes are present in the ovule in the form of cells containing practically no cytoplasm at all and consequently none of the future chlorophyll elements, i.e. chloroplasts. In the new plant the latter originate solely from the female gamete which always contains ample cytoplasm.

Since the haploid plants produced from the microspores are green, the question was whether they came from the mononucleate microspore, with no differentiation of the two nuclei after the first division into the vegetative and generative nuclei, or if, after the first division and differentiation of the two nuclei, only one of the two, in this case the vegetative nucleus with its abundant cytoplasm, produced the future embryo and the haploid plant. Very recently two English scientists, N. Sutherland and F.M. Wicks, observed that the second hypothesis was confirmed more often and consequently it is normal to obtain chlorophyllous plantules. In the majority of cases, therefore, the haploid plant does not come from the generative nucleus, i.e. the one which will produce the two male gamete nuclei, but from the vegetative nucleus which is really the somatic support for the male gametes. There could, however, be some exceptions, since we recently obtained a completely white haploid plant, without chlorophyll, and this is perhaps the only case of a plant originating from the generative nucleus, and thus from the actual male gamete. One can virtually exclude the spontaneous mutation theory for an "albino" of a polyploid species such as tobacco.



After the haploid plantules have developed in the culture tubes, where the anthers are placed on a more or less complete culture medium under aseptic conditions, these plantules are separated and replanted singly in culture tubes containing another synthetic medium, called a "minimum" medium because of its much simpler composition.

This medium enables the plantule to continue its development without any neoformation of undifferentiated tissue and, more especially, induces the growth of numerous roots.

Some weeks later the plantules are taken out of the tubes and put into soil in pots. At this stage it is vital to keep the plants in a very humid atmosphere for several days so as to avoid too violent a shock as a result of this sudden "return to earth".

The haploid plant then continues to develop normally, it has delicate leaves and abundant flowers but is totally sterile because it is impossible for gametes to form.

From a sterile haploid to a fertile diploid

In order to revert to fertile plants by doubling the number of chromosomes, another possibility offered by *in vitro* cultures and tobacco plants is used.

In the vast majority of species the number of chromosomes in the somatic nuclei may vary considerably in the zones which have already been differentiated (some of the nuclei are polyploid). In the same way, with the *in vitro* tissue culture the number of chromosomes varies in the undifferentiated developing tissues.

It was therefore thought that by culturing the pith of a tobacco plant stem *in vitro* it might be possible to induce mitosis of the polyploid nuclei, thereby obtaining a tissue and then some plantules. In practice, by reculturing tissue discs taken from the stem internodes of the haploid plants, a tissue is formed and then new diploid plants are differentiated. A haploid stem disc can thus differentiate a considerable number of new diploid plantules which are then separated, pricked out on the minimum medium and subsequently planted in soil.

These plants, having thus doubled the number of their chromosomes, now possess the very important characteristic of being isogenic, in other words absolutely pure from the genetic point of view. Every characteristic is doubled, but remains exactly as it was initially in the haploid plant. No characteristic will have an *A* allele and an *a* allele, i.e. be heterozygous, but all of them will be either *AA* or *aa*, i.e. homozygous. The plants' descendants will therefore be perfectly uniform.

The haploid plant—ideal material for the geneticist

Why are these investigations so important? Let us first see why it is desirable to obtain haploid plants at will using *in vitro* anther cultures.

First of all these haploid plants provide a source of haploid tissue which can be kept *in vitro* without differentiation and can then be dissociated into free haploid cells. In this way it will be possible to obtain real suspensions of haploid cells and to carry out new genetic research on the higher plants, by applying the techniques used for microorganisms (mutation studies at the physiological level, biochemical analyses, etc.) and then to regenerate whole plants.

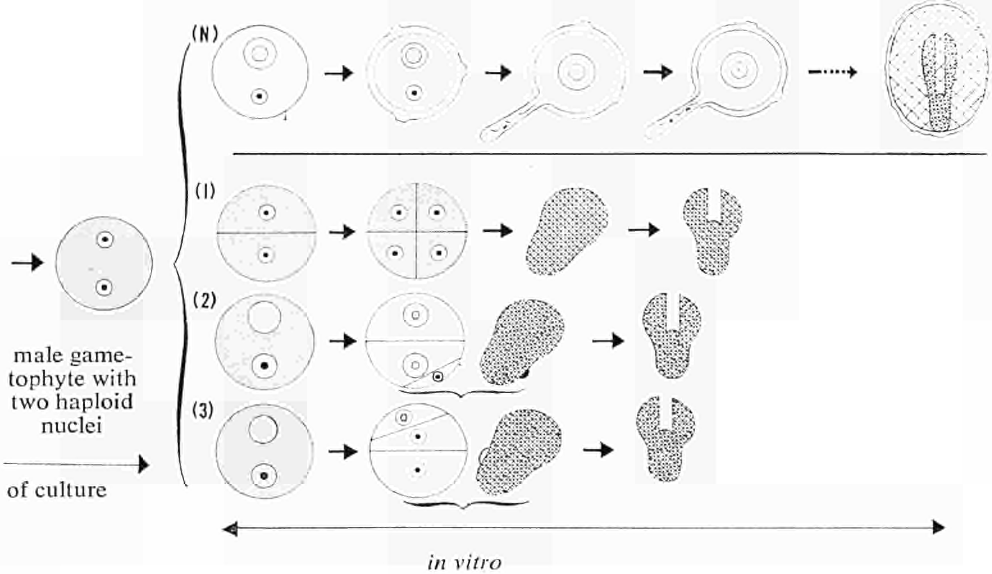


Figure 1: *Development of the male tobacco gametophyte—*in vitro *anther culture. The third part of the diagram shows the further development of the male gametophyte after the first haploid division, first under normal conditions (N), then* in vitro, *according to three hypotheses. (N) In normal conditions, there is a differentiation of the vegetative nuclei (top) and the generative nuclei (bottom); after dissemination, the pollen germinates on the flower stigma and the second haploid division takes place in the pollen tube. After fertilisation, the embryo develops into the future seed.*

In vitro, *three hypotheses are possible:*

(1) *No differentiation of the two nuclei after division and formation of the embryoid (unlikely);*

(2) *Differentiation of the two nuclei: the vegetative nucleus continues to divide, while the generative nucleus degenerates; the embryoid gives a green plant (very likely);*

(3) *Differentiation of the two nuclei: the generative nucleus continues to divide, while the vegetative nucleus degenerates; the embryoid gives an albino plant (exceptional case).*

At present the only remaining difficulty is the instability of the cultured tissues, caused by the spontaneous polyploidy which has just been mentioned.

Haploid plants are already being put to numerous uses; it is possible directly to identify mutations caused in this material by radiation or by mutagenic chemical substances, because since all the genetic factors are present singly (one allele), induced changes become evident from the first generation onwards; there is no opposition of dominant and recessive alleles as is the case at present when diploid material is being dealt with.

The various haploid plants regenerated from the male gametophytes of one plant have another characteristic which is that they show all the variability of the original plant, since they originate from the haploid cells which result from meiosis, where all the genetic recombinations occur, and since none of the genes is masked by a dominant allele.

The prospects offered by the diploids' genetic purity

Because of their being isogenic the fertile diploid plants obtained by duplicating haploid plants are extremely important for nature research.

This new technique makes it possible to stabilise plants very quickly which are normally heterozygous, such as allogamous plants (i.e. those reproducing by cross-fertilisation) or the offspring of crosses, and in this way to obtain perfectly homogenous descendants. In the case of allogamous plants the extreme purification of the different lines should make it possible to achieve maximum heterosis (hybrid vigour) when recrosses are carried out.

Furthermore the effects of eco-climatic factors could easily be isolated by working with these isogenic plants.

Studies of spontaneous mutability and consequently experimental studies of evolution would also be possible.

Many other studies both theoretical and applied still remain to be undertaken on haploid material and on isogenic plant lines but it is impossible to describe them briefly within the limits of this article.

To conclude, one can say that these two new possibilities in plant biology, which have resulted from the use of *in vitro* cultures, open up extensive new horizons to research on plant genetics and to the problems involved in the improvement of cultivated plants. It is most likely that in the not too distant future these results will lead to new and important discoveries.

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The weather forecast - a problem in data processing

It was recognised decades ago that the weather must be predictable but at that time there was no means of performing the enormous mass of calculations required. It is only now that we are on the way to constructing the high-speed computers essential for a job of this kind.

ERNST LINGELBACH

WEATHER FORECASTING is a typical problem in data or information processing. The "information" is generally acquired by observation, and is "processed" in a particular way. The outcome is the weather forecast, which, at least in theory, provides an indication of the forthcoming weather pattern, its quality depending on the completeness of the input data and the effort expended on their evaluation.

In the simplest case the observations are made at little cost and their evaluation is equally simple. The result is correspondingly poor.

observation:
rain before seven;

forecast:
fine for eleven;

observation:
Friday fine;

forecast:
Sunday shine;

observation:
the fish are jumping;

forecast:
there'11 be a hot summer.

Prof. ERNST LINGELBACH is responsible for meteorology in the West German Ministry of Transport.

We have all heard examples of this kind of weather lore. It is amusing, and may sometimes have a grain of truth in it, because it is also based on the "observation, processing, forecast" principle, if only in a very simple form. Some of these sayings about the weather are even quite effective for very short-range forecasting, covering the next few hours. The official meteorological services, however, have something far better to offer, although the effort which they put forth in order to achieve it is considerable. As in many other fields, the principle of no reward without effort also applies in weather forecasting.

In the "processing" of the observed data, weather sayings like those quoted above rely on existing information of a quasi-statistical nature, based not on genuinely statistical methods but on intuition, i.e. subjective impression. Whether Friday's weather is the same as Sunday's, for example, can hardly be gauged from memory.

In this case figures for the years 1901-10 show that on 278 Sundays the weather was the same as on the previous Friday, whereas on 243 Sundays it was different. The ratio was 53 to 47. Therein lies the grain of truth in the saying. Nowadays it would be comparatively easy, using electronic data processing systems, to establish statistics of this kind accurately, without relying on memory. A glance at the physical phenomena which ultimately determine the weather shows, however, that it would be pointless to look for simple connections between observations and the subsequent weather such as those which form the basis of the old saws. The mechanism of the atmosphere is far too complicated for that.

Simulating the mechanism of the atmosphere

For an optimum weather forecast, therefore, the mechanism of the atmosphere must be simulated as fully as possible, using a model atmosphere that is "speeded up" in relation to reality, rather like the motion of the stars in a planetarium.

If the model is aligned with actual atmospheric conditions it will then show, say, an hour later, the state of the atmosphere 24 hours ahead, thus providing a 23-hour forecast. If the same model is run for two hours it indicates the conditions 46 hours ahead, and so forth. Since very high speeds are possible with modern computers, a model can conceivably be designed to supply the desired result in one second.

The precise nature of a model of this kind, however, is at the moment an open question.

There are two considerable difficulties to be overcome: the model must be brought into alignment with actual atmospheric conditions at a specific moment in time, and it must simulate the physical laws governing the atmosphere. A fairly crude model could, for example, take the form of a water tank rotating like the earth, with the water representing the air. It would, however, be quite impossible to make the model reflect the state of the atmosphere at a particular moment in time and to represent anticyclones and depressions, storms and calms, or rain and snow.

Though other mechanical models might be envisaged, they all have to be rejected out of hand for the same reason. Only mathematical models,

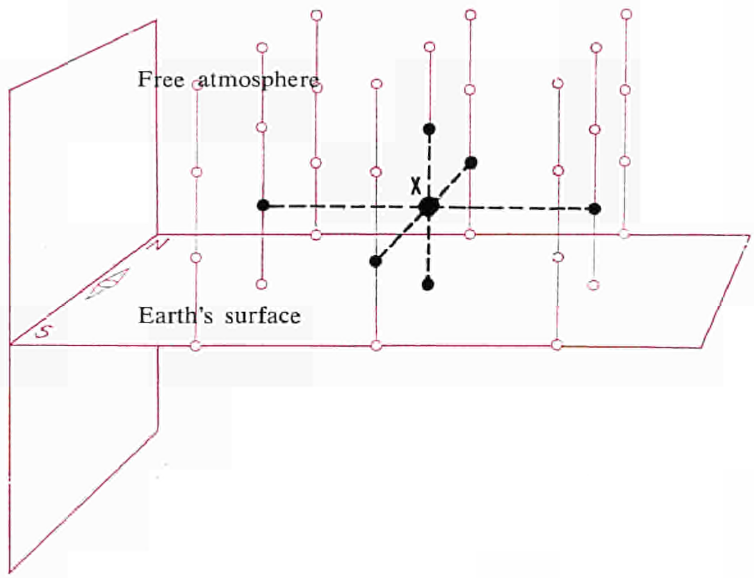


Figure 1: *Detail of the grid structure of a mathematical model of the atmosphere. A point x is shown along with the adjacent points. The future values of the atmospheric parameters at the point x are computed by comparison with the (present) values at the adjacent points. More distant points are also taken into consideration.*

There are some 20,000 points in the grid and each is treated in turn as point x. In order to produce a 24-hour forecast the calculations described in the text are performed about 1,000 times for each point in the grid, assuming a model of medium complexity.

which can be rendered extremely flexible, are a practical proposition.

Input data

A mathematical model simulates the state of the atmosphere by using digital data to denote each point in space. A numbering system is used to identify the points considered, e.g. the longitude and latitude and height above sea level. The data contain code letters relating the figures to temperature, wind, barometric pressure, humidity, etc., and are recorded in some appropriate manner—the simplest being to list them in columns. An example might read like this: Point 52° 30′ N, 13° 20′ E, height 5 km, 1 September 1970, 0600 hrs GMT, P 550, T −16, F 80, W 230/38. This would mean that over Berlin, at 5,000 metres altitude, the air pressure is 550 millibars, the temperature −16°C, the relative humidity 80%, and the wind is blowing from the southwest at 38 km/h. The letters could be dispensed with if the data were always presented in the same sequence.

There is no difficulty in setting up the initial conditions on this type of model. The data can only be given for individual points, however, and not continuously, as in the actual atmosphere. Even if a fairly wide-meshed three-dimensional grid is envisaged, the resulting number of points is very considerable. If only the intersections of the meridians and parallels and the height at 1,000 metres intervals were taken as the basis, for instance, over a million data on the pattern described above would be required in order to represent the state of the portion of the earth's atmosphere of interest. The use of records in the form of lists as a means of establishing the initial state can therefore be ruled out for reasons of time, even if the grid is made appreciably less dense.

Large electronic data-processing systems, however, have no difficulty in storing such quantities of data. These systems can easily generate a static model of the state of the atmosphere at a specific moment.

A difficulty arises, however, from the fact that for practical reasons meteorological observations and measurements are not made on a uniform grid; indeed, it is quite rare for an observing station to be located at a grid point. In many areas the stations are comparatively thick on the ground, while in others, e.g. oceans and inhospitable regions, they are few and far between.

The values relating to the various grid points can, however, be worked out by interpolation, generally with satisfactory accuracy, provided that the interpolation procedures are comprehensive enough and make allowance, where necessary, for variations with time; linear interpolation would not be sufficient. The high computing speeds of modern electronic data processing facilities permit interpolation on this massive scale.

The next step is to incorporate the working of natural laws in the atmosphere into our model.

Linking the data together

Instructions must be formulated for the further handling of the starting data. Such instructions are difficult to put into words, but relatively easy to express in mathematical symbols. They link the data with neighbouring points in space. This type of link may, for example, take the following form:

The west-east component of the wind changes in the course of a unit of time by an amount calculated from the product of the component itself and the change therein on proceeding to the next observing point eastwards, plus the product of the north-south component of the wind and the change in the west-east component on proceeding to the next observing point northwards, plus the product of a geographically determined constant for that particular location and the north-south component of the wind, plus a quantity which depends on several factors, such as the temperature difference between the measuring points at different heights on the same vertical and the difference between the differences in the east-west components found at measuring points above and below the one under consideration. The air density at that measuring point and the difference in air pressure with respect to the nearest grid point to the east are also included in the calculation.

In the simplest case there are six of these instructions, and they are interrelated.

The computer then has the task, using these instructions, of determining the variation with time of the individual parameters, e.g. the east-west component of the wind, as mentioned above, and the temperature, pressure, humidity, etc., for each point in the grid. For reasons stemming from the laws of physics and mathematics the time step cannot be taken as much higher than 10 minutes.

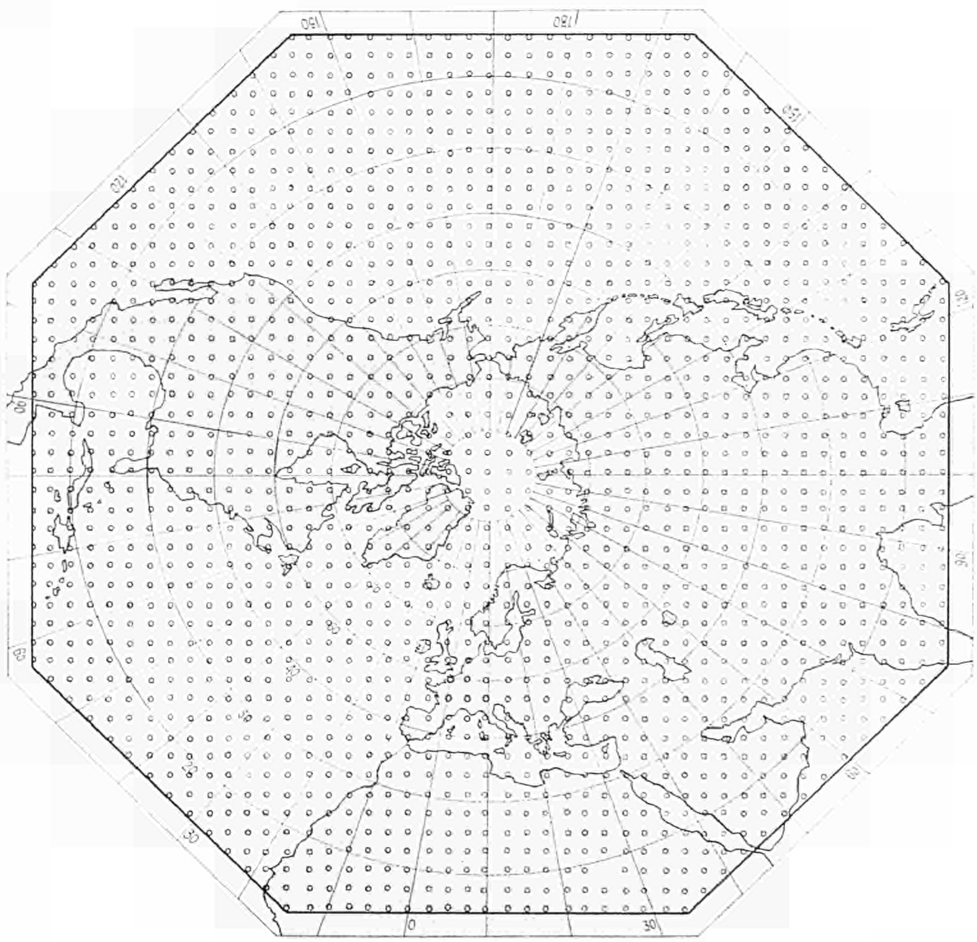
When the machine has performed the calculations for all grid points, which entails several iterations for each point on account of the correlation of the six instructions, the model "works". It now contains the values of the atmospheric parameters that will come into operation 10 minutes later than the starting conditions. This is tantamount to a forecast, if the computer completes its task in less than 10 minutes, say in one minute.

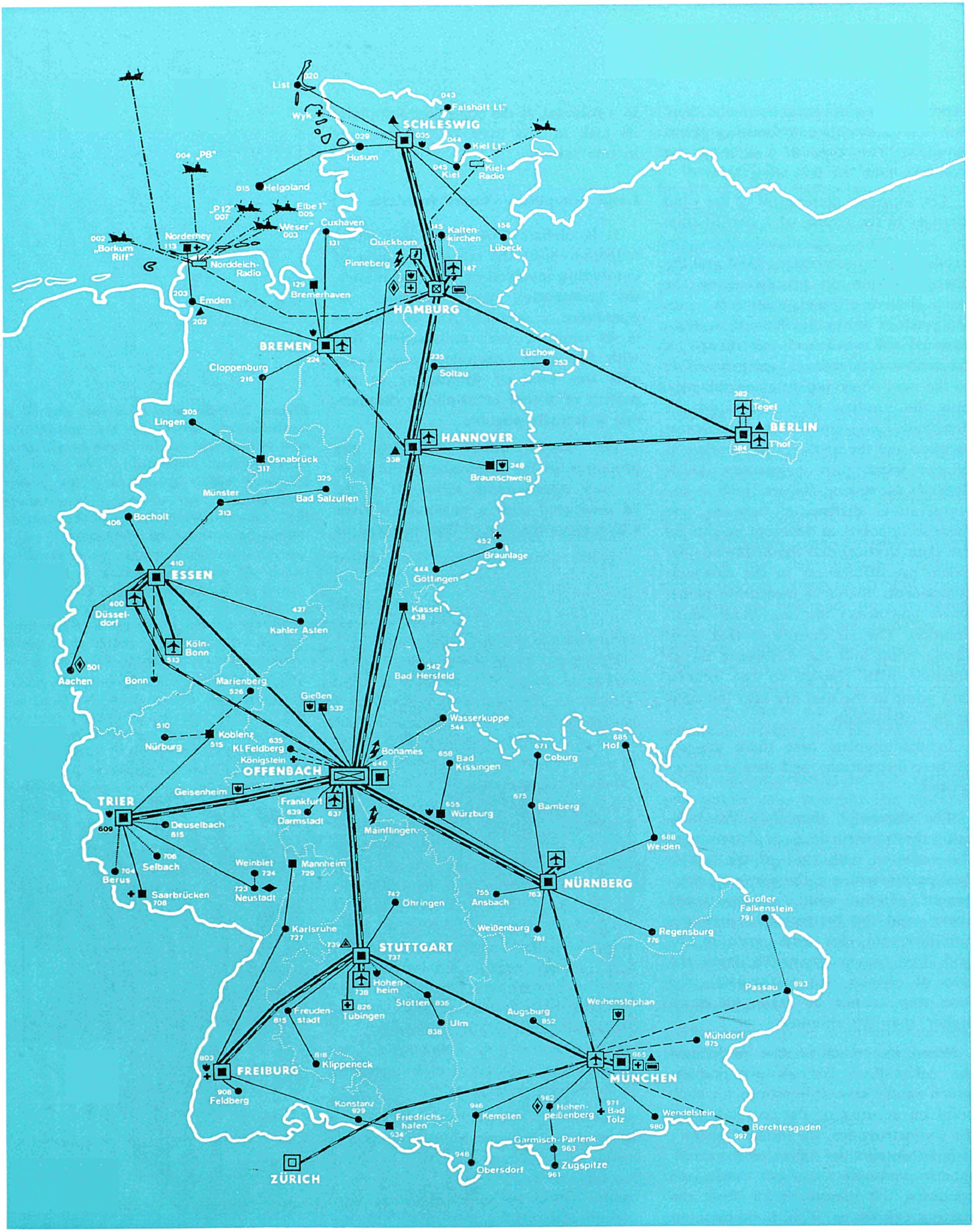
Large computers—better forecasts

It is difficult for the human mind to comprehend the colossal amount of computing involved or, for that matter, the computing speed—millions of operations a second. All we can do is to observe, with satisfaction, that with the large computers now available this kind of forecasting of the pattern of future atmospheric phenomena is actually possible.

The above model describes the processes in the atmosphere, but only in very approximate terms. It might be compared with a model of a river which states the rate of flow but ignores

Figure 2: *Base points on the grid of a mathematical model of the atmosphere now in practical use (northern hemisphere, stereographic projection). The grid is relatively widely spaced, with few points over Europe, for example. This means that many important details of the weather cannot be covered by the model.*

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Lingen
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Tegel
BERLIN
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T'hof
HANNOVER
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Osnabrück
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Figure 3: *A typical meterological observing network supplying the input data for the mathematical grid used in weather forecasting by computer (German Meteorological Service).*
The whole world is covered by such grids, although some are much less dense. They are essential to weather forecasting.

Key to symbols used

- Central Forecasting Office
- Meteorological radio transmitter
- Telecommunications Group
- Nautical Weather Office
- Regional Weather Office
- Aeronautical Weather Offices
- Observing Station
- Auxiliary Observing Station
- Aerological Research and Testing Station
- Aerological Observing Station
- Training School
- Meteorological Station
- Instrument Laboratories
- Agricultural Meteorology Research Station
- Agricultural Meteorology Advisory Centres
- Medical Meteorology Research Stations
- Medical Meteorological Outstations
- Weather Ships
- No. 1 Teletype Channel
- No. 2 Teletype Channel
- Teletype Link of the Service
- Public Teletype Link
- Telephone Link
- Radio Link.

the eddies downstream of bridge piers and the special flow patterns by the banks, etc. If knowledge of the flow rate is all that is required, it is a good model, but as regards fine details it leaves a great deal to be desired.

There are two reasons why the model increasingly diverges from the actual pattern of events in the atmosphere the longer it is run without being updated with fresh data.

Firstly, it is difficult to establish the true initial state of the atmosphere at all the numerous points on the grid, where it must be accurately measured, and secondly, serious problems arise in taking account of all the processes at work in the atmosphere by computer routines of the type mentioned (designed to supplement the six basic instructions). Some of these processes, such as atmospheric turbulence, cannot even be treated in detail but only broadly.

With the observational data and large-scale computing facilities available nowadays the average deviation between the model and actual atmospheres in forecasts for up to 36 hours is relatively small. Usable results are even obtained for 72 hours ahead. Only the basic atmospheric data are supplied, however. Models describe primarily the variation in air pressures and temperatures and changes in the pattern of the wind, but most of them say little or nothing about precipitation zones, cloud cover, visibility and other important parameters. In this respect meteorologists still have a decisive role to play in supplementing the information supplied by machines.

Such is the aim of present development, however, that eventually they will be entirely relieved of this task, and their job, in this field of meteorology—daily forecasting—will be the continuous improvement of the models.

Advances can certainly be made by improving the network of observing stations and refining the data-processing instructions. This presupposes a denser grid network. Overall, computing requirements are increasing very

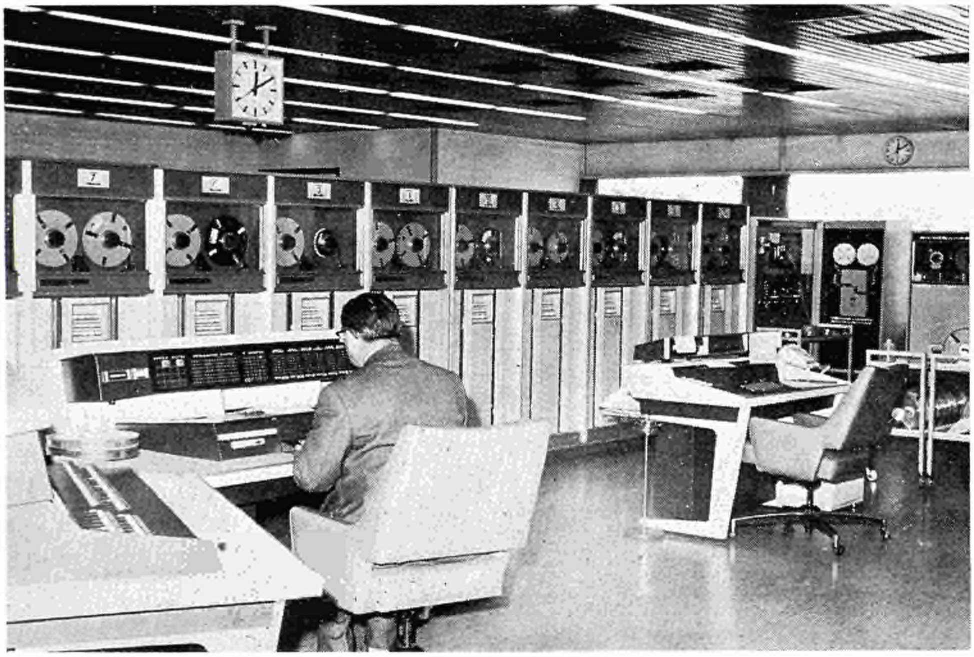

Figure 4: *Part of the German Meteorological Service's computer facility at its Central Forecasting Office, Offenbach am Main. The photograph shows the control consoles and magnetic tape units.*

The installation is used to operate a 24-hour programme providing up-to-the-minute advice to aviation, shipping, agriculture and forestry, the construction industry and many other branches of the economy.

The facility is also used for meteorological research and almost all other fields of activity covered by the meteorological service (climatology, agricultural and medical meteorology).

considerably and can only be met by the very biggest machines.

With present-day technical capabilities, forecasts covering seven to ten days should not prove impossible.

Whether a computer/model combination can be developed to produce genuine long-range forecasts, i.e. covering periods measured in years or even in centuries, we shall simply have to wait and see.

International cooperation

At present efforts in all countries are being directed towards the provision of better initial data, research into more comprehensive software, and the use of higher-power computers.

Improved observing networks over land and sea, special weather ships and buoys, meteorological satellites and sounding rockets—all these will enable the starting conditions fed into the model atmosphere to be brought closer to reality than is now the case. Cost/benefit analyses show that considerable spending on this exercise is warranted by the great economic importance of longer-range weather forecasting.

National efforts in this field should needless to say be backed up by close international or regional cooperation. This explains why proposals have been advanced for a European meteorological computer centre with the task of carrying out research aimed at making seven- to ten-day forecasting a practical proposition for the European area.

Europe's national meteorological services could then concentrate more fully on short-range forecasts for their own countries, possibly using a much more closely-spaced grid and even more sophisticated computing procedures. Orographic features could thus be taken into account and details covered which would complicate the "long-range" model unnecessarily.

To abide by our example of the flow model described above, the European computer centre could provide the broad-brush picture, thereby supplying the national services with the input data for a very thoroughgoing prediction of small disturbances and local phenomena.

This division of labour will be necessary because not even a very large computer centre will be able to supply all the information needed in Europe for aviation, shipping, agriculture, construction, public health, etc. At present it would also be uneconomic—even if the requisite data could be generated centrally—to set up the required fast data-transmission network.

The aim can be clearly discerned. Better observational data, more refined mathematical models and high-speed computers with large storage capacity will lead to a substantial improvement in weather forecasting over the next ten years. Such an optimistic view is justified by recent experience.

EUSPA 9-15

Under this title *euro-spectra* regularly reports some of the new processes or equipment recently developed at the *Joint Research Centre's* establishments or at the works of firms or institutes performing research under contract to the Commission.

It will be recalled that, under the Euratom Treaty, knowledge thus acquired by the Commission can be communicated to interested firms in the European Community under favourable conditions.

Any firms interested in acquiring a deeper insight into these possibilities should write to: Commission of the European Communities, D.G. XIII-A, 29, rue Aldringer, Luxembourg.

Unidirectional solidification of eutectic alloys

A method for producing composite materials

GIORGIO BEGHI and GIOVANNI PIATTI

A DOMINANT FEATURE of the trend of technical progress in the last decade has been the continued demand for materials with more and more sophisticated mechanical properties which can withstand increasingly severe chemical and physical operating conditions.

This trend seems likely to continue; on the other hand, there is a risk that the possibilities opened up by new discoveries may remain to some extent untapped if new materials are not devised.

A feature of developments during the last few years has been the increasing use of combinations of different materials. These materials are known as "composites" and, because of a synergic effect, they often display characteristics which are an order of magnitude better than those of their individual constituents (or of a very different kind).

The idea behind these composites is not new, and is to be found in nature itself: wood is an example of a combination of strong fibres (cellulose) and a ductile matrix (lignin). The optimum combination of these two substances produces the good mechanical properties of wood, which are not to be found in cellulose or lignin alone. From the earliest times, man has imitated nature by developing materials based on the composite concept. The ancient Egyptians made a wood with special isotropic resistance properties (i.e. equal in all directions) by superimposing alternately crossed layers of wood with individual anisotropic strength properties. Other classical examples are the swords of the craftsmen of Damascus and the Samurai of Japan, which consist of alternate layers of different types of steel, from the hardest to the mildest. This results in a sword which is made of a hard material, but at the same time is sufficiently ductile to be curved and is virtually unbreakable.

What is a composite material?

There have been many different definitions of composite materials, according to the field of interest to the scientist concerned (magnetic properties, electrical characteristics, mechanical strength, etc). Broadly speaking, a composite material may be said to be a material consisting of at least two chemically distinct phases, with a definite separation interface and characteristic properties which are not to be found in the separate constituents.

The criteria on which classification is based also vary, but they usually relate to the morphology of the material. Besides structures made up of alternate layers of different constituents, various dispersions in a matrix and impregnated frameworks, there is the fibrous structure, which is considered typical. Materials described as fibre-reinforced are those in which one phase is present in the form of filaments (or lamellas) with diameters (or thicknesses) ranging from fractions of a micron to several microns, for values of concentration by volume ranging from a few per cent to as much as 70%; moreover, these filaments or fibres usually lie in one direction.

At this point it is worthwhile recalling a particular characteristic displayed by many materials in the fibrous state, namely a considerable increase in their strength properties compared with the normal solid state. The mechanical properties of materials with a whisker structure, i.e. single crystals a few microns in diameter and virtually free

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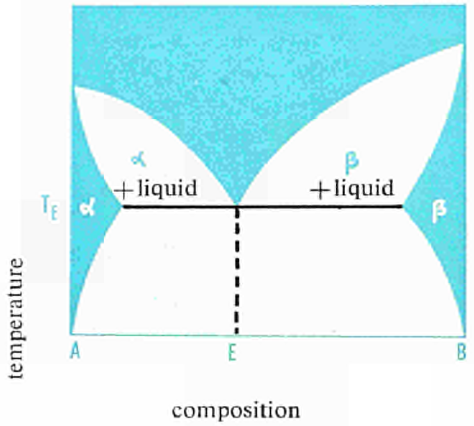


Figure 1: *Example of a binary eutectic diagram.*
E=eutectic composition. The element (or compound) B is partially soluble in A and vice versa.

of the imperfections found in ordinary crystal structures, are even better.

With fibrous composites, the high strength of the fibre can be exploited: the basic principle here involves the use of the deformation of the matrix to transfer the stress applied to the composite, via the interface, to the constituent fibres, which can withstand a heavy load. The resistance of the composite in this way comes close to that of the fibres.

Another interesting feature of these materials is their better resistance to crack propagation. A crack formed at the surface of a homogeneous material may propagate under stress and ultimately lead to the rupture of the material itself. In the case of the composite, fracture of one of the fibres may be caused by the presence of a defect but it cannot spread to the others since the fibres do not form a coherent whole.

The possibility of using strong but brittle composite materials means that ceramics and refractories can also be considered as possible constituents, so that fibres made from substances maintaining their good properties even at high temperature are conceivable. Composite materials thus have an attraction if very good high-temperature mechanical properties are required, since they offer a means of overcoming the limitations imposed by high temperature on all types of material. The impetus in this direction stems from the requirements of advanced technology in connection with developments in the field of space, high temperature reactors, gas turbine technology, etc.

It should be borne in mind, however, that the oriented fibrous structure is anisotropic and therefore the material also behaves anisotropically. This fact to some extent limits the scope of these materials, which are thus not in general use. The anisotropy, however, is at the same time a reason for opening up new fields of development in that it can be turned to good use in order to attain particular objectives; this is the case with some of the physical properties, rather than the mechanical strength of these materials. In these cases the choice will fall on composite systems with two phases having different characteristics with respect to electrical conductivity, thermal conductivity, magnetism, optical properties, etc. A possible example is that of a composite made of conducting fibres in a semiconductor matrix: the electrical resistance of the material can be varied considerably when the composite is placed in a magnetic field, depending on whether the field is parallel or perpendicular to the fibres. It is possible here to create a contactless switch, since all that has to be done is to influence the direction of an external magnetic field.

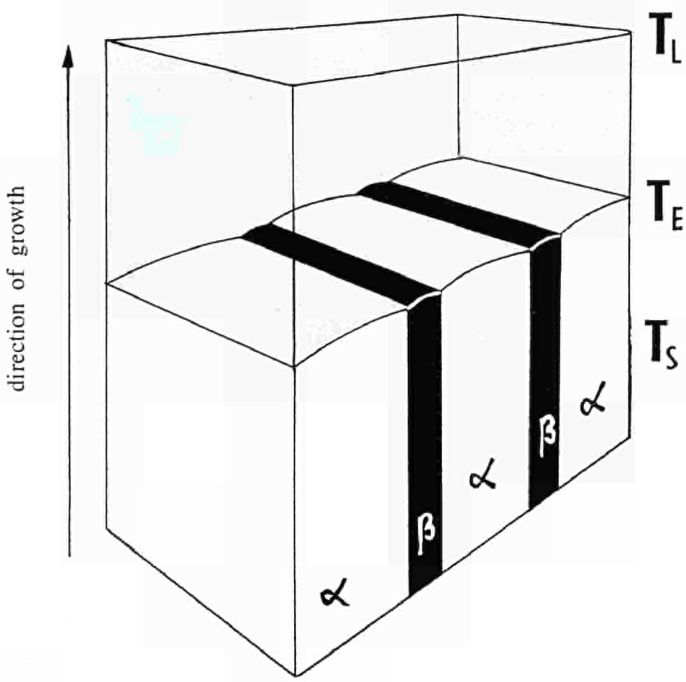


Figure 2: *Formation of a lamellar structure (α and β phases) in the solidification of a eutectic. The solidification front is perpendicular to the direction of growth. T_L, T_E and T_S are respectively the temperature of the liquid, the temperature of the solidification interface (eutectic temperature) and the temperature of the solid.*

The unidirectional solidification of eutectic alloys

There are numerous techniques for the production of composites, all consisting of two main stages, namely production of the fibres and their incorporation in the matrix.

For the production of the fibres, the methods used include mechanical processes, vapour deposition, chemical reaction with deposit on a substrate, or direct production from the liquid phase. Further processing is required to obtain the composite: the matrix can be combined with the fibres in the liquid state, by an infiltration process, or in powder form, using mixing techniques similar to those employed in powder metallurgy, or by making alternate layers of foil, or by other methods. Other operations are also necessary to obtain the final form of the composite, such as hot extrusion, rolling, diffusion treatment, etc. Whatever the production method used, great care must be taken that (a) breakage of the fibres is kept to a minimum, (b) the strength of the fibres is maintained during each phase of the process, (c) there is a good bond between the fibres and the matrix, and (d) the desired distribution and orientation of the fibres are achieved.

One method for the production of composites which differs from the others in one particular respect is what is known as the unidirectional solidification of eutectics; with this technique the fibres can be formed *in situ,* since they are grown directly in the matrix in a single operation. The conditions in which the two phases are produced are close to equilibrium, thus giving a structure with high thermal stability at high temperatures—very important for purposes of practical application.

Let us now examine briefly the eutectic reaction and the experimental equipment required for using it for the above-mentioned purpose.

Eutectic reaction

Many binary phase diagrams show the eutectic reaction, which consists in the transformation of a liquid phase into two solid phases at a specific and constant temperature. From the phase diagram it is possible to determine the composition of the two solid phases constituting the eutectic, their fraction by weight in the eutectic structure and the volumetric ratio if the respective densities are known. An example of a phase diagram with a eutectic is shown in Fig. 1. When an alloy of eutectic composition in the molten state is solidified using a conventional technique (e.g. sand or shell casting), the microstructure obtained is a mixture of the two phases making up the eutectic (α and β constituents in Fig. 1), which show irregular forms (dendritic, globular, etc.) and different orientations.

If solidification is controlled and heat is passed off in a single direction, the two phases of the eutectic structure obtained are lamellar and parallel to one another, or else the second phase is in the form of aligned fibres or lamellas immersed in the first phase, which acts as the matrix. The alignment of the lamellas and fibres is the same as the direction of heat extraction. The morphology may, however, vary, depending either on the system used or on the various factors involved in solidification, which in turn are governed by the experimental conditions.

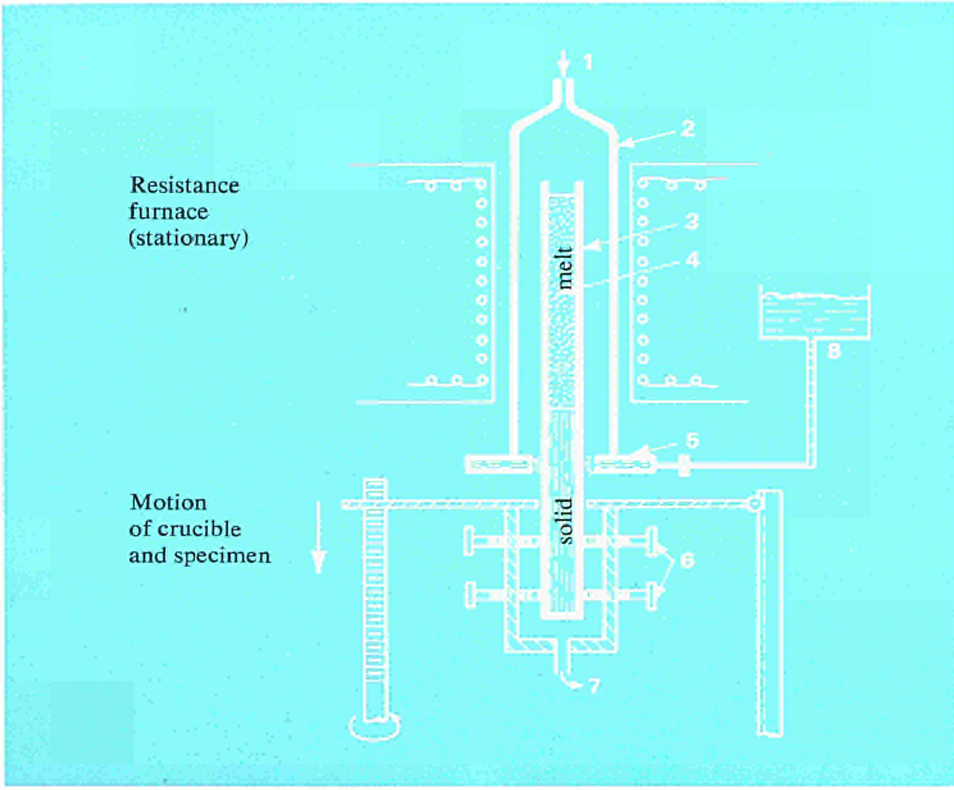
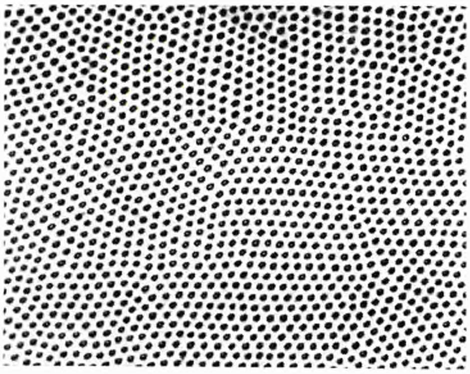


Figure 3: *Diagram of the unidirectional rig used in the Metallurgy Division laboratory at Ispra to obtain composite structures in various aluminium-base eutectic systems (Al—Al_2Au, Al—Al_4Ca, Al—Al_4Ce, Al—Al_2Cu, Al—Al_3Y, Al—Al_3Ni, Al—Al_3Pd, Al—Al_4Pt, Al—AlSb). The velocity of the solidification front can be varied between 0.1 and 80 cm/h. The desired temperature gradient G is obtained from a combination of various factors: furnace temperature, position of cooling jet, flow of cooling water.*

1) Ar
2) vycor tube
3) graphite crucible
4) specimen
5) water spray collar (stationary)
6) mounting screws
7) H_2O exit
8) constant head tank



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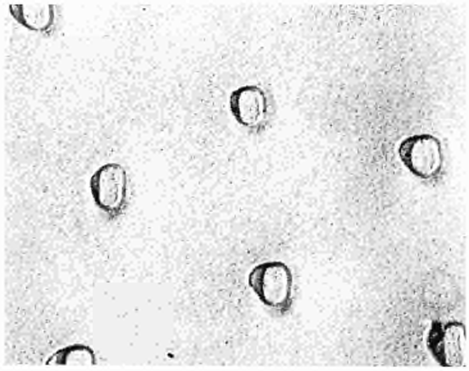

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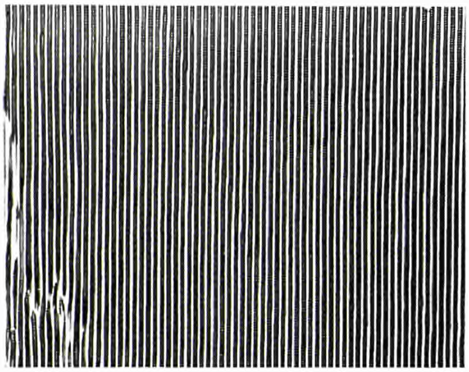

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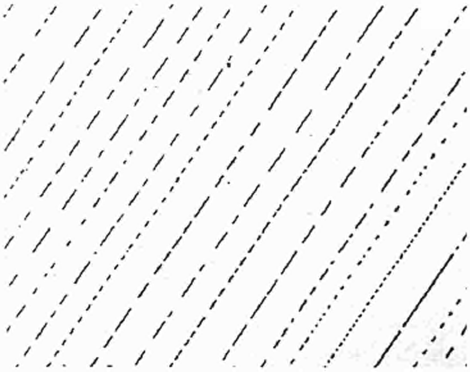

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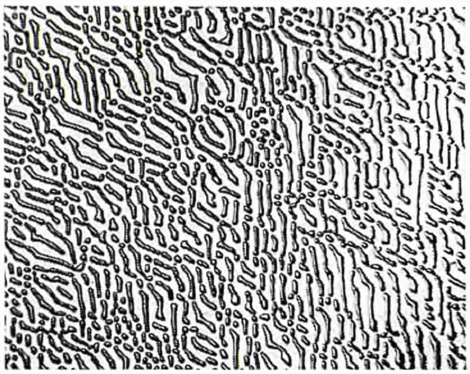

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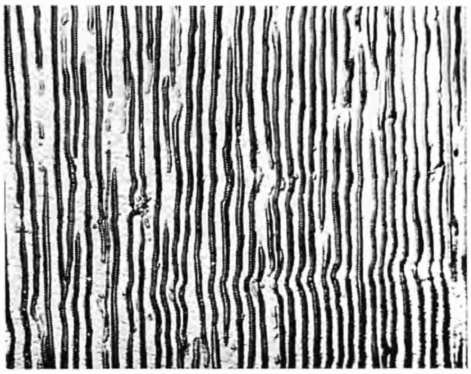

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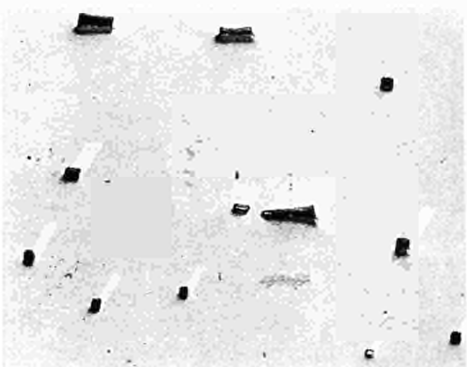

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Not all eutectic alloys can be used to obtain structures of the composite type defined above. There are as yet no complete theories to explain the phenomenon. Only experiments can provide direct information on each system; with the data obtained from phase diagrams it is impossible to predict whether the structures obtained will be fibrous or lamellar.

Experimental apparatus

The basic idea is to create a mainly uniaxial heat flux. This can be done by extracting the material from the furnace in the liquid state; a plane liquid/solid interface forms perpendicular to the direction of extraction from the furnace. This interface passes along the entire length of the ingot at a specific velocity.

Because the two phases solidify at the liquid/solid interface and follow this front as it moves, the resulting

Figure 4: *Fibrous structures cross-sections.*
(a) *Al_3Ni fibres in an Al matrix (×600).*
(b) *Al_4Pt fibres in an Al matrix (×12,500).*

Figure 5: *Lamellar structures.*
(a) *Continuous Al_4Ca lamellas in an Al matrix. Longitudinal section (×300).*
(b) *Broken AlSb lamellas in an Al matrix obtained from eutectic Al—Sb. Cross-section (×250).*

Figure 6: *Mixed lamellar and fibrous structure. The bent lamellas have a virtually constant angle. Cross-section* (a) *and longitudinal section* (b) *(×150). The structure was obtained with the Al—Al_4Ca eutectic unidirectionally solidified at a rate of $R=0.3$ cm/h.*

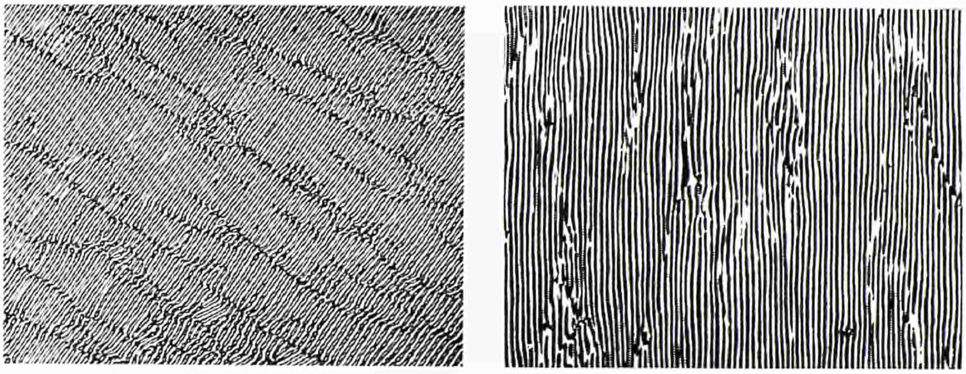
Figure 7: *Electron micrograph of the Al—Sb eutectic after unidirectional solidification (×2,500). The oriented phase represented by the AlSb intermetallic compound was revealed first by prolonged chemical attack to make the fibres project from the aluminium matrix, and then by a shadow effect obtained during preparation for electron microscopy.*

structure is made up, as has already been mentioned, of two phases oriented parallel to the direction in which the heat is passed off. The diagram in Fig. 2 illustrates the formation of a lamellar structure.

The experiment can take various forms, depending on the chemical and physical characteristics of the alloys processed (e.g. diffusion temperature, crucible compatibility).

One of the rigs used in the Metallurgy Division laboratories of the *Joint Research Centre's* Ispra Establishment is shown diagrammatically in Fig. 3; this apparatus is used for studying aluminium eutectics. The main parameters involved in unidirectional solidification which, as was stated above, determine the structure and morphology of the solidified material are:

(a) The temperature gradient G, which follows the solidification front in the direction of motion;



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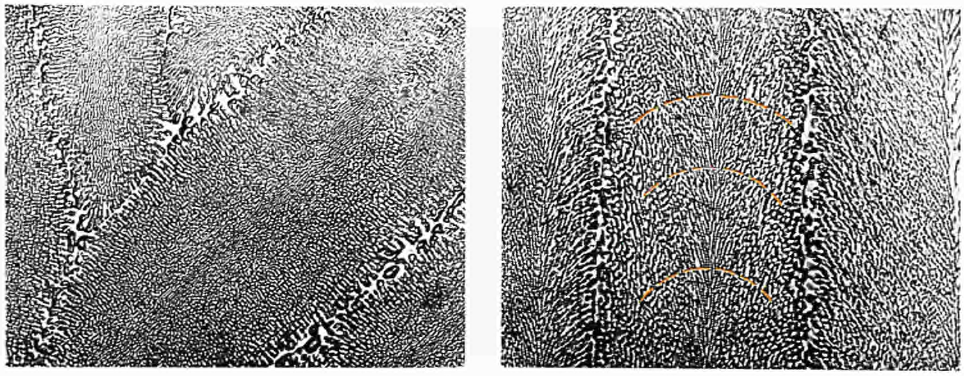

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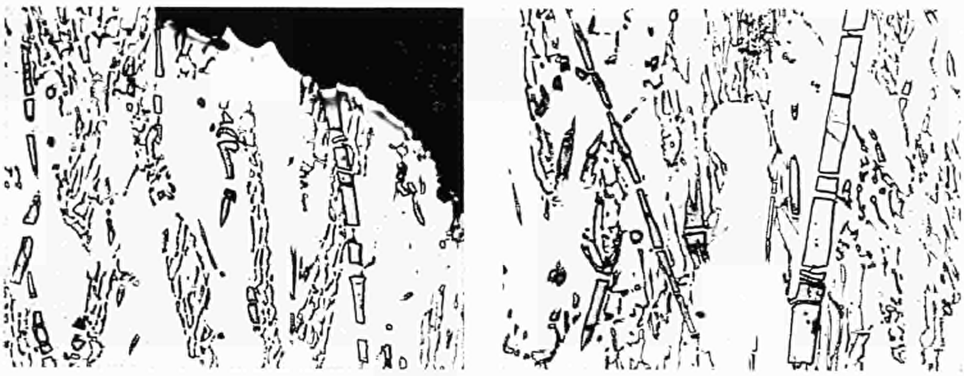

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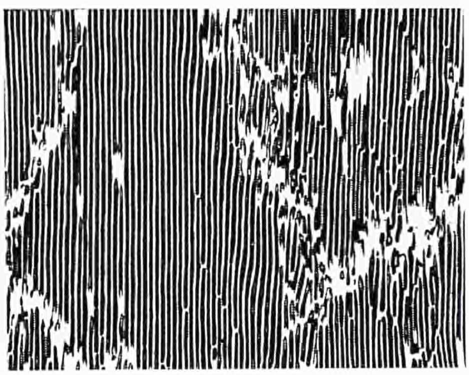

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Figure 8: *Defects formed during growth of lamellas: cross-section* (a) *and longitudinal section* (b) *of an* Al—Al_4Ca *eutectic solidified at* $R=9$ *cm/h* ($\times 300$).

Figure 9: *Cellular microstructure (colonies)* ($\times 300$).
The cross-section (a) *shows that the structure tends to be lamellar in the central area of the colony and fibrous at the grain boundary.*
In the longitudinal section (b) *the curvature of the solidification front can be reconstituted. The structure was obtained with the* Al—Al_4Ca *eutectic.*

Figure 10: *Micrographs of a specimen of the* Al—Al_3Y *eutectic after tensile testing to failure; the fractures of the fibres in the matrix are clearly visible.*
(a) *Rupture zone.*
(b) *Uniform strain zone* ($\times 200$).

Figure 11: *Specimen of the* Al—Al_4Ca *eutectic after tensile testing to rupture at a temperature of 450°C. The fractures in the fibres are visible, particularly in the zones adjacent to alignment defects.*

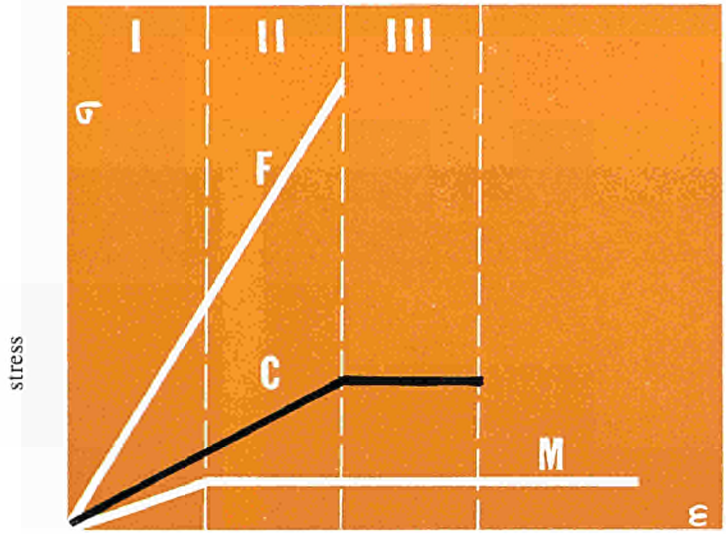


Figure 12: *Stress-strain curve (broken line C) representing the behaviour typical of a composite fibrous material subjected to tensile stress. The corresponding curves for the matrix and the fibre are shown by the continuous lines M and F respectively. Stage I represents the elastic deformation of the fibre and matrix, Stage II the elastic deformation of the fibre and plastic deformation of the matrix, and Stage III rupture.*

(b) The solidification rate R, corresponding to the velocity at which the solidification front moves.

Other parameters to be considered are the impurity content, which may have a considerable effect on the morphology, disturbances due to convection currents in the liquid and mechanical or thermal fluctuations of the solidification front caused by irregularities in the operation of the equipment.

Composite eutectic structures

The typical structures obtained by the technique described are of two kinds: fibrous and lamellar.

Examples of these structures, obtained with various types of eutectic alloys and in various experimental conditions at the Metallurgy Division laboratories, are shown in the micrographs in Figs. 4 and 5. Depending on the experimental conditions, different morphologies are obtained, such as mixed lamellar and fibrous structures (Fig. 6).

The clear distinction between the two phases, matrix and fibre, can be well demonstrated under the electron microscope (Fig. 7). The structures obtained may contain defects of different types, affecting continuity, perfection or direction. An example of this is the lamellar eutectic shown in Fig. 8.

The micrographs give an idea of the variety of morphologies possible, the various parameters concerned in the unidirectional solidification influencing the structures to varying degrees.

Let us consider, for example, the temperature gradient G, defined as $\frac{dT}{dx}$ where T is the temperature and x the distance from the solidification front.

When impurities are present, it can be demonstrated that, for a very slight temperature gradient, the solidification front can no longer be plane and takes on a convex form; this is the origin of cellular-type microstructures (colonies). Moreover, a critical value has been determined below which the G/R ratio no longer allows a front to be formed and leads to a cellular structure.

Furthermore, when the G/R ratio drops to values well below the critical value, dendrites are formed. An example of a colony microstructure is shown in Fig. 9. In certain cases dendritic structures are produced which depend on the influence of the various parameters involved and on the type of system. This proves that, in the case of eutectic systems, oriented (fibrous or lamellar) structures can be obtained by unidirectional solidification only if the various parameters involved are strictly controlled.

Moreover, the very nature of the system has a great bearing on the production of composite material. For instance, the volumetric fraction of fibre, which must be high in order to ensure that the composite has the desired mechanical properties, naturally depends on the eutectic composition. This composition can obviously not be regulated at will, so not all eutectic systems lend themselves to the production of composites. It should, however, be noted that similar structures can be obtained even in the case of systems which are not strictly eutectic.

Table I: *Comparative mechanical properties of two composite materials and two conventional alloys with aluminium base.*

	Al—Ce composite	composite Al—Y	Duralumin (Al—Cu—Mg)	Conventional heat-resistant alloy (Al—Cu—Fe—Ni)
Ultimate tensile stress at 400°C (kg/mm^2)	11.2	6.9	5.3	6.0

Mechanical properties

As has already been mentioned, a composite material uses a ductile matrix which undergoes deformation and transmits to the fibre, via the matrix/fibre interface, the stress applied to the composite. Bonding of this kind causes these fibre-reinforced materials to display a characteristic behaviour which can be seen from the stress-strain curves recorded in tensile tests. There are several different stages, described briefly below.

When the stress applied is below the yield point of either the matrix or the fibre, there is an initial strain on the composite due to elastic deformation either in the matrix or in the fibre. In the next stage the stress causes plastic deformation of the matrix, while the fibre deforms further elastically; when the fibre's limit of elastic deformation is reached, it breaks (Figs. 10 and 11). The typical rupture mechanism of a composite containing a ductile matrix and a brittle fibre is demonstrated in the stress-strain diagram in Fig. 12.

The mechanical properties determined for the composite materials are generally discussed with reference to the properties of the two constituents. The breaking stress of a composite is normally expressed as follows:

$$\sigma_c = \sigma_f \cdot V_f + \sigma'_m \cdot (1 - V_f)$$

where:

σ_c σ_f = breaking stress of composite and fibre, respectively;

σ'_m = stress in matrix for a strain equivalent to that leading to rupture of the fibres;

σ_f = volumetric fraction of fibres.

This formula is valid for continuous fibres. When the fibres are broken, other factors have to be introduced, namely the length of the fibres, l, the critical length of the fibres, l_c, and the critical volume of the fibres, V_c.

The term "critical length" (l_c) is taken to mean the minimum fibre length required for the matrix, when undergoing plastic deformation, to transfer to the fibres the stress applied to the composite. The critical volume (V_c) is the minimum fibre volume required to give the composite a strength greater than that of the matrix.

When $V_f > V_c$, still in the case of broken fibres, the formula giving the breaking stress becomes:

$$\sigma_c + \sigma_f \cdot V_f \left(1 - \frac{l_c}{2l}\right) + \sigma'_m(1 - V_f)$$

This formula has to be corrected when the load applied is not parallel to the direction of the fibres or lamellas. Obviously, in this case the mechanical strength of the composite drops as a function of the angle between the fibre direction and the stress orientation.

The alloys developed in the Metallurgy Division laboratories at Ispra (some of which are patented) can be divided into two types: aluminium-base eutectic alloys and heat-resistant alloys produced by other methods.

Al—Ce alloys containing 10 wt% of cerium, corresponding to approximately 12 vol% of the composite Al_4Ce, and Al—Y alloys containing 9 wt% of yttrium corresponding to approximately 16 vol% of the composite Al_3Y, have the mechanical properties shown in Table 1 and compared with those of conventional aluminium alloys.

At the Ispra Establishment a new composite obtained by unidirectional solidification and based on the Ni—Ta binary eutectic is under development. In the case of the simpler lamellar structures obtained, the breaking strength is of the order of 100 kg/mm^2 at 20°C and 70 kg/mm^2 at 800°C. These values are similar to the characteristics of special nickel alloys designed for use at high temperatures. Moreover, above 800°C, because of their high thermal stability, the mechanical strength of the Ni—Ta or similar composites is superior to that of these special alloys.

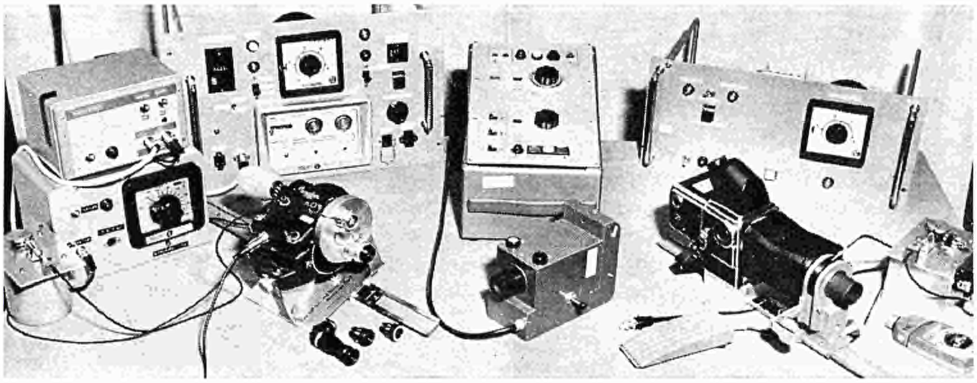
Unidirectionally solidified Ni—base eutectics are therefore of practical interest for temperatures of the order of 1,000°C and above.

These investigations confirm the potential attraction of this technique, which, if suitably applied, can in certain systems produce results warranting its industrial application.

EUSPA 9-16

Euratom patent list: (1) *British Patent 1,188,590:* The preparation of an aluminium-niobium alloy. (2) *British Patent 1,211,467:* Fibre reinforced alloy.

Technical Notes



The Commission's *technical notes* give descriptions of original results obtained under the Euratom research programmes. Their purpose is to enable firms to decide whether they should consider industrialising these results.

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Requests for additional information should be sent to: Commission of the European Communities, D.G. XIII-A, 29, rue Aldringer, Luxembourg.

— 55/C: Automation of still photography and/or filming

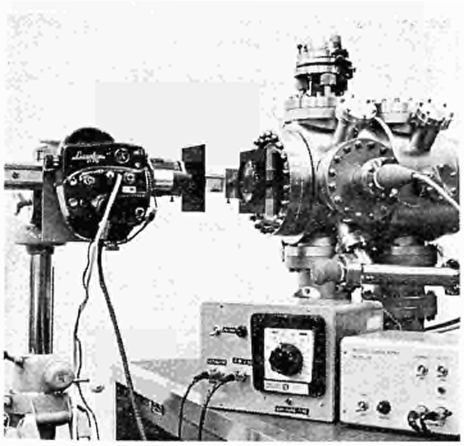
The study of long-time phenomena frequently calls for the use of time-lapse cinematography and this has led to the development of a fully automated camera system.

The system is designed to operate with 16, 35 or 70 mm film and permits, without the need for any outside attendance, the cyclic sequencing of complex operations differing considerably in detail over a period of one second to several hours, during which the modulation of subject lighting, the actual taking of the shots, the setting of the required exposure and the complete monitoring of the accessories are carried out reliably and automatically.

The system is self-monitoring and this capability also extends to all the accessories for which experience has shown the need. Audio-visual and telephonic fault alarms are provided. The system was designed by the Structural Analysis Department (*RML* Section) at the *JRC*, Petten. On completion of its own operating sequence it also switches off the accessories, which it also monitors, in the required time sequence.

— 56/C: Filming of quasi-static subjects in unfavourable lighting conditions

Internal modifications to a 16 mm cine-camera now make it possible to film in unfavourable lighting conditions without using an expensive electronic auxiliary lens system. During the filming of quasi-static subjects and continuous image sequences the shutter is electronically controlled so as to permit actual exposure times of between 1/10 and 2.5 sec.



A lightmeter working on the TTL (transistor-transistor logic) principle is used to measure picture brightness according to the sensitivity of the emulsion in use or to determine the shutter speed.

In these circumstances—with the camera loaded with sensitive film (400-8,000 ASA)—the whole of the available brightness scale can be covered up to the point where the image transmitted to the camera by the full-reflex viewfinder on the body is extinguished, i.e. until framing and sharp focusing become impossible.

This conversion of a cine-camera for night-time filming, astronomy, cine-micrography and -macrography, research laboratories, etc. was undertaken by the Structural Analysis Department, *RML* Section, at the *JRC*, Petten.

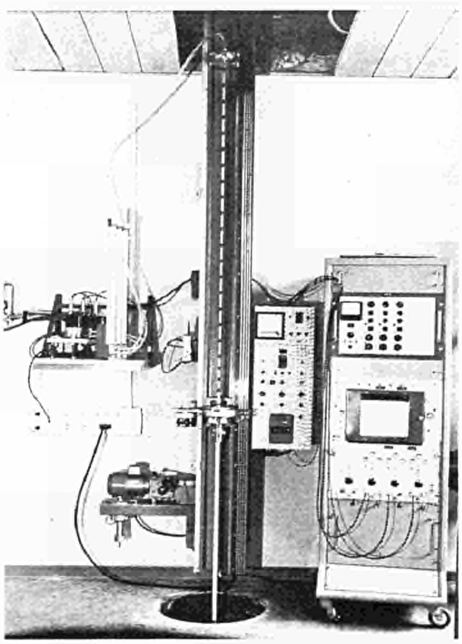
— 57/C: Vertical universal measuring bench

This measuring bench, the motions of which are fully automatic and infinitely variable, can be used for the mensuration of cylindrical componants along any desired envelope curve. The object to be measured passes in front of the measuring element, describing the prescribed curve either in steps or continuously. The measuring element can be installed at any point on the guide bed and can be applied either to the outer or inner surface of the tube.

Applications:

Broadly speaking, this equipment is suitable for comprehensive symmetry measurements on long cylindrical parts. Material and surface defects can also be readily detected on this bench with the aid of X-radiography or ultrasonic testing. In addition, the bench enables tube wall thicknesses to be determined easily and as frequently as desired by means of eddy-current or beta-ray methods.

It was specially developed for measuring the inside diameters of tubes by the *Solex* pneumatic method.



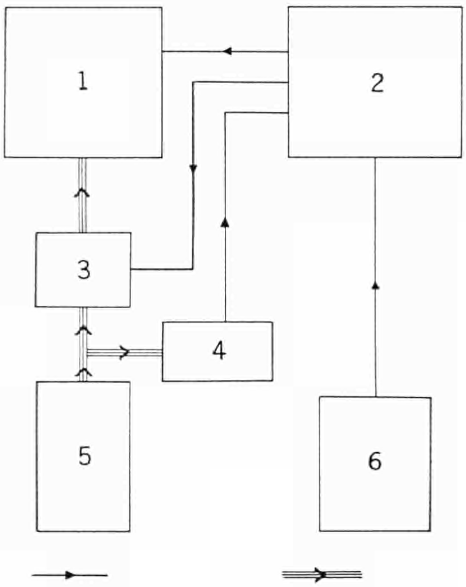
Performance data:

maximum span width: 50 mm
maximum measuring length: 3 m
motions possible:

- —rectilinear, vertical motion;
- —rectilinear, vertical step-wise motion;
- —rectilinear, vertical step-wise motion, combined with step-wise rotary motion;
- —vertical helical motion;
- —vertical, step-wise helical motion, combined with step-wise rotary motion;
- —rectilinear and helical, vertical step-wise motion;
- —continuous rotary motion;
- —step-wise rotary motion.

— 58/C: Automatic anti-vibration device for use in micrography

A 6×6 format micrography system has been constructed by carefully integrating a number of separate components and a specially developed and programmed remote control set-up. It is immune from vibration during operation and even the exposure time is automatically set. The system can be used to make a programmed sequence of 70 pictures without an operator. The film used is 70 mm. The illustration shows a block diagram of the system, which was designed by the Structural Analysis Department, *RML* Section, *JRC*, Petten, in order to facilitate photography through a microscope.

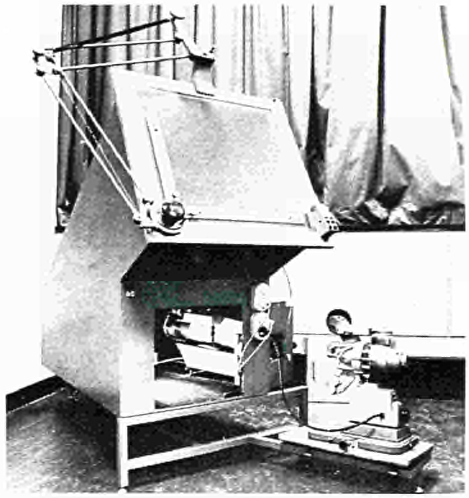


Electrical connections   Optical path

1) *70 mm electric reflex camera*
2) *Operating and control unit*
3) *Electronic shutter*
4) *Photoelectric call*
5) *Microscope*
6) *Programming unit*

— 59/C: Viewer for the analysis of films and slides in a wide range of sizes

This is a device for the macroscopic projection of films and photographs of



all sizes on to a large (50×50 cm) transparent screen. Having remote controls for advance, fine focusing, scale selection (by means of variable-focus lenses), counting out and positioning, it can be used for reading off linear dimensions and angles directly on the screen as well as for the numbering and statistical analysis of films, documents on film and slides of all sizes. The angular and linear measurements are accurate to 0.5° and 0.3 mm respectively.

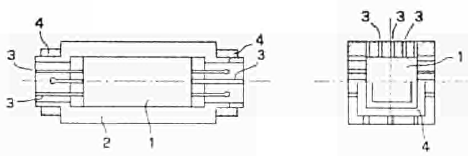
— 708: Method and apparatus for detecting radiation-induced inhomogeneities in metal wires

Radiation damage in thermocouple leads generates a thermal stress, which it is important to ascertain in order to ensure accurate temperature measurement. A precise method of detecting such faults is described, in which the lead is joined to an identical, but non-irradiated wire of the same length and then introduced into an oven, beginning with the join. The stress generated between the two unattached ends is attributable solely to the effects of radiation, since other influences cancel each other out owing to the opposite directions of the temperature gradients in the two wires. This development results from research arising out of co-operation between the *CEN* and Euratom on the operation of the *BR-2* reactor.

(German patent application 1,573,469; French patent 1,501,381; British patent 1,150,707.)

— 711: Capsule for irradiation specimens

The purpose of capsules of this type is to hold the specimen during loading, irradiation and unloading and to protect it from mechanical damage. This is done, without the use of complicated spring mechanisms, by means of a housing (2), which has slots (3) in its wall in order to increase its elasticity in at least one direction. At right angles to the slots are retaining clamps (4), made in a material with an appropriate coefficient of expansion, so that the specimen (1) is located with a constant pressure and free from play, even during temperature variations. This dispenses with the need to allow for the coefficient of expansion of the housing itself. By means of suitable insulation the slotted structure can be turned into a meander-shaped heating element for the electrical heating of the specimen.



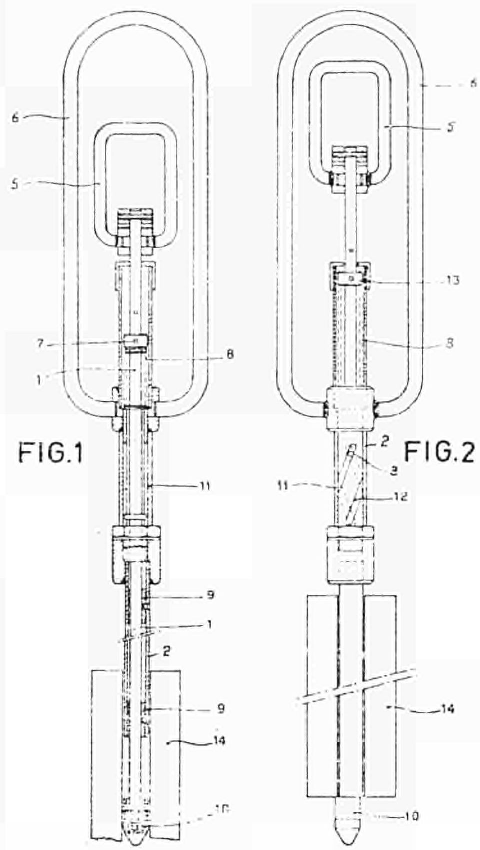
(French patent 1,490,832; Luxembourg patent 52,029; Italian patent 780,284.)

— 723: Liquid-level indicator

The position of a float provided with a magnetic marker and moving in a vertical tube is often determined by means of a coil and an oscillator circuit whose frequency variation is measured. If a single coil is used, accuracy can only be held constant over the whole length of the tube by moving it with a motor. This method is both time-consuming and expensive. According to the present invention, however, a single-layer coil with a large number of equidistant taps covers the whole measuring range. The taps are routed to a switching unit in pairs which are alternately connected to a common oscillator. The position of the marker is measured by cyclically scanning the tap pairs and simultaneously ascertaining the frequency variation of the oscillator. It is beneficial to arrange for overlapping of the measuring ranges, i.e. to pair non-adjacent taps.

— 863: Bar-shaped grapple for lifting and conveying tubular fuel elements

The grapple consists of a bar (1) which slides and rotates excentrically in a tube (2). At its lower end is a dog, (10) which is likewise eccentric. The dog is retracted into the outer tube extension piece (2) to enable the grapple to be introduced into the tubular fuel element (14) to be moved. During the



actual transfer operation the dog projects over the outer tube.

Two retaining collars (5 and 6) are located at the upper end of the grapple.

The collar (5) is connected to the inner bar and serves for the transport; collar (6) serves for the locking and releasing of the element being handled. There is no risk of operating errors.

(French patent 1,524,730; British patent 1,149,756.)

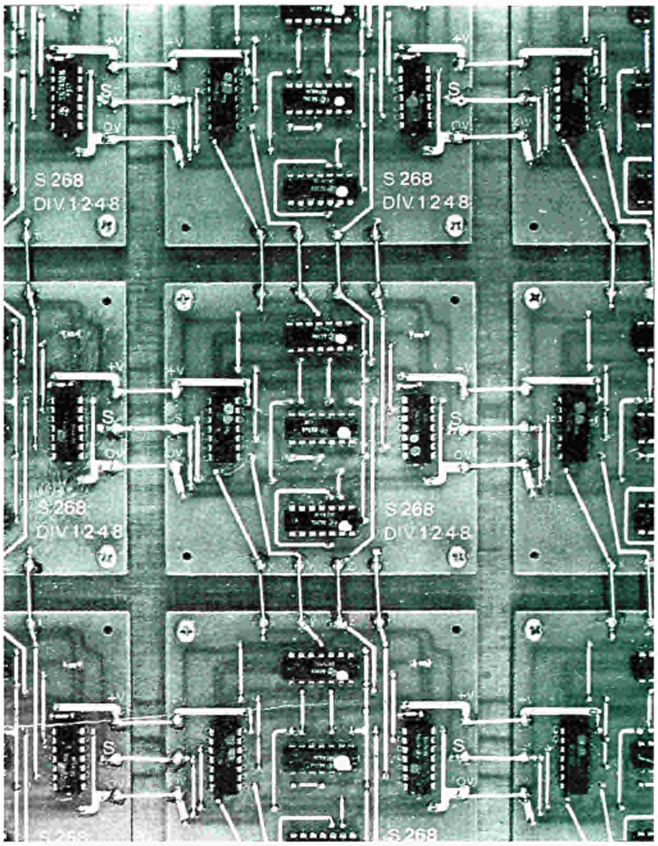
— 987: Device for the rapid detection of pressure-tube ruptures

Pick-up microphones mounted on the ceiling of the room to be monitored, gamma-radiometers and pressure sensors have all proved to have excessive response times and insufficient directional accuracy when used for monitoring leaks in nuclear installations. According to the present invention, however, sound-conducting narrow-bore tubes are fitted directly on the critical pipelines. The sound-transmission characteristic of the tubes is tailored to frequencies typical of leaks by means of transverse holes bored through them. Accordingly, a microphone at the end of the tube produces a significant signal only in the event of a leak in the section under surveillance. This section may, however, pass through wall penetrations or be rendered inaccessible for other monitoring systems by the presence of insulation layers; in such cases the tube is embedded in the insulating material or the penetrations.

(German patent 1,284,756; French patent 1,535,886; Italian patent 807,072.)

— 1450: Binary-to-decimal code converter

This is an encoding/decoding matrix for converting decimal figures into binary and vice versa. The matrix has a special structure and consists of identical logical cells, all interconnected in the same way.



The advantage of this type of structure is that it can easily be produced on a considerable scale as an integrated circuit. Depending on the possibilities of this design as integrated circuit, the manufacturer can begin by fitting one cell in a housing, then several and ultimately a very large number, since the network structure is very simple.

This converter also offers a number of advantages to the user:

- the principle can be employed without regard to the code in which the decimal figure is presented; although the circuit of the particular cell is dependent on the code, the interconnections are always the same. Consequently, these converters can be made for any code (1 2 4 8 — 1 2 4 2 — Excess 3, etc.);
- the same circuit can be used for binary-to-decimal conversion and the reverse operation;
- the network can also be extended; if, for example, the user has a circuit for decoding three-place decimal figures and has to decode six-place figures, he can interconnect four circuits in order to obtain the required decoding hook-up;
- several converters can be led off from the network in series and used to form an integrated circuit.

The picture shows part of the decoding matrix constructed in the Ispra laboratory. Each cell was built up from five integrated circuits of the conventional dual-in-line variety, mounted on a printed circuit. This was just a breadboard model to prove the theory experimentally. The definitive version would be manufactured on a large scale with integrated circuits.

The ease with which the network can be added to can be judged from the regular form of the interconnections between cells, as shown on the photograph.

References:

1) A. BAUDIN, M. COMBET: Conversion séquentielle binaire-décimale. *Automatisme, (1969) 10, 511-519.*

2) M. COMBET: Decimal-binary conversion by iterative array. *Electronics Letters;* to be published shortly.

NEWS FROM THE EUROPEAN COMMUNITIES

Power reactors in operation, under construction (*) or planned (**) in the Community

1. The total net electric capacity of the nuclear power plants in operation, under construction or planned is 18,111 Mwe, broken down as follows:

a) Proven-type reactors		
Gas/graphite		
Chinon 1 (EDF 1)	F	70
Chinon 2 (EDF 2)	F	200
Chinon 3 (EDF 3)	F	480
St. Laurent 1 (EDF 4)	F	480
St. Laurent 2	F	515*
Bugey 1 (St. Vulbas)	F	540*
G 2 Marcoule	F	40
G 3 Marcoule	F	40
ENEL (Latina)	I	200
Boiling water		
KRB (Gundremmingen)	D	237
KWL (Lingen)[1]	D	174
VAK (Kahl)	D	15
ENEL (Garigliano)	I	150
GKN (Doodewaard)	N	52
KKW (Würgassen, Weser)	D	640*
KKB (Kernkraftw. Brunsbüttel)	D	770*
ENEL 4 (Caorso)	I	783**
KBE (Badenw./EVS Philippsburg)	D	864*
Pressurised-water		
KWO (Obrigheim)	D	328
SENA (Chooz)[2]	F	266
ENEL (Trino Vercellese)	I	257
BR 3 (Mol)	B	10
KKS (Stadersand Elbe)	D	630*
S.E.M.O. (Tihange s/Meuse)[3]	B	870*
Centr. Nucl. de Doel (Doel s/Escaut)	B	780*
PZEM (Borssele)	N	450*
RWE (Biblis/Rhein)	D	1,150*
BASF (Ludwigshafen)	D	1,200**
Fessenheim (Rhin)	F	850**
b) Advanced converters		
Heavy water		
MZFR (Karlsruhe)	D	50
KKN (Niederaichbach)	D	100*
EL 4 (Monts d'Arrée)	F	70
CIRENE (Latina)	I	32**
High temperature		
HKG (Schmehausen)	D	308*
AVR (Jülich)	D	13
KWSH Schl. Holstein	D	22*
Sodium/zirconium hydride		
KNK (Karlsruhe)	D	19*
Nuclear-superheat		
HDR (Grosswelzheim)	D	22
c) Fast breeders		
Phenix (Marcoule)	F	233*
SNR (Weisweiler)[4]	D	300**
d) Type not yet decided		
TWS + Neckar W + B. Bahn (ex Lauffen)	D	750**
ENEL 5 (...)	I	p.m.
Chem. Werke HÜLS + VEW (Marl)	D	600**
KKW Schmehausen (VEW) (Westfalen)	D	600**
GKB Isaramperwerke/Bayernwerk	D	800**
RWE Farbw. Hoechst (Main)	D	600**
PZEM (Borssele 2)	N	450**

2. Percentage breakdown of the reactors in operation and under construction, according to type

Gas/graphite	2,565 Mwe	21.7%
Boiling water	3,685 Mwe	31.2%
Pressurised water	4,741 Mwe	40.1%
Heavy water	221 Mwe	1.9%
Other advanced converters	384 Mwe	3.1%
Fast breeders	233 Mwe	1,9%
	11,829 Mwe	100%

1. Excluding conventional superheat 2. Franco-Belgian power plant (50/50) 3. With French participation (EDF) of 50 % 4. Breakdown of participation: Germany 70 %, Netherlands 15 % and Belgium 15 % 5. Participation and commissioning date not yet settled 6. Including 400 Mwe for steam supply.

Index

Volume IX (1970)

Index to articles
(issue and page are indicated).

Index to Technical Notes
(left : serial numbers of notes ; right : issue and page).

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THE draft Euratom research programme and budget for 1971 proposed by the Commission was adopted by the Ministers for Research of the Community countries at their meeting in Luxembourg on 13 October 1970; it totals 58,823 million units of account, including 52.51 million for the research programme.

The Council also decided on a minor amendment to the 1970 programme, and the establishment of a working party to investigate, with a two-month time limit, certain aspects of the construction of the *SORA* pulsed reactor proposed by the Commission as part of the work on solid state physics carried on at Ispra (for the *SORA* project see *Euratom Bulletin* VI (1967) 3, 66-74).

ON 10 November 1970 the **millionth document of nuclear interest** was fed into the memory of the computer used by the semi-automate nuclear documentation system of the European Communities' *Centre for Information and Documentation (CID).*

TEN iron and steel technical research projects are to receive financial aid totalling nearly 4 million u.a. from the Commission of the European Communities. This decision was taken after endorsement of the projects by the *ECSC* Consultative Committee.

THE use of nuclear methods for the assay of trace elements in precious metals of high purity and of precious metals in ores and concentrates is to be the subject of a Community-wide promotion programme organised by the *Eurisotop Office*, to run from 1971.

THE Commission of the European Communities has authorised a **new research programme as part of the programme on "Physiopathology and clinical aspects of respiratory diseases"**, launched in 1964 by the European Coal and Steel Community (*ECSC*).

This new research programme, which deals with *chronic respiratory complaints*, will comprise extensive epidemiological surveys conducted at work sites, in areas with heavy air pollution, and in areas free of industrial fumes likely to pollute the air.

CONFERENCES

"Coal research—Application to mining techniques—Basis for new products" were the subjects of the Symposium held by the Commission in Luxembourg on 8-9 December 1970.

"The mastery of firedamp release—Improving the climate" are on the programme for the Symposium to be held by the Commission in Luxembourg on 24-25 February 1971.

Radioecology applied to the protection of man and his environment will be the theme of an international symposium to be held under the patronage of the Commission of the European Communities and the *Comitato Nazionale per l'Energia Nucleare* in Rome in September 1971.

Structural mechanics in reactor technology will be the subject of a conference organised by the *Bundesanstalt für Materialprüfung*, Berlin, and under the patronage of several organisations including the Commission of the European Communities. The Proceedings of the conference, which is to take place in Berlin on 20-24 September 1971, will be published by the Commission.

JUST PUBLISHED

- **Séminaire sur la décontamination externe et interne des travailleurs exposés aux rayonnements ionisants.** *EUR 4569 d,f,i,n.*
- **Second meeting on prestressed concrete reactor pressure vessels and their thermal isolation.** *EUR 4531 d/f/i/n/e.*
- **Pression des terrains et soutènement dans les mines.** *EUR 4533 d,f.*
- **Proceedings of the meeting of specialists on the reliability of electrical supply systems and related electro-mechanical components for nuclear reactor safety.** *EUR 4517 e.*
- **Studies on the radioactive contamination of the sea.** *EUR 4508 e.*
- **Régime de déclaration et d'autorisation applicable en vertu des Normes de radioprotection de l'Euratom dans les Etats membres de la Communauté aux activités et opérations concernant les combustibles nucléaires et autres substances radio-actives.** *EUR 4515 d.f.i.n.*
- **Proceedings of the 6th symposium on fusion technology.** *EUR 4593 e.*
- **Situation de l'approvisionnement en combustibles nucléaires.** *Série Energie — N° 3.*

These publications can be obtained at the *Sales office for official publications of the European Communities*, 37 rue Glesener, Luxembourg.

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