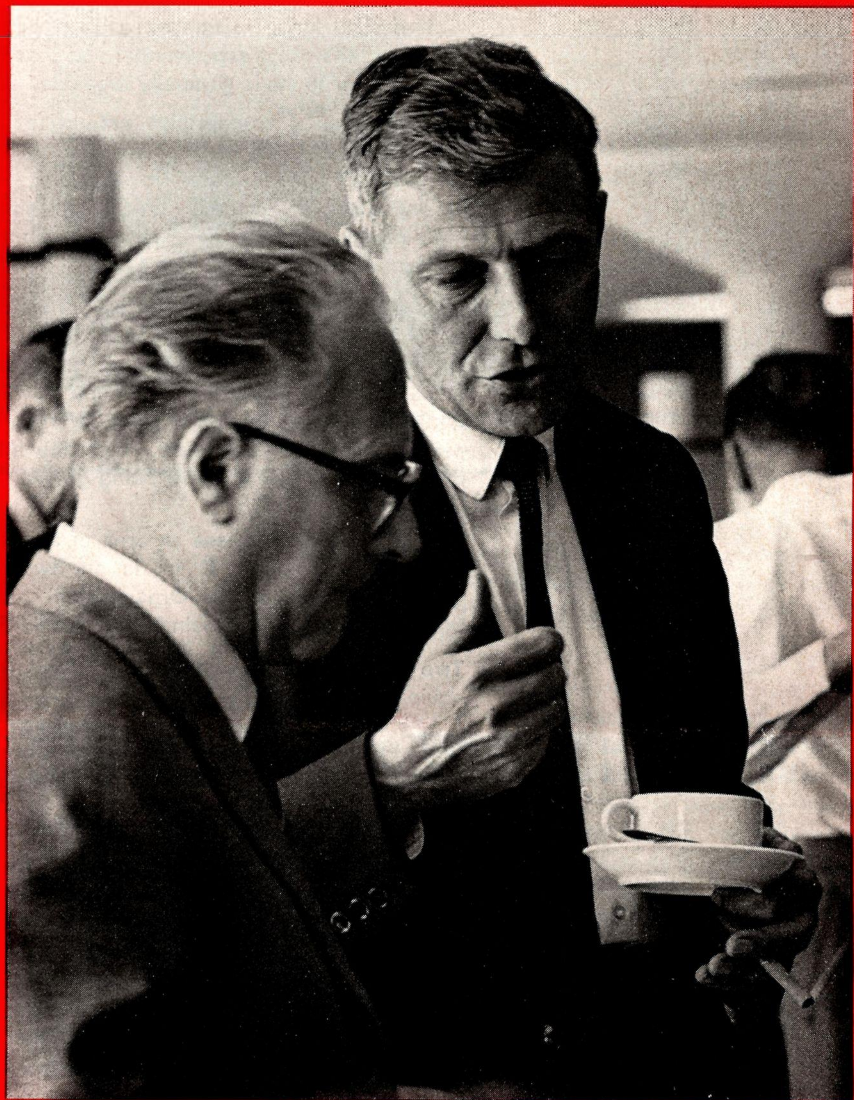
CERN COURIER



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CERN COURIER

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Contents

The cover photograph : The Director General, Professor Gregory (right) in conversation with Professor Amaldi, Italy, during a break at the CERN Council Meeting in June. Professor Amaldi, as Chairman of the European Committee for Future Accelerators (ECFA), presented to the Council the conclusions coming from the first six months work of the reconvened ECFA.

The CERN COURIER is published monthly by CERN in English and in French editions. It is distributed free of charge to CERN employees, and others interested in the construction and use of particle accelerators or in the progress of sub-nuclear physics in general.

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The European Organization for Nuclear Research, more commonly known as **CERN** (from the initials of the French title of the original body, 'Le Conseil européen pour la Recherche nucléaire', formed by an Agreement dated 15 February 1952), was created when the Convention establishing the permanent Organization came into force on 29 September 1954.

In this Convention, the aims of the Organization are defined as follows:

> **'The Organization shall provide for collaboration among European States in nuclear research of a pure scientific and fundamental character, and in research essentially related thereto. The Organization shall have no concern with work for military requirements and the results of its experimental and theoretical work shall be published or otherwise made generally available.'**

Conceived as a co-operative enterprise in order to regain for Europe a first-rank position in fundamental nuclear science, CERN is now one of the world's leading laboratories in this field. It acts as a European centre and co-ordinator of research, theoretical and experimental, in the field of **high-energy physics,** often known as **sub-nuclear physics** or the **physics of fundamental particles.**

High-energy physics is that front of science which aims directly at the most fundamental questions of the basic laws governing the structure of matter and the universe. It is not directed towards specific applications — in particular, it plays no part in the development of the practical uses of nuclear energy — though it plays an important role in the education of the new generation of scientists. Only the future can show what use may be made of the knowledge now being gained.

The laboratory comprises an area of about 80 ha (200 acres), straddling an international frontier; 41 ha is on Swiss territory in Meyrin, Canton of Geneva (the seat of the Organization), and 39.5 ha on French territory, in the Communes of Prévessin and St.-Genis-Pouilly, Department of the Ain.

Two large particle accelerators form the basis of the experimental equipment:
- a 600 MeV synchro-cyclotron,
- a 28 GeV proton synchrotron,

the latter being one of the two most powerful in the world.

The CERN staff totals about 2300 people.

In addition to the scientists on the staff, there are over 360 Fellows and Visiting Scientists, who stay at CERN, either individually or as members of visiting teams, for periods ranging from two months to two years. Although these Fellows and Visitors come mainly from universities and research institutes in the CERN Member States, they also include scientists from other countries. Furthermore, much of the experimental data obtained with the accelerators is distributed among participating laboratories for evaluation.

Thirteen Member States contribute to the cost of the basic programme of CERN in proportion to their net national income:

Austria (1.90 %)	Italy (11.24 %)
Belgium (3.56 %)	Netherlands (3.88 %)
Denmark (2.05 %)	Norway (1.41 %)
Federal Republic of Germany (23.30 %)	Spain (3.43 %)
France (19.34 %)	Sweden (4.02 %)
Greece (0.60 %)	Switzerland (3.11 %)
	United Kingdom (22.16 %)

Poland, Turkey and Yugoslavia have the status of Observer.

The 1966 budget for the basic programme amounts to 149 670 000 Swiss francs, calling for contributions from Member States totalling 145 860 000 Swiss francs.

Supplementary programmes, financed by twelve states, cover construction of intersecting storage rings for the 28 GeV accelerator at Meyrin and studies for a proposed 300 GeV accelerator that would be built elsewhere.

32nd Session of Council


CERN/PI 132.6.66

The following pages cover the major topics from the Council Meeting held at CERN on 15 and 16 June.

Progress Report

The Director General presented the Progress Report of the Divisions, covering the work at CERN from November 1965 to May 1966. Information which has already been given in CERN COURIER during this period will not be covered here again in much detail.

The Physics Programme

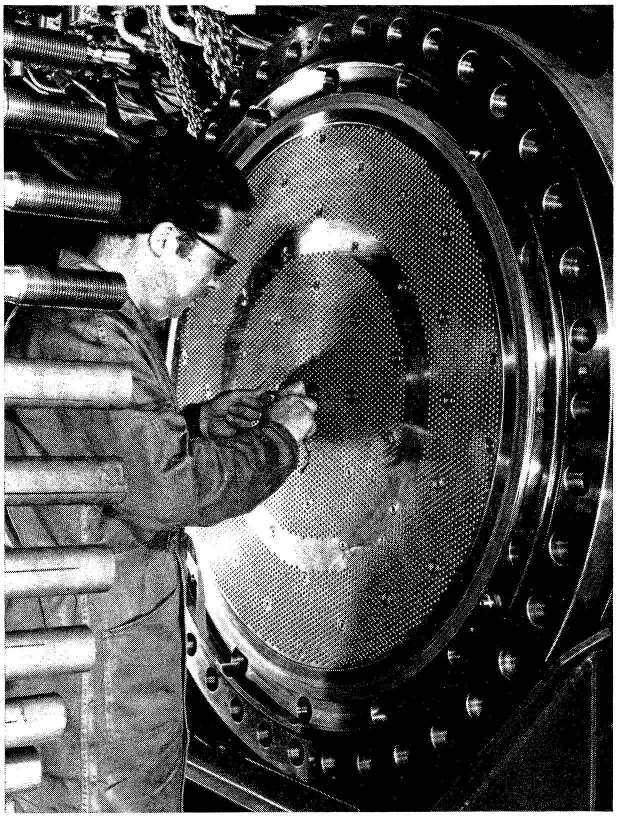
Professor Gregory remarked on the growing demand from teams of scientists in the member States to use the CERN accelerators. The increase has been very marked over the past year and particularly so for experiments using electronic counters. 19 experiments of this type had been accepted for the research programme on the proton synchrotron; four of them involved teams completely composed of scientists from outside CERN and another nine were mixed CERN-outside teams. This growing demand by visiting teams for the use of CERN facilities is a health sign of the vitality of the Laboratory, Professor Gregory said. Professor Gentner (Fed. Rep. of Germany) also welcomed this trend as a very good development for the training of young physicists.

Substantial results came from the few weeks running at the PS and from analysis of last year's runs. Notable contributions to the Conference on High-Energy Two-Body Reactions at Stony Brook, New York (22—23 April) included the observation of strong polarization effects in π^-p scattering at high energy and in the π^-p charge exchange process, the backward scattering of 3.5 GeV/c pions on protons, and antiproton-proton charge exchange scattering. The Director General said that he was very pleased to see that the scale and quality of the European contribution to the Conference matched that of our American counterparts.

The 2 m hydrogen bubble chamber took about 300 000 photographs in November and December. 1 200 000 photographs were taken in its first full year of operation.

Tests started in January to see whether the chamber can be modified for fast cycling. If the speed of the expansion — compression cycle can be increased it may be possible for example to take two or three sets of pictures at each pulse of the PS. The stainless steel piston in the pressure system, which was still in good condition after functioning for some 2½ million cycles, has been replaced by a piston made from titanium. This has the same strength as the stainless steel piston but reduces the weight of the assembly from 100 kg to 70 kg requiring less total energy in the cycle. This will be important for fast cycling. Another indication of the scale of operation at the bubble chambers is the fitting of a system to recover the silver from the development of the bubble chamber film. Several hundreds of kilograms of silver are expected to be recovered each year.

The 1.2 m heavy liquid bubble chamber has been prepared for the experiment to look for the decay of K^0_L into two neutral pions. This involved various modifications to the chamber including the installation of a vacuum pipe running through the centre (where the K meson decays to be observed will occur) and a suspended mirror to enable the cameras to see round the pipe. The magnet has been overhauled and parts of the cooling system replaced. A temporary arrangement to examine the possibility of using the 'Scotchlite' illumination method in the chamber is being prepared. For the coming experiment, the chamber was moved from the North to the South Hall; this involved clearing some 2000 tons of concrete and 5000 tons of steel shielding in the South Hall.



CERN/PI 181.5.66

Adjustments being made on the compression side of the CERN heavy liquid bubble chamber. The chamber has been moved to the South Hall for an experiment on K meson decay, which involved major modifications to the chamber.

The work of the Theoretical Study Division has continued to concentrate on the major problems which have emerged in sub-nuclear physics research over the past few years. Group theory, especially attempting to reconcile SU (6) symmetry with relativity theory, remains under investigation but the search for higher symmetries of the strong interactions has taken second place to studies of the 'algebra of currents'.

Other topics under study in the Division include high-energy collisions (the revived Regge pole model, the 'shadow' model, the simple impulse-approximation quark model); phase shift analysis; electromagnetic and weak interactions; analyticity and axiomatics; and nuclear structure.

The data processing operations and the computing service are beginning to show signs of smooth operation after going through a difficult period. A planned programme of engineering improvements by CDC on the 6600 computer is due for completion in July and in September the computer will be subjected to the 'quality assurance' tests used on the current production machines. Considerable work remains to be done on the operating system, the development of routine operation and maintenance procedures and on bringing several 'real time' devices into simultaneous operation. The backlog of work which has accumulated over the past year has also to be cleared. (The future plans for the CERN computing system were given in the last issue of the COURIER, p. 90.)

The flying spot digitizers (see CERN COURIER, vol. 6, no. 1 (January 1966) p. 7) HPD Mark I and Luciole 66 are now in regular operation on-line to the 6600 computer, with the HPD scheduled for an average of 12 hours per day. Two IEPs (instrument for the evaluation of photographs) are now connected on-line to the 6600 and an order has been placed for a CDC 3100, to be delivered this summer, to be used for on-line operation of the IEPs.

The accelerators

Research at the 28 GeV proton synchrotron was interrupted in February by the breakdown of the magnet power supply. Of the 2260 hours scheduled for physics, 43.5 % was lost. Fortunately the $3\frac{1}{2}$ months taken to repair the power supply, included six weeks already planned for a shut-down and the opportunity was taken to do a considerable amount of extra work around the machine which could not have been fitted into the six weeks.

For example, a rapid and intensive re-evaluation was done of all the plans for beams from the PS especially in the East experimental hall. This was also influenced by the unsatisfactory performance of the r.f. separated beam (u1) to the 2 m hydrogen bubble chamber which allowed through too many unwanted particles. An improved version (u3) of this beam, with better momentum definition, has been set up. The ejected proton beam (e2), taken from straight section 58 of the PS, can use slow or fast extraction. (See CERN COURIER, vol. 5, no. 10 (October 1965) p. 148.) It has been arranged to provide a slow ejected beam for a large electronic experiment on proton-proton scattering,,and fast ejected beams to produce a 2.4 to 5 GeV/c K-meson beam (m6) for the 2 m chamber and a 1 GeV/c π meson beam for an emulsion experiment. Plans are also under way for the use of a new slow extracted beam from straight section 62.

The major part of the huge steel filter for the new neutrino beam has been constructed. Most of the components of the extracted proton beam for the neutrino experiment which are inside the synchrotron ring were installed during the machine shut-down and the components which are inside the beam tunnel will be installed towards the end of the summer. The general plan of the installation for the CERN heavy liquid bubble chamber and Gargamelle, the large (10 m^3) heavy liquid chamber under construction in France, both of which will be used in the neutrino experiments, has been settled.

After a period of disappointingly low beam intensities from the PS, beams of 10^{12} protons per pulse were achieved once more at the end of 1965 when a multi-turn injection system was brought into operation. During the shut-down a new pre-injector incorporating a duoplasmatron ion source followed by a short accelerating gap was installed and resulted in the first 100 mA beams from the linac (as reported in the last issue of the COURIER).

To obtain the best use of the accelerated protons work continues on installing versatile target and ejection systems in the magnet ring. The aim is to be able to use several internal targets and ejected beams in one machine cycle. One limitation has been the time taken to move a target head into or out of position and a new unit is being developed to reduce this time from 70 ms to 20 ms for a 20 gm target head.

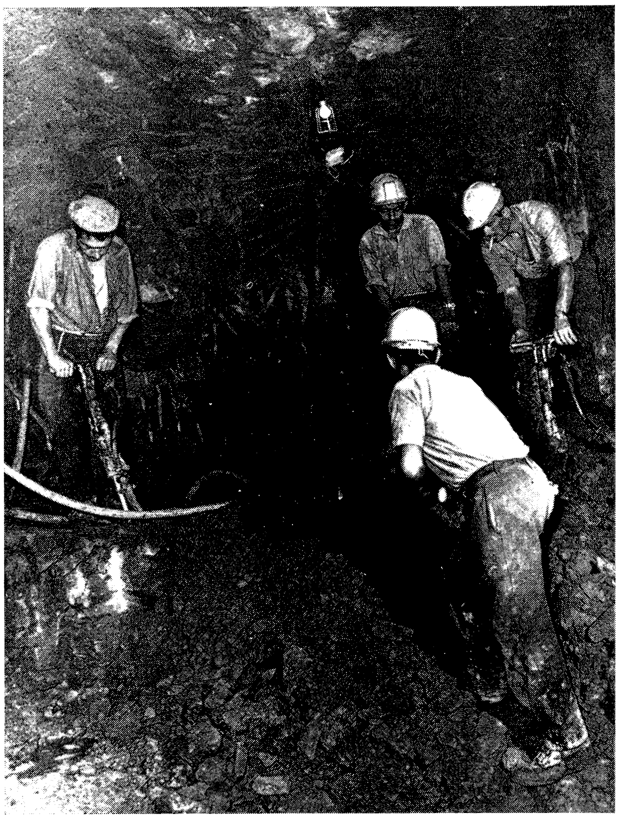
The increasing versatility of the machine brings complications in machine operation and an IBM 1800 computer and a data acquisition system have been ordered to help in machine operation.

The breakdown of the PS threw an additional burden on the use of the 600 MeV synchro-cyclotron which provided test facilities for eight additional teams during this time on top of its planned programme of research. As many as 13 teams used the SC in one week and up to 10 ran simultaneously. Full use had to be made of all the possibilities of beam sharing and time sharing.

The machine operating schedule was reorganized into periods of a fortnight continuous running, omitting a weekly maintenance. This gave a $7^1/_2$ % gain in experimental time. 2781 hours were available for physics research with 2281 hours used for 'parasiting'.

Following modifications to the machine r.f. system a 25 % increase of the internal proton beam was achieved. Also during this time a small synchro-cyclotron, which is to be used to study the problems occurring at the central region of the machine, was brought into operation.

Construction of the underground tunnel nearing completion at the synchro-cyclotron. The tunnel will take an external proton beam from the machine through the foundations of the SC building to the new underground laboratory of the ISOLDE (Isotope Separator On-Line Development) project.



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300 GeV

As mentioned in the report of the last Council Meeting, the European Committee for Future Accelerators (ECFA) has been reconvened, under the Chairmanship of Professor Amaldi (Italy), to consider the European high-energy physics situation as it has developed since the first ECFA presented its conclusions (the 'Amaldi Report') in 1963. Two full meetings of the new ECFA have been held this year and in addition the Committee set up two Working Groups — the first to consider relations between national and international Laboratories; the second to look again at the proposed design of the 300 GeV accelerator (recommended in the Amaldi Report) and at the possibilities of its experimental exploitation.

Conclusions of ECFA

Professor Amaldi made the following report to the Council:

Both the Working Groups have made interim reports to the Committee and, though the work of ECFA and the Groups still continues (the final report will be presented in a year's time), the Committee felt itself to be in the position already to present the following conclusions to the Council —

'1. The conclusions of the Amaldi Report are still essentially valid, for both the 'summit' and the 'base of the pyramid' programmes.' (The summit programme concerns the intersecting storage rings at CERN and a new proton accelerator of a very high energy. The base of pyramid programme concerns national or regional projects for meson factories, a high-energy electron machine, etc.)

'2. The Committee expresses its satisfaction that some of the high-energy facilities recommended or envisaged in the Amaldi Report have been authorized in the meantime, namely the ISR for CERN/Meyrin, the meson factory at Zurich, the 2.5 GeV electron synchrotron at Bonn and the electron storage rings at Frascati.' (The Zurich machine was described in the last issue of CERN COURIER, p. 93; the machine at the Physics Institute at the University of Bonn is scheduled for completion in 1967; the Frascati rings, called Adone, are (1.5 + 1.5) GeV and are expected to begin operation at the end of this year.)

'3. The Committee considers it of the utmost importance to keep Europe in the forefront of high-energy physics. It therefore urges all member States to implement further the programme of high-energy facilities as recommended in the Amaldi Report brought up to date to take account of progress in the field, as set out in more detail under 4 and 5 below.

4. The 300 GeV project remains the primary objective of the international high-energy programme in Europe. While some aspects of the project are still being studied, it appears however that the main characteristics of this accelerator should correspond to the design by the Study Group of CERN based on the recommendations of ECFA in 1963. The

Committee therefore urges the member States to authorize this project at the earliest possible date.

5. In order to profit fully from the 'summit programme', Europe will need the support of powerful schools of high-energy physics spread over the member States, working in intimate contact with the universities and having at their disposal adequate research tools as is the case in the United States. This is the aim of the 'base of the pyramid' programme recommended in the Amaldi Report. Therefore the following steps impose themselves:

   a. More of the national or regional facilities of the type recommended in the Amaldi Report should be constructed as soon as possible. This appears to be the task of the larger member States, or of groups of small member States. All these Laboratories should be open to European physicists.

   b. The improvements programme of CERN/Meyrin will allow an increase in quality and quantity of the experiments performed at the Laboratory. There is a very healthy trend towards an increase in the number of outside groups participating in the CERN experiments. In order to carry out this programme, the member States should support their own scientists adequately so that they can avail themselves efficiently of the opportunities offered by CERN and other large Laboratories. A preliminary study of this point suggests that such adequate support is not possible unless a country spends at least as much money internally on high-energy physics as it contributes to CERN.

   Since the number of high-energy physicists is increasing at least as fast as predicted in the Amaldi Report, there will be no problems of manpower even if a sizeable fraction of students move into other fields after training in high-energy physics.'

Professor Puppi, speaking as Chairman of the Scientific Policy Committee, endorsed the ECFA conclusions. He said that the project has a sound technical basis, a large measure of support from the European physicists and that a number of suitable sites for the machine had been found. He urged the Council to undertake practical steps to implement the project.

The site requirements

On the burning question of the site for the proposed accelerator, a large, detailed, preliminary report (CERN/644) has been prepared, entitled 'Proposals by the CERN member States for a site for a European 300 GeV proton synchrotron'. The report gives an account of the investigations which have been under way since 1962. It presents various important features of the site proposals which are now under active study without attempting to draw any conclusions about the relative merits of the sites.

The introduction to the report emphasizes that the 300 GeV project, involving a tenfold scaling up of the largest existing accelerator, is near the limit of what is technically feasible. Every component of the machine needs to be chosen to give maximum reliability and one of the most important components is the site.

The main requirements are summarized as follows:

1. It must be sufficiently large to accommodate the machine (2.4 km in diameter) with its experimental areas and have scope for possible future extensions of the Laboratory. (This is in accord with the Amaldi recommendation that the 300 GeV machine should be the backbone of high-energy physics in Europe in the years 1975—90 and therefore should have ample possibilities for extensions such as storage rings. The minimum area of the site is set at about 20 km^2 with a minimum width of 3.5 km.) It must be reasonably flat (horizontal to within about 20 m over a substantial fraction of the area is recommended).

2. The ground must be extremely stable under all circumstances. (The magnet ring with a total circumference of 7.5 km needs to be placed on a foundation stable enough to guarantee that misalignments stay within 0.15 mm over about 100 m. Artificial foundations for this precision, on this scale, have never been constructed and the best solution is to rely on the stability of the ground itself. The more rocky types of ground such as limestone, granite, sandstone, etc., are considered to be good provided that the ground is homogeneous, free from strong seismic activity and with ground water level low enough not to cause instabilities.)

3. There must be sufficient primary services to run and exploit the accelerator. (For electrical power, 10 MW of installed capacity would be required immediately, 100 MW in 8 years when the synchrotron begins operation, and possibly up to 300 MW in 15 years if for example storage rings are built. For cooling water, 0.1 m^3/sec would be needed initially and perhaps 2 m^3/sec in 8 to 15 years.)

4. The location must be such as to facilitate the construction and later the running of the Laboratory (this refers to the proximity of roads, an airport and a railway station, and also the availability of appropriate local industries, local labour, etc.).

5. The place must be such that it attracts the expert staff necessary to construct and operate the Laboratory. (As many as 15 000 people, including staff and their families, can be expected to be brought to the area around the Laboratory. The existence of a town or towns nearby, which can absorb this increase in population, is important. Also the more attractive the area, the more likely it is that staff will be easily recruited. This takes in such things as educational and cultural facilities, language, standard of living, climate, recreational facilities, etc.)

Site investigation

Since 1962, over 140 places have been considered in an informal way but most were found unsuitable. In response to the request for official offers from member States, made by the Council in June 1964, 22 proposals were received. In most of the States who originally offered several sites, one site was the subject of immediate investigation, with the result that 12 sites in 9 States are under active study. These are shown in Figure 1. (Of these sites, Asphropyrgos, near Athens

Figure 1. The locations of the twelve sites, offered by member States for the proposed 300 GeV accelerator, which are under active study.

in Greece has been put forward only recently and geological investigations have just started.) The Committee of Council decided that further studies should be restricted to one site in each member State. It has been agreed that in Italy this site will be Doberdo, and in Germany the conclusion of a national group of experts is awaited.

A questionnaire was sent to all the member States, who were putting forward sites, with 23 questions covering the various topics listed above and replies have been received and incorporated in the report. On all the sites intensive geological and geotechnical studies have been carried out in accordance with a programme worked out between CERN specialists and national experts. Discussions have been continued with national authorities on all the associated facilities — electricity, water, transport, industries, labour, housing, schools, etc.

Several Council members stressed that it was important that information coming from the different sites should be strictly comparable. It is to this end, that some of the more detailed studies will be carried out by the same team of people from CERN and, because of the volume of work involved, it is important to keep the number of sites as small as possible.

The next steps

Discussion has been going on in the Committee of Council concerning the Convention for the proposed Laboratory. There are two possibilities — that the present CERN Laboratory and the 300 GeV Laboratory, while being executively autonomous, be brought under the same umbrella by making a minimum of changes to the present CERN Convention, or that a completely new Convention be drawn up for the new Laboratory.

The first alternative, which avoids duplication of Councils and Committees and provides for simpler coordination of European policy, will be pursued as the basis for present discussion; a draft of a suitably rewritten CERN Convention will be prepared in the next month to be discussed at a special meeting of the Committee of Council on 29 July and then sent, with accompanying information, to the Governments of the member States. It is hoped that at the Council Meeting in December 1966, Governments will express a preference, or even give a decision, as to which of these courses should be followed.

The following sequence of events is seen as a realistic programme for implementing the 300 GeV project —

June 1967	Presentation of the final documents to the Council and from there to European Governments.
December 1967	Agreement in principle to the building of the accelerator; selection of the site.
1969	Start of construction work on the site.

Improvements Programme and ISR

Professor Gregory reported on the progress of the improvements programme for the proton synchrotron and its associated experimental equipment.

The new power supply for the PS, which will allow the machine to operate at a higher repetition rate, will be installed in a year's time. The Director General pointed out that there is a tendency to demand higher energy secondary beams. This involves running the PS at full energy when the repetition rate is only 1 pulse every 5 seconds; the new power supply will greatly improve this situation. Work is also progressing satisfactorily at Saclay on the large heavy liquid bubble chamber, Gargamelle, and at CERN on the three additional accelerating cavities for the magnet ring. Other topics being pursued in connection with the development of experimental techniques include superconductivity, where it is intended to increase the scale of activity in the future.

For the second stage of the improvements programme, it has been decided that the TART system (see CERN COURIER, vol. 6, no. 4 (April 1966) p. 63) has advantages over a higher energy linac and detailed studies are now under way.

A study group of scientists, engineers and technicians from Ecole Polytechnique and Saclay (France), DESY and Heidelberg (Germany) and from the CERN Track Chamber Division was set up at the end of 1965, to establish the dimensions and optimum configuration for a very large hydrogen bubble chamber given certain scientific, technical and financial conditions. The group has proposed as the best solution a cylindrical chamber with an interior diameter of 3.5 m and a volume of 30 000 l. Other components of the proposed system are a superconducting magnet to produce a field of 30 kG in the chamber; 'fish-eye' lenses and a 'Scotchlite' illumination system. The group is preparing a report for the Council and if this project is approved at the end of 1966, construction could start at the beginning of 1967.

The Intersecting Storage Rings Division was set up in January of this year to carry out the construction of the ISR and is planned to grow to 170 staff by the end of 1966. The study of the 300 GeV project remains in the Division since many of the staff have been involved in both projects.

More and more parameters for the ISR have been fixed or the limits for possible variation narrowed. After a review in the Autumn of 1965 a structure was decided which is very similar to that in the main ISR report (AR Int. SG/64-9). Magnet model I was completed in December and measurements with the model are continuing. Most of the basic development work with the first high-power, full-size model of an ISR r.f. cavity is nearing completion. Various vacuum pumps are being tested with emphasis on performance between 10^{-9} and 10^{-10} torr. Beam transfer problems, control systems and the general site layout continue to be studied. Preliminary work on the site (main service

Survey measurements being taken on the ISR site at the end of May. The sunshade was an essential part of the equipment in the intense heat.

tunnel, main drain and road) has started; geodetic monuments for the survey for the civil engineering are installed and survey measurements began at the end of May. The civil engineering contract has been approved by the Finance Committee and major work on the site will begin this month.

A working party has been set up to look at the problems of experimentation at the intersecting storage rings and has already arranged six seminars on this topic. Detailed discussions led to a change in the proposed experimental areas to give greater flexibility.

Professor Amaldi took up the suggestion that the ISR could be used for electron storage and colliding beam experiments. He said that the possibility of using the rings also for electron-electron (4.5 GeV energy in each beam) or electron-proton experiments is extremely interesting and should be taken into consideration.

Dr. Johnson pointed out that work with electron beams would involve such things as an electron injector and more r.f. power capability. It seemed reasonable to introduce these additional facilities only after experience with proton-proton experiments. However because of this possibility, care was being taken in the design of the ISR not to build anything into the machine which would exclude electron experiments at a later date; for example, the magnets were being constructed so that they could operate at the lower field levels required for electron beams.

CERN Reorganization

The Council approved a reorganization of the structure of CERN internal management, proposed by the Director General. Previously, four Directorate Members and twelve Division Heads were responsible immediately to the Director General. In the new organization seven Departments have been created to incorporate the existing Divisions and the functions of the Directorate.

The Departments are as follows:

1. Physics I, Director Prof. Paul — includes Nuclear Physics Division (Leader Prof. Preiswerk), and the Synchro-cyclotron Division (Leader Dr. Brianti).

2. Physics II, Director Prof. Peyrou — includes Track Chambers Division.

3. Theoretical Physics, Director Prof. Van Hove — includes the Theory Division (Leader Prof. Prentki).

4. Proton Synchrotron, Director Dr. Germain — includes the Proton Synchrotron Division (Leader Dr. Standley) and the Nuclear Physics Apparatus Division (Leader Dr. Ramm).

5. Applied Physics, Director Dr. Hine — includes the Data Handling Division (Leader Dr. MacLeod).

6. Intersecting Storage Rings, Director Dr. Johnsen — includes the ISR Division.

7. Administration, Director Mr. Hampton — includes Personnel Division (Leader Mr. Ullmann), Finance Division (Leader Mr. Tièche), Site and Buildings Division (Acting Leader Mr. Tirion) and certain other small sections.

The Council also confirmed the appointment of Prof. G. Puppi as Chairman of the Scientific Policy Committee (see CERN COURIER, vol. 6, no. 3 (March 1966) p. 44).

BOOKS

Lie groups for pedestrians, by Harry J. Lipkin (Amsterdam, North Holland Publishing Company, Fls 18).

Pedestrians have a hard life these days. Not only do they live in danger of being run down by more powerful means of transportation, they also take much longer to get anywhere. There are three possible attitudes to this situation. The first is the fruitless reaction to envy those who sit in the motor cars, trains and jet-planes. The second is much better: to be content with walking and to enjoy each beautiful detail on the way. Perhaps, luckiest of all are those who belong to the third group of people: those who can own a car but still enjoy a walk for its pure pleasure.

This book for pedestrians has been written by one belonging to this last class for the benefit of the second class (there is no help available for the first one): it is worth reading also by those used to travelling by car — it might encourage them to use their feet occasionally.

But let us turn to the physics. On the molecular, atomic, nuclear and 'elementary-particle' level, the word 'physics' means essentially quantum mechanics. In quantum mechanics physical states are characterized by a set of numbers, namely the quantum numbers, which are the eigen-values of (in general) conserved operators. The operators constitute a Lie algebra and the Lie algebra generates a Lie group — the symmetry group of the considered physical system. Therefore Lie groups are an integral part of all quantum mechanics; in particular when applied to atoms, nuclei and elementary particles. No physicist, pedestrian or car driver, can avoid encountering Lie groups when dealing with objects that require a quantum-mechanical description.

Most physicists in fact have already met a Lie group and a Lie algebra without noticing it: the three angular momentum operators J_x, J_y, J_z, constitute the basis of a Lie algebra, namely the Lie algebra of the rotation group. All the theory of the rotation group (all its representations, Clebsch Gordan coefficients and so on) is implicitly contained in the three equations $[J_x, J_y] = iJ_z$; $[J_y, J_z] = iJ_x$; $[J_z, J_x] = iJ_y$. And all the multiplet structures (the j-m-states), selection rules, branching ratios for various reactions, coupling coefficients, level splittings, etc. can be derived from the above commutation rules without ever mentioning the words group, representation, character, reduction to irreducible representations and similar ones that frighten the pedestrian. And that is why he can become familiar with all these things and enjoy the whole beautiful landscape without needing more than heavy boots and good will — and time.

Admittedly, there are Lie algebras more complicated than the angular momentum algebra, but all of them share the property that there are a finite number of basic elements $L_1, L_2, \ldots L_n$ with commutation relations $[L_i, L_r] = C^l_{ir} L_l$ (sum over l). One of these Lie algebras which recently attracted much interest, is that of SU_3. But there are many others which have applications in physics. It is remarkable that a Lie algebra may be of physical importance even if the corresponding Lie group is not a symmetry group of the physical system under consideration.

Lipkin takes the pedestrian-physicist by the hand, shows him in a gently way that he has known at least one Lie algebra ever since he learned to walk and tells him not to be afraid of the others. He then introduces some of the others, always stressing the analogy to the angular momentum algebra. A lot of attention is given to the SU_3 algebra, where it turns out that results can be obained by looking not at the whole algebra at once, but rather at the algebras of two of its subgroups. These algebras namely isospin and U-spin (or V-spin) are the same as for angular momentum.

The book is worthy of its title; but a pedestrian who wants to read it, should really be a passionate pedestrian. He will have to work himself through the book, not just read it. But there is no book in the world which teaches you in three hours what it took the author three years to learn.

In the last appendix there appears a footnote, which illustrates that Lipkin is not only a good guide on the long and sometimes difficult walk, but also one who does not claim to be infallible himself. We read: '*However, once a convention is chosen, confusion and errors are avoided by using the same convention throughout a particular calculation*'. And Lipkin adds the footnote: '*Do not believe this sentence. There are always confusion and errors. You have to live with them*'.

R. Hagedorn

Cheminement des particules chargées (The Penetration of Matter by Charged Particles; An introduction to the use of radiation in physical chemistry — vol. 1) by Y. Cauchois and Y. Héno (Paris, Gauthier-Villars et Cie, Ed. 1964; Fr. 52.—).

This volume is the first of three, which the publishers (Gauthier-Villars) plan to publish in the series 'Monographs on Physical Chemistry', dealing, as fully as the present state of knowledge permits, with the vast problem of the interaction of radiation with matter. The word 'radiation' is taken as covering both high frequency electromagnetic radiation (X and γ) and beams of charged (α, β or p) and neutral particles, with energies ranging from a few tens of keV to extreme relativistic energies.

This first volume deals essentially with the laws concerning the attenuation of charged particles in matter. Their individual behaviour is considered first by concentrating on elastic and inelastic collisions, and on energy losses by bremsstrahlung and by the Cerenkov effect; this is followed by a general study of total energy losses, scattering and straggling laws and particle tracks of thicknesses traversed. At the same time, the authors consider the behaviour of ideal charged particle beams when crossing layers of homogeneous matter. Interest is centred on the modifications which the interactions produce in the characteristic parameters of the incident particles and also on the secondary radiation emitted by 'thin' and 'thick' targets, rather than on the effects produced in the matter which is penetrated by the particles. The volume is concluded by a series of addenda which remind the reader of the fundamental laws mentioned in the text.

This work is directed to those with university training in mathematics and physics: it is intended mainly for physical chemists, but physicists will also find it interesting and useful. The two further volumes which are to be published, will deal respectively with the interactions of X and γ rays, and of neutrons.

A. R.

CERN News

PS back in action

The 28 GeV proton synchrotron was brought into operation again on 25 May as scheduled, after its shut-down which had been lengthened from six weeks to three months for repair of the magnet power supply. On the first day of operation the beam intensity reached 7×10^{11} protons per pulse and this intensity has been reliably maintained. On 4 June, 1½ days before the end of the first running period, a water leak on the septum of the slow ejected beam magnet in straight section 58 flooded about one tenth of the PS vacuum chamber with water and molten copper. After clearing up the chamber and fitting a new septum the physics programme started again a day late on 10 June.

The physics programme began on 26 May, and the following experiments received beam in the first week:

S45 – to obtain a more accurate determination of the decay parameters of the Λ^0

S46 – which is looking for the production of neutral resonances and their decay into neutral particles

S50 – to examine the β-decay of the Ξ hyperon

S43 – which uses a polarized proton target investigating the scattering of a beam of π mesons to determine how the scattering depends upon the spin

S39 – one of the experiments concerned with the decay of the K^0_L meson into two π mesons, which looks for interference between K^0_S and K^0_L (see CERN COURIER, vol. 6, no. 3 (March 1966) p. 43)

X4 – a bubble chamber experiment, using the CERN 1.2 m heavy liquid chamber, to look for the decay of the K^0 into two neutral π mesons

S35 – to investigate charge exchange in the scattering of a π meson beam from a polarized proton target

S42 – to look for electromagnetic decays of resonances.

Rencontres de midi

The guest speaker at the 'Rencontres de Midi' held at CERN on 23 May was Mr. Haas, Directeur de l'Hôpital Cantonal, who spoke on 'The Geneva Hospital, now and in the future'.

Some 28 000 patients are registered at the Hospital each year. Each patient stays on average for 20 days which represents about 80 % use of the hospital's 2000 beds. A fundamental problem at the Hospital is the recruitment of sufficient, appropriate staff. 2680 people work there including 1327 nurses, but in Switzerland there is a shortage of around 4000 medical staff.

The annual budget of the Hospital is 50 million Swiss francs, of which 39 million is allocated to the staff salaries. 57 % of the cost comes from the State; the cost to the patient is not higher than 24 francs per day on average whereas the actual cost per day at the hospital is 86 francs.

The problems which the hospital will have to face in the future are concerned with increasing life expectancy (which has now reached 78 years for a man and 82 years for a woman); road accidents (which are now five times higher than 20 years ago); the increasing technicality of medical treatment; the tendency to use hospitals more; the shortage of space.

Visit

On 10 June a group of scientists, government officials and representatives of industry from Spain visited CERN. The visit was organized at the initiative of Professor Otero Navascués, President of the 'Junta de Energia Nuclear' and follows the visit of the Director General of CERN to Spain in May. The visitors had an introductory talk about CERN from Prof. Armenteros and spent a large part of the day seeing the accelerators, experiments and analysis equipment at the Laboratory. Professor Gregory joined the group for discussions in the afternoon.

CERN/PI 59.6.66

A group of visitors from Spain at CERN on 10 June. This photograph was taken in the NPA Building where they saw several electrostatic separators and the operation of a laser used in experiments on the development of pulsed separators. Mr. Jeannerot (in the white coat) is describing the operation of the separators.

DG in transit

Following his visit to Spain, reported in the last issue of CERN COURIER, Professor Gregory, Director General of CERN, went with three CERN colleagues (Dr. Citron, Dr. Lock and Prof. Peyrou) to the Soviet Union on 24 May. The purpose of this visit was to continue the discussions with the Soviet scientists (including Professor Petrosiants, Chairman of the USSR State Committee on the Use of Atomic Energy) about future collaboration between CERN and the Laboratory at Serpukhov where the largest accelerator in the world, a 70 GeV proton synchrotron, is nearing completion.

The principle of such collaboration was supported at the CERN Council Meeting in December 1965 and the continuing talks between representatives from Serpukhov and CERN are directed towards working out the extent and the detail of the collaboration. A proposal will eventually be presented to the CERN Council when the negotiations have reached an appropriate stage.

As a further indication of the growing exchange between Europe and the USSR in the field of sub-nuclear physics, an agreement is being negotiated between France and the Soviet Union for the use at Serpukhov, by joint teams of Soviet and French physicists, of a very large hydrogen bubble chamber being constructed at the Saclay Laboratory. The chamber is called 'Mirabelle' and is scheduled for completion in 1969.

On 5 June, Professor Gregory travelled to Holland to be present at the opening of the '1966 CERN School of Physics' where he gave a seminar on the PS experimental programme. He had discussions with the Dutch high energy physicists about their future plans (they are at present proposing a National Institute for High Energy Physics to co-ordinate some of the work of the groups active in different Universities, — Amsterdam, Nijmegen, Utrecht, Groningen and Leiden — for projects beyond the capability of a single University) and talked with the Netherlands' Minister for Education and Sciences. During his stay in Holland, the Director General also visited the Zeeman Laboratory (Amsterdam), the University of Nijmegen and the Philips Laboratory at Eindhoven.

On 8 June, Professor Gregory moved on to Belgium. He visited the high energy physics Laboratory at Brussels and gave a talk on 'High Energy Physics at CERN' at the 'Fondation Universitaire'. On 10 June he was received in audience by H.M. Baudouin I, King of the Belgians.

Schools

The 1966 CERN School of Physics was held at Noordwijk-aan-Zee, Holland, from 6—18 June. It was the fifth in a series of courses which have been previously held at St.Cergue, Switzerland (twice); Herceg Novi, Yugoslavia and Bad Kreuznach, Germany. They are directed at young experimental physicists, regardless of the particular technique in which they are working, from Laboratories closely associated with CERN. 99 students from 19 countries (including 8 non-member States of CERN) attended this year's school.

The school was opened on 6 June by His Excellency Mr. Diepenhorst, the Netherlands' Minister for Education and Sciences. The course included a series of lectures on major topics of current interest in sub-nuclear physics given by Professors Van Hove (CERN), Tolhoek (Groningen), de Swart (Nijmegen), Miller (Berkeley) and Dr. Bell (CERN). There were also seminars by the Director General, Prof. Kronig (Delft), Prof. Steinberger (Columbia/CERN), Dr. Hyams (CERN), and Dr. Sens (Netherlands/CERN).

The International School of Physics 'Ettore Majorana' began on 19 June and will continue until 4 July. This is the fourth time the School has been held at Erice in Sicily and the course this year is devoted to 'Strong and Weak Interactions — Present Problems'. Among the lecturers was Prof. Gell-Mann who spoke on 'Current algebras and broken symmetry'.

The second course in 1966 of the International School of Physics 'Enrico Fermi' began on 27 June and will continue until 9 July. The topic of the course is 'Interaction of High-Energy Particles with Nuclei'. The School is being held at Varenna in Italy.

News from Abroad

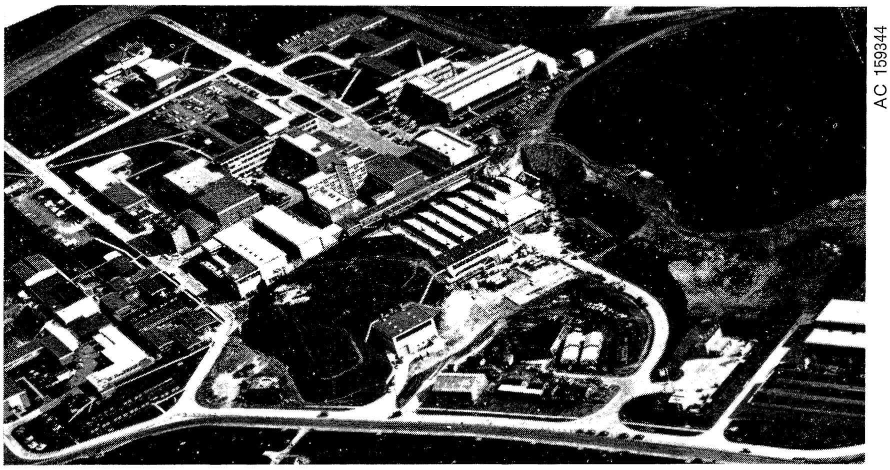
Rutherford Laboratory

The 7 GeV proton synchrotron, Nimrod, which suffered a power supply failure in 1965, is back in action at the Rutherford Laboratory, in the UK. The accelerator has just completed an intensive period of operation extending over three months with only four 12 hour maintenance periods. The performance of the machine improved steadily throughout the run to give about 80 % efficiency during scheduled experimental time. Beam intensities of 10^{12} protons per pulse or better were reliably achieved. The extracted proton beam efficiency reached 22 %.

The newly commissioned 1.4 metre heavy liquid bubble chamber has taken 200 000 photographs examining the decay of the eta meson. An 82 cm hydrogen bubble chamber, on loan from Saclay, France, has now taken 1.7 million pictures at Nimrod and is working extremely well.

The Laboratory is particularly proud of the relationship it has established with the British universities where it has pioneered collaboration between a government establishment and universities. Over 200 university physicists (20 research groups from 13 physics departments) including about 60 postgraduate students, take part in the research programme. University staff are involved in management of the Laboratory at all levels and the research is organized, as far as possible, to enable the visitors to carry out their normal university duties also.

A programme of work on superconducting magnet technology is under way. A 6 ft bending magnet with a 30 kG field is under construction for the external proton beam and consideration is being given to the use of a superconducting magnet for a very high field bubble chamber (perhaps 70 kG over 1.5 metres). Some preliminary thought has also been given to the possibility of a conversion of Nimrod to a 50 GeV strong focusing machine using superconducting magnets.



An aerial view of the Rutherford Laboratory site. The circular shape of the earth mound covering the NIMROD magnet ring with its injector can be seen in the centre of the photograph. The smaller of the two accelerators at the Laboratory, a 50 MeV proton linear accelerator is in the building on the far left. (Reproduced with acknowledgement to the Rutherford Laboratory).

No decision has been taken yet on the future national programme of high energy physics research in the UK. A 4 GeV electron synchrotron, Nina, at Daresbury, is expected to provide its first beams by the end of 1966, but beyond that, much will depend upon the progress of the European programme.

Stanford

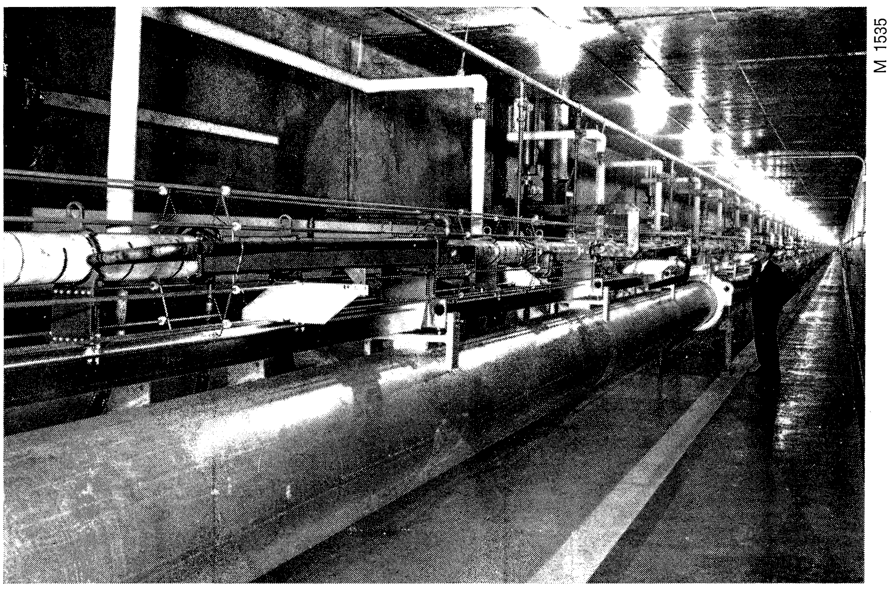
Electron beams with an energy of 10 GeV were achieved for the first time at the Stanford Linear Accelerator Centre (SLAC) on 21 May. The electron linear accelerator, designed for an energy of 20 GeV, is the most powerful electron machine in the world.

Stanford University proposed the construction of this accelerator in April 1957 to produce an electron beam of high intensity in the energy range 10 to 20 GeV. Authorization was given in 1961 under a contract with the U.S. Atomic Energy Commission. The machine represents a logical extension of the work begun at Stanford in 1946 under the guidance of the late Professor Hansen. In 1951, this work resulted in the completion of a 1 GeV linear electron machine (called the Marx III accelerator).

The 20 GeV accelerator is 10 000 ft long, housed in a tunnel 25 ft underground. The electron beams travel in a 4 inch diameter copper tube and are accelerated by electromagnetic waves set up by 240 klystrons. These klystrons will each give 24 MW of power in pulses 2.5 μs long, 360 times per second. The average beam current will be 30 μA in pulses 1.7 μs long. At 20 GeV the mass of the electrons is 40 000 times greater than their rest mass and they are travelling at 0.999 999 999 7 of the velocity of light. At the end of the accelerator is a 1000 ft long 'beam switchyard' where powerful magnets are set up to switch the beam onto different experiments in two large experimental areas.

The project started in April 1962 and it is hoped to have high energy physics experiments under way before the end of 1966. The machine will be used for studies of basic electron produced interactions, for studies of particle structure (Professor Hofstadter has already gained a Nobel Prize for his work on this topic using the smaller Stanford machine), for experiments with secondary particle beams of neutrinos, photons, etc., and for tests of basic electromagnetic theory.

It is intended that the machine will be available to physicists from Stanford, from other parts of the United States, and from throughout the world.



A view along the two mile beam tunnel of the 20 GeV electron linear accelerator at Stanford. The smaller, higher, white-covered tube is the beam pipe along which the electrons travel. The large aluminium pipe at the bottom is its support structure which is also used for alignment purposes by shining a laser beam down the pipe. The accelerator components have to be aligned straight to an accuracy of 1 mm along its entire length. (Reproduced with acknowledgement to Stanford University News Service.)

Chalk River

A project to build an intense neutron generator (ING) has been proposed at Chalk River in Canada. As mentioned in the last issue of CERN COURIER (p. 89) the project may involve a new type of accelerator first developed by F. M. Russell of the Rutherford Laboratory. This is a separated orbit cyclotron (SOC). (Another possibility is a linac to provide continuous, intense beams.) The SOC combines many of the good features of other types of accelerators into one machine. It can be operated to provide pulsed or continuous beams; it is strong focusing and operates at fixed field and fixed frequency; there are no resonance problems; injection and extraction of beams is straight forward.

The machine is effectively a coiled-up linear accelerator which nevertheless, as with the circular machines, uses the same units many times. A proton beam introduced at the centre is accelerated by a series of r.f. cavities alternating with focusing magnets. The cavities give the protons very large energy gains per turn and hence keep the turns separated even at high beam energies which makes extraction very easy as opposed to the conventional cyclotron.

The Chalk River project envisages beams of up to 80 mA at 1 GeV. The power requirements of the r.f. cavities are very great and Russell has proposed a system (now called the super SOC) whereby an intense electron beam could be used to excite the cavities. Two 2 A, 4 MeV electron beams from Van de Graaff type machines (also involving a new idea from Russell) would be decelerated to 2 MeV in the cavities giving up their energy to accelerate the proton beam. The system thus becomes a particle energy transformer.

Neutrons would be produced from the spallation process by firing the proton beam into a molten lead-bismuth target. About five times less heat is generated per neutron with the spallation process compared with fission. As opposed to nuclear reactors, which are the most intense neutron sources currently available, there is no problem from the neutron source going 'critical'.

It is estimated that the project could provide about 5×10^{17} neutrons/s. It would be used for neutron beam research (with applications in solid state physics, etc.), for materials testing (reactor technology), as an isotope producer and could be used to breed fissile material by surrounding the target with a blanket of thorium. This fissile material could then be used in a reactor which would supply the accelerator with its power. On paper, the system could produce more power than it consumes.

The project obviously involves many new, untried features. The estimated cost is $ 150 million.

A conference on separated orbit cyclotrons and beam cavity interactions will be held at the Rutherford Laboratory on 6–8 July.

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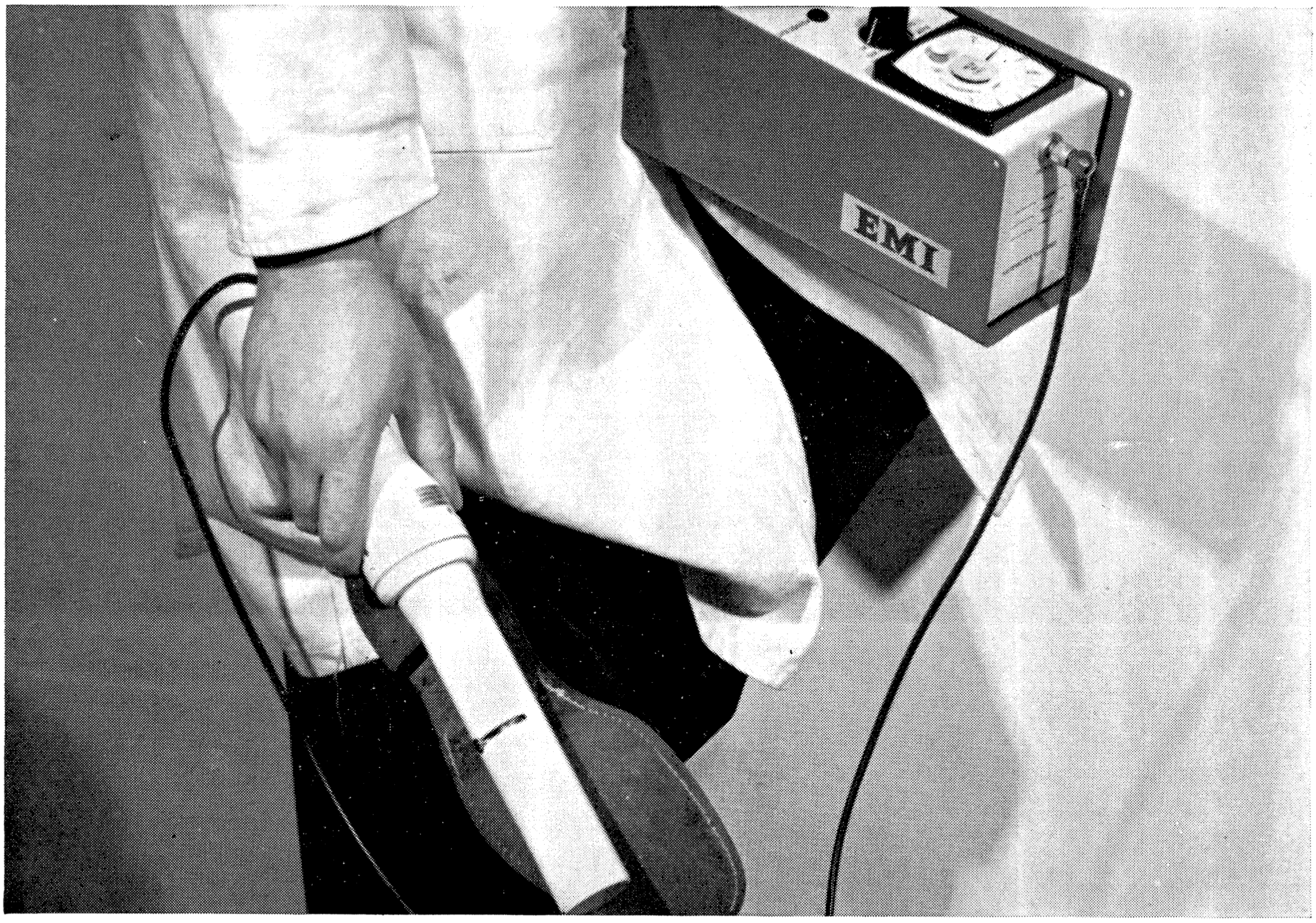

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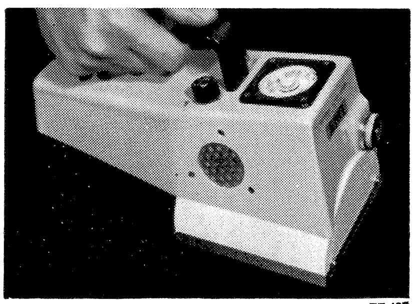

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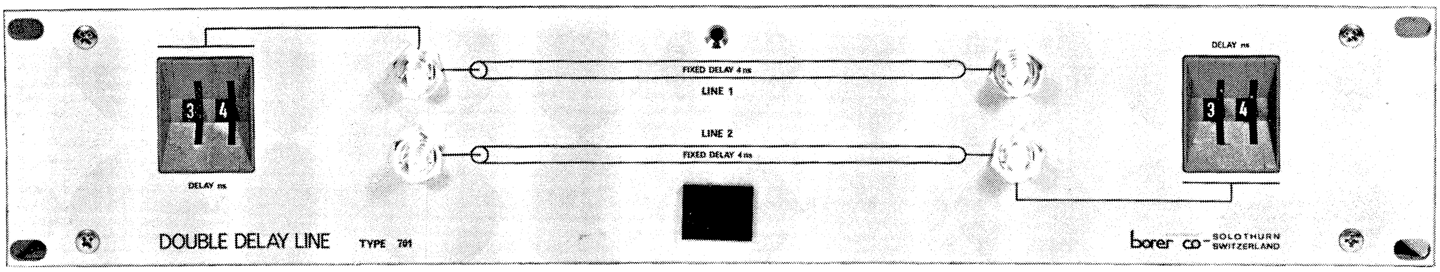

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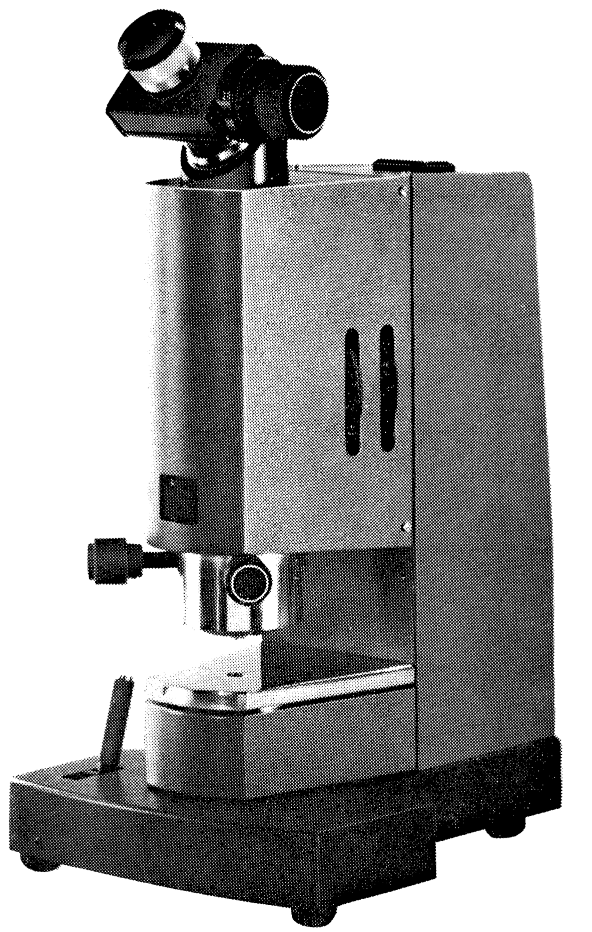

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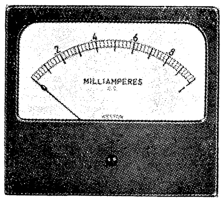

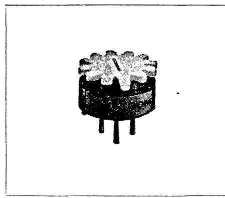

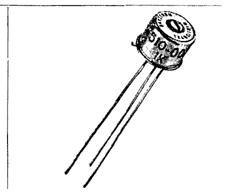

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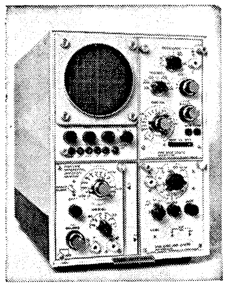

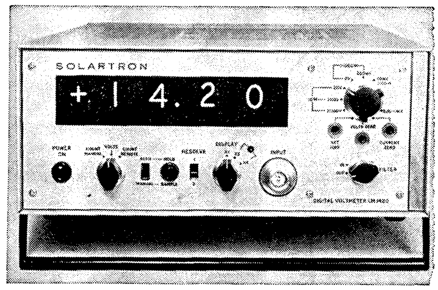

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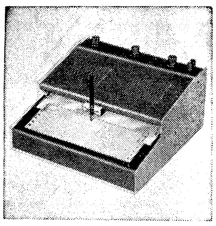

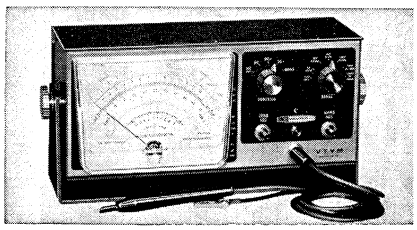

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