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EUROPEAN ORGANIZATION FOR NUCLEAR RESEARCH

The European Organization for Nuclear Research (CERN) came into being in 1954 as a co-operative enterprise among European governments in order to regain a first-rank position in nuclear science. At present it is supported by 13 Member States, with contributions according to their national revenues : Austria (1.96%), Belgium (3.85), Denmark (2.09), Federal Republic of Germany (22.86), France (18.66), Greece (0.60), Italy (10.83), Netherlands (3.94), Norway (1.48), Spain (1.68), Sweden (4.25), Switzerland (3.20), United Kingdom (24.60).
Contributions for 1964 total 107.2 million Swiss francs.

The character and aims of the Organization are defined in its Convention 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.'

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The cover photograph shows one of CERN's 'IEP' operators (Mrs. Yvonne Prodon) looking at part of the punched paper tape produced by her machine. On the stand above the tape punch is a folder containing rough prints of each bubble-chamber photograph to be examined, with instructions concerning the tracks to be measured. The film is projected on to the large glass screen and the operator then moves the image so that, one after the other, particular points on the desired track are accurately aligned with a reference marker on the screen. By depressing a pedal the position co-ordinates of each point are automatically punched in coded form on to the paper tape. The typewriter on the right is used for punching subsidiary information, such as the number assigned to each track. Although machines such as these, not to mention their operators, are at present invaluable for measuring the tracks on bubble-chamber picture, the number of pictures taken each year is increasing so rapidly that more automatic methods are also being developed. More information can be found in the article beginning on p. 73, dealing with the electronic computer and its uses at CERN.

CERN COURIER

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Last month at CERN

Almost exactly a year after full-energy protons were first ejected from the CERN PS to give an external proton beam, another 'world première' was achieved with the **fast-ejection equipment** in May.

It will be recalled that the circulating beam inside the accelerator consists of twenty separate bunches, distributed evenly around the ring. So far, the fast-ejection equipment has enabled either one or all twenty of these bunches to be ejected, the time required to eject all of them being just over two millionths of a second. In practice, since the principal user of the external beam up to now has been the neutrino experiment, demanding a high intensity, only the second alternative has been used. During the April shut-down new components were installed, and subsequent tests in May showed that it was possible in addition to eject 19, 18 or 17 bunches at will, leaving the other 1, 2 or 3 inside the machine for use with internal targets. This gives a well-controlled method of beam sharing which, for instance, allows a large hydrogen bubble chamber to be operated at the same time as the neutrino experiment.

Basically, the system works by adjusting the duration of the pulse in the kicker magnet of the ejection system so as to eject just the required number of bunches. Considering the high currents and very short times involved, this is no easy thing to do and, in fact, the whole operation is more complex than might at first be imagined. The 19, 18 or 17 bunches are ejected about ten thousandths of a second before the beginning of the 'flat top', that is, just before the field of the accelerator guiding magnets reaches its peak level. The 1, 2 or 3 remaining bunches circulating inside the vacuum chamber induce too weak a signal in the pick-up electrodes to remain 'phase-locked' to the accelerating system, so that they are no longer accelerated but travel on an orbit of steadily decreasing radius (about 5 mm/ms) as the magnetic field continues to rise.

During the flat top, therefore, the beam circulates nearer to the inside of the vacuum chamber than usual, so that a target can be placed in position on the normal orbit. At this time the ejection magnets are withdrawn from their operating positions. When the magnet field afterwards begins to decrease, the protons spiral gradually outwards again to hit the target. The duration of the pulse of secondary particles from the target, usually either a 'long burst' or a 'short burst', depends on the rate of fall of the magnetic field strength.

Beam sharing with the ejected beam is not new, since the 'rapid beam deflector' has been used to direct a small fraction of the circulating beam on to a target at 80-90% of full energy, whilst leaving the rest to be ejected after further acceleration. An additional 5-10 % of the number of protons is often lost, however, because of the disturbance to the beam. The new scheme, developed in the Nuclear Physics Apparatus Division, is particularly promising, since it is inherently 'cleaner' and also enables the protons hitting the internal target to have as high an energy as those in the external beam.

June saw two more major technical achievements at the proton synchrotron. One of these, on 14 June, was the successful test of part of CERN's **microwave particle separator,** now installed in the o_2 beam in the East hall. This apparatus is the first of its kind in the world, relying on the curious properties of a particular kind of electromagnetic wave to deflect high-energy particles as they move with the wave through a waveguide. The tests were done with positive particles of 10 GeV and the deflexion obtained was found to correspond with the theoretical predictions, bringing satisfaction to those concerned in the Accelerator Research Division and finally dispelling the doubts thrown on the validity of the theory during the early stages of development, some years ago. Although further equipment has to be finished before the complete separator can be

CERN/NPA

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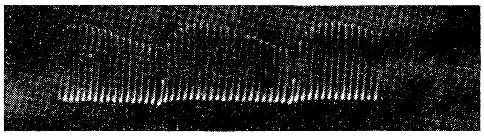

1. Oscilloscope trace showing structure of the PS internal beam 1 millisecond before ejection. The signal is induced by the circulating beam in a wide-band pulse transformer, and each peak marks the passage of one proton bunch. The half peak is the proton bunch mutilated at inflection and the distance between these half peaks corresponds to one period of revolution, that is, 2.1 microseconds.

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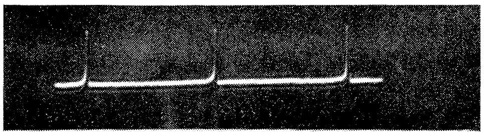

2. Beam structure 1 millisecond after the ejection of 19 bunches, showing a single bunch circulating in the accelerator.

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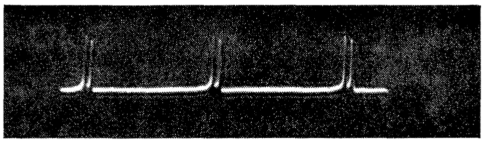

3. Beam structure after ejecting 18 bunches : 2 bunches remaining.

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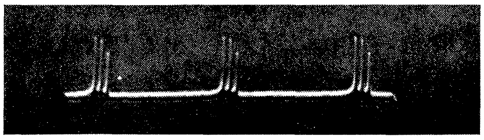


4. Beam structure after ejecting 17 bunches : 3 bunches remaining.

put into operation, the success of the deflexion tests is regarded as the passing of a crucial stage in the development of this new type of particle separator, which is expected to supersede the conventional electrostatic separator at the higher energies now being considered.

At about the same time, remarkable results were achieved with the **new m_4 beam** in the South hall, specially designed to give large numbers of negative kaons up to a momentum of 1. 8 GeV/c and antiprotons up to 2.7 GeV/c, with a minimum contamination of other particles. The initial tests showed already that the intensity of antiprotons in the beam was at least ten times greater than had been obtained anywhere before, a feature of great importance for the detailed study of the interactions of these rare particles.

Apart from the success of the completed beam, its construction was an achievement of no mean order. To obtain such a high intensity, special beam-transport magnets were designed and built ; in particular, a 'window-frame' magnet fitted inside the vacuum chamber and two quadrupoles, with large usable apertures (36 cm) but small overall dimensions (70 cm), close to the accelerator ring magnet. Originated by the Nuclear Physics Division, the whole beam was designed and constructed in the record time of six months.

The main experiments during the first two weeks of **synchrotron operation** after the start-up on 29 April were on **proton-proton scattering,** using sonic spark chambers and the c_8 beam in the East hall, and on the **magnetic moment of the sigma-plus,** with emulsions in the a_8 beam of the North hall. Much attention was also given to testing the various beams constructed during the shut-down as well as a new programming system for internal targets. This system provides even greater flexibility in target use and beam sharing than before, especially as it can now also control the operation of the fast-ejection magnets. For instance, beam pulses can be ejected or directed on to an internal target according to a previously decided programme.

For the **microwave-separator tests,** the **fast-ejection system** was used to perform another trick. The kicker magnet was arranged to deflect the beam inwards, instead of outwards, and the subsequent oscillation of the beam about its mean orbit carried it well clear of the ejection magnet on its first circuit and then through a target on the other side of the accelerator on its second one. There it produced a two-microsecond burst of particles for the o_2 beam. Most of the protons did not interact in the target but were subsequently carried by their oscillatory path into the ejection magnet and hence out of the accelerator.

Later in the month the new **targeting equipment** was put to good use, when the neutrino experiment was 'main user' of the accelerator — but not the sole user, as was the case last year. For example, at one time nine out of ten pulses were arranged so that some 5% of the proton beam was directed (by the rapid beam deflector) on to target M 60 and the rest ejected on to the neutrino target, whilst for every tenth pulse the beam was divided more or less equally between target 64 and target 6. From target M 60, the o_3 beam led protons of 18 GeV/c to a copper target, identical with the one in the neutrino horn, situated in the **École Polytechnique heavy-liquid bubble chamber.** The purpose of this experiment was to investigate further the nature of the particles emitted from the target, as part of the calibration measurements for the **neutrino experiment.** Target 6 fed the a_8 beam, continuing the **sigma-plus experiment,** and target 64 the d_{16} beam for an experiment on **'charge-exchange'** reactions of pions. (For further information on the various experiments, see the article by W.O. Lock in last month's *CERN COURIER.*)

In its report prepared for the Annual General Meeting of the **CERN Staff Association,** on 12 May, the outgoing Committee recalled its three outstanding preoccupations during the year 1963-64:

- the crisis concerning the salary claim, and the general revision of salary scales at present in force ;
- the development of closer and more systematic co-operation between the Association and the Administration for studying problems concerning the staff ;
- improving external relations by increasing contact with local communities and the organizations representing them.

Under the last heading, a number of specific examples were given, including :

- affiliation to the 'Arts et Loisirs' organization of Geneva ;
- contacts with the Residents Association of the 'Cité-Satellite' at Meyrin ;
- membership of a 'liaison committee', the 'Commission de la Genève Internationale', bringing together members of the staff of the international organizations and prominent people in Geneva, under the auspices of the 'Intérêts de Genève';
- wider invitations given for lectures and exhibitions held at CERN ;
- contacts maintained by the various clubs, notably those of the CERN Music Club.

Attempts have also been made to establish better contacts with the other international organizations in Geneva, particularly through the Committee of Associations of International Officials in Geneva and the Federation of International Civil Servants Associations.

Technical and Scientific Press Day

On 19 May, ten years, almost to the day, after the ground was first broken on the Meyrin Site, some 30 scientific correspondents of European and American newspapers or periodicals were received at CERN by the Director General.

In also welcoming them, Mr. G. H. Hampton, Directorate Member for Administration, emphasized the changes they would find in CERN since the previous Press Day, almost two years ago. Roger Anthoine then briefed the journalists on what they would see and hear during their visit, after outlining for them the present organization and briefly explaining the aims and means of CERN.

The main business of the day began with a talk by the Director General, Prof. V. F. Weisskopf, on the present state of fundamental-particle research, in the course of which he explained how the development of atomic and sub-atomic research could be seen in three stages :

— recognition of the existence of electron shells in atoms, proceeding from the conception of the quantum theory ;
— study of the nucleus of the atom, made possible by the rise of accelerators to produce energetic particles capable of penetrating further into the atom than before ;
— investigation of the structure of the particles making up the nucleus (the nucleons, or protons and neutrons), following the development of larger particle accelerators, culminating in those at CERN and Brookhaven.

In the first stage the role of the electromagnetic force keeping the electrons in the atom was worked out. In the second, a new physical force was discovered : the nuclear force. The latest stage of research has produced four more phenomena :

— nuclear force quanta,
— excited states of nucleons,
— antimatter,
— weak interactions.

Prof. Weisskopf concluded with some remarks on the possible 'next generation' of accelerators that should lead us even closer to a basic explanation of matter.

This subject was taken up by Dr. M.G.N. Hine, Directorate Member for Applied Physics, who provided details of the two largest European projects :

— a pair of intersecting storage rings for the present 28-GeV synchrotron at CERN ;
— a new 300-GeV proton synchrotron, more than ten times larger than any existing machine, with a diameter of 2.4 km.

It is hoped to build the storage rings on the extension of the CERN site promised on French territory. They would have a diameter of about 300 m and would induce two beams of 28-GeV protons to collide head-on, with an effect equal to that of a 1700-GeV beam striking a stationary target. Both the storage rings and the new large accelerator have been proposed by a committee of leading European physicists, under Prof. E. Amaldi, as a 'summit programme' to balance the 'base-of-pyramid programme' comprising developments in national laboratories dealing more directly with universities (see *CERN COURIER*, vol. 4, no. 2, Feb. 1964).

Such developments will obviously cost money. By 1973, said Dr. Hine, the total annual cost of the existing accelerators and the new 'summit programme' would be 1100 million Swiss francs, that is some three times the present rate of spending. In 1963, Europe spent about 350 million Sw.F. on high-energy physics — 100 million Sw.F. directly on CERN and 250 million Sw.F. in national laboratories ; about 40 million Sw.F. from the latter sum were used by national groups collaborating with CERN.

Dr. Hine's talk also included what he called 'a digression on the classification of scientific work', in which he made a clear distinction between development,' applied research, non-fundamental basic research and fundamental basic research.

A very lively discussion then took place between the Director General, the Directorate members and the scientific correspondents, continuing over lunch in the CERN restaurant, where Division leaders joined the party in anticipation of the afternoon's tour of parts of the laboratory.

The technical and scientific press day ended about 5 p.m., after the visitors had met again over refreshments for final informal talks with Prof. Weisskopf, Dr. Hine and Mr. Hampton. On their way out, the correspondents had good reason to ponder a quotation from Prof. I.I. Rabi's book, *My life and times as a physicist*, framed near the Public Information Office:

> 'I invite and challenge those who are interested in ideas to come over to our side, work through what we have, and tell it to the world in poetry or in prose. I promise you an interesting and rewarding experience' ●

The '**1964 Easter school for physicists using the CERN proton synchrotron and synchro-cyclotron**', successor to the 'Easter school for emulsion physicists' of the previous two years, was held at Herceg Novi, Yugoslavia, during 18-31 May, by invitation of the Yugoslav Federal Nuclear Energy Commission.

Organized by a committee including members from the University of Belgrade, the Yugoslav Federal Nuclear Energy Commission and the University of London, as well as CERN, the school was intended primarily for young experimental physicists engaged in the analysis of bubble-chamber pictures and nuclear emulsions. About 120 physicists attended, from universities and research institutes all over Europe, including a few from CERN, two from Dubna and about twenty from Yugoslavia itself. An unusual feature, even for a meeting of this kind, was that part of the 'Proceedings', containing the texts of some of the lectures given at the school, was published in advance (CERN 64-13, 3 volumes) ●

Computers at CERN

by F. BECK, Data Handling Division

It was announced a short while ago that by the beginning of next year CERN will be equipped with the most powerful computer installation in Europe. This article, after a brief introduction giving the history of computer use at CERN, gives examples of the problems that the computer has to deal with and how the work is organized.

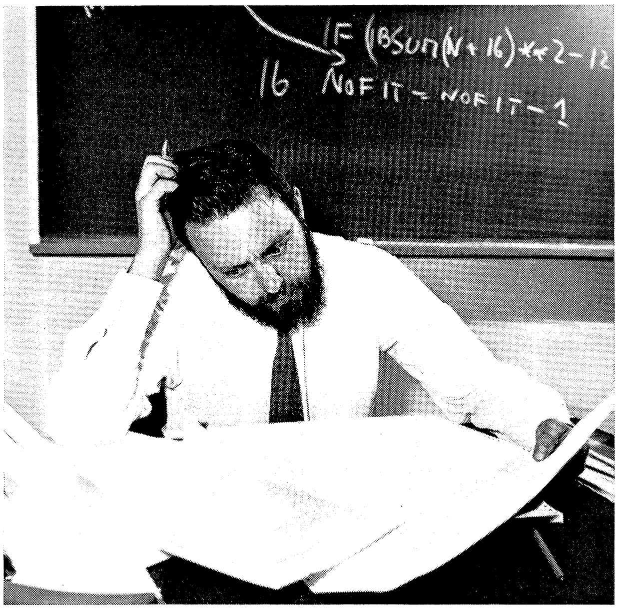
> 'I will yet venture to predict that a time will arrive when the accumulating labour which arises from the arithmetical applications of mathematical formulae, acting as a constantly retarding force, shall ultimately impede the useful progress of the science, unless this (computing machine) or some equivalent method is devised for relieving it from the overwhelming incumbrance of numerical detail.'

Thus wrote the English mathematician, Charles Babbage, in a letter dated 6 November 1822 ! There must be few places where the truth of this prophecy has been as clearly shown as at CERN, where much of the work would now be quite impossible without the use of large high-speed computers.

Development of computer use

The popular picture of a biologist shows him wearing a white coat, peering through a microscope. If it is at all possible to draw a popular picture of an experimental high-energy physicist, he will probably be sitting at his desk and looking at his output from the computer. For the computer is increasingly becoming the tool by which raw experimental results are made intelligible to the physicist.

By one of those apparent strokes of luck that occur so often in the history of science, electronic digital computers became available to scientists at just that stage in the development of fundamental physics when further progress would otherwise have been barred by the lack of means to perform large-scale calculations. Analogue computers, which had been in existence for a number of decades previously, have the disadvantage for this work of limited accuracy and the more serious drawback that a more complicated calculation needs a more complicated machine. What was needed was the equivalent of an organized team of people, all operating desk calculating machines, so that a large problem in computation could be completed and checked in a reasonable time. So much was this need felt, that in England, for example, before digital computers became generally available, there was a commercial organization supplying just such a service of hand computation.



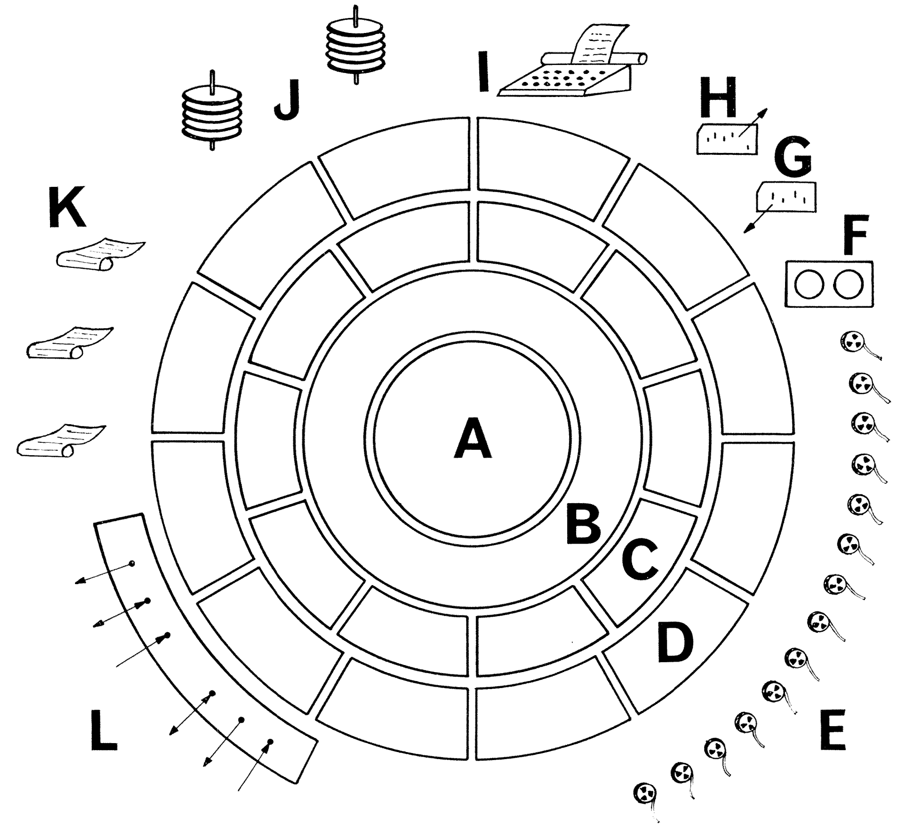
CERN/PI 55.5.64

' Sitting at his desk and looking at his output from the computer ' (A. Cooper).

At CERN the requirement for computing facilities in the Theory Division was at first largely satisfied by employing a calculating prodigy, Willem Klein. Mr. Klein is one of those rare people who combine a prodigious memory with a love of numbers, and it was some time before computers in their ever-increasing development were able to catch up with him. He is still with us in the Theory Division, giving valuable help to those who need a quick check calculation. It is of interest to note, however, that he has now added a knowledge of computer programming to his armoury of weapons for problem solution !

The first computer calculations made at CERN were also done in the very earliest days of the Organization. Even before October 1958, when the Ferranti Mercury computer was installed, computer work had been sent out to an English Electric Deuce in Teddington, an IBM 704 in Paris and Mercury computers at Harwell and Manchester. Much of this work was concerned with orbit calculations for the proton synchrotron, then being built.

We have now reached a stage at which there is hardly a division at CERN not using its share of the available computer time. On each occasion that a new beam is set up from the accelerator, computer programmes perform the necessary calculations in particle optics as a matter of routine ; beam parameters are kept in check by statistical methods ; hundreds of thousands of photographs from track-chamber experiments are ' digitized ' and have kinematic and statistical calculations performed on them ; the new technique of sonic spark chambers, for the filmless detection of particle tracks, uses the computer more directly. In addition, more than 80 physicists and engineers use the computer on their own account, writing programmes to solve various computational problems that arise in their day-to-day work.



Schematic diagram showing a minimum configuration for CERN's CDC 6600 computer system. The exact number and kinds of peripheral units in the system are not yet fully determined. Note that the units A and C constitute eleven individual computers, all capable of calculating simultaneously. The multiplier, divider, adder and other units are separate electronic units and can all be working at the same time, and input and output may be proceeding simultaneously with calculation, using the channels D.

Numbers are stored by the following methods :

- **During arithmetic operations, in 24 super-high-speed stores in A.**
- **During calculations, in 131 000 high-speed stores in B or 4000 high-speed stores in each unit C.**
- **For longer periods, in the disc stores J, giving fairly rapid access to about 15 million numbers.**
- **For permanent and semi-permanent storage of numbers, on the magnetic tapes, mounted on units E, giving the machine the facility of recording a virtually unlimited library of information, any part of which can be referred to subsequently.**

KEY

A = high-speed arithmetic unit ; B = central magnetic core memory ; C = peripheral processors, each having computing facilities and its own memory; D = data channels; E = magnetic-tape units; F = display console with two cathode-ray tubes; G = card reader; H = card punch; I = teleprinter for machine operation and monitoring; J = magnetic-disc store; K = high-speed line printer; L = connexions to various on-line devices.

There are now two computers at CERN, the original Ferranti Mercury and the IBM 7090, a transistorized and more powerful replacement for its predecessor, the IBM 709. The 7090, in spite of its great speed (about 100 000 multiplications per second !), is rapidly becoming overloaded and is to be replaced towards the end of this year by a CDC 6600, which at present is the most powerful computing system available in the world. It is hoped that this new machine will satisfy the computing needs of CERN for upwards of five years. The Mercury computer is now being used more and more as an experimental machine and there is, for instance, a direct connexion to it at present from a spark-chamber experiment at the proton synchrotron. Calculations are performed and results returned to the experimental area immediately, giving great flexibility.


CERN/ PI 91.10.63

A corner of the IBM 7090 computer room at CERN. At the back are five of the magnetic-tape units, and in front of them the main control desk. In the right foreground is the on-line printer which provides instructions to the operators and information on the progress of the calculations. Also in the picture (left to right) **: Richard Milan, Lucio Gourdiole, and Eric Swoboda.**

A digital computer is a machine that will store numbers, retrieve them from the store as required, and perform the elementary operations of arithmetic (addition, subtraction, multiplication and division).

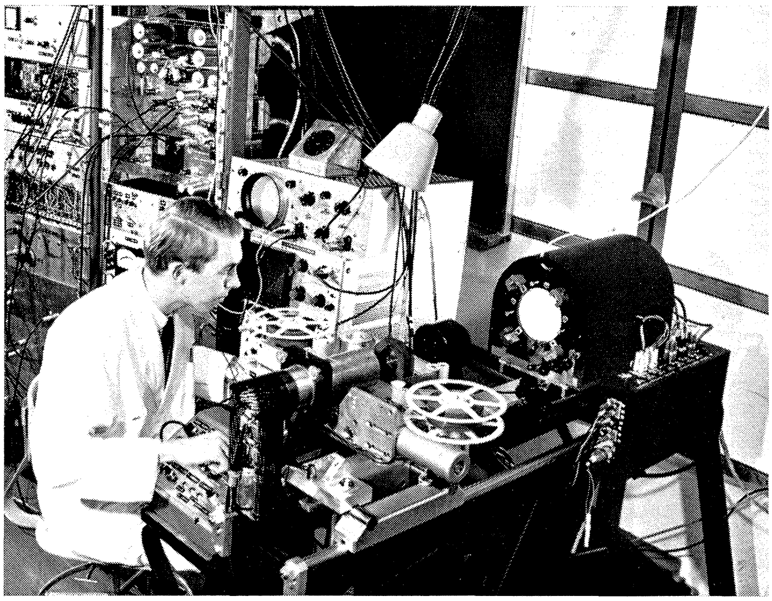
An instruction causes the computer to carry out one of the above steps. Each instruction is represented by a number and can thus be stored and manipulated, as well as obeyed, by the computer.

Data are the numbers on which the machine works during the solution of a problem. Instructions can be used to bring data into the machine from outside, as and when required.

A programme is a sequence of instructions arranged for the performance of a particular task, for example the solution of a mathematical problem. Since it is a series of numbers it can be stored in the machine.

A mathematical problem can be solved by reducing it to a series of arithmetic operations and compiling a programme to perform these operations. This is called programming. In principle, any computer can solve every problem that can be programmed, but the amount of number storage available provides a limitation.

The speed at which computation can be carried out provides another limitation. Modern electronic machines can perform about a million elementary steps per second, but even at this speed the analysis of a bubble-chamber picture takes about a minute — and often tens of thousands of pictures have to be analysed for a single experiment.



CERN/PI 86.1.64

' Luciole ', an apparatus to provide fully automatic scanning and analysis of spark-chamber photographs. The moving spot of light produced by the high-precision cathode-ray tube seen on the right is projected by a lens system through the stationary film on to the light-sensitive face of a photomultiplier. This produces an electrical signal which varies according to the pattern of sparks on the film, and in this way information on the location of each spark with respect to certain reference marks is fed directly to the computer. Working with the device here is Bent Stumpe.

Track-chamber photographs

Among the biggest users of computer time are the various devices for converting the information on bubble-chamber and spark-chamber photographs, usually on 35-mm film, into a form in which the tracks of the particles can be fitted with curves and the entire kinematics of an event subsequently worked out. To this end, from the earliest days of CERN, IEPs (instruments for the evaluation of photographs)* have been built and put into use. These instruments enable accurately measured co-ordinates of points on a track, together with certain identifying information, to be recorded on punched paper tape. Their disadvantage is that measuring is done manually, requires skill and, even with the best operator, is slow and prone to errors. The paper tapes produced have to be copied on to a magnetic tape, checking for various possible errors on the way, and the magnetic tape is then further processed to provide in turn geometric, kinematic and statistical results.

It was recognized at an early stage, both in Europe and in the United States, that for experiments demanding the digitization of very large numbers of pictures, for example those requiring high statistical accuracy, some more-automatic picture-reading equipment would be needed. Two such devices are now coming into use at CERN. One, the Hough-Powell device (known as HPD), developed jointly by CERN, Brookhaven, Berkeley and the Rutherford Laboratory, is an electro-mechanical machine of high precision, which still requires a few pilot measurements to be made manually, on a measuring table named ' Milady ', when used for bubble-chamber pictures. It has already been used in one experiment, for the direct processing of 200 000 spark-chamber photographs (for which the pilot measurements are unnecessary). The other device is called ' Luciole ' a faster, purely electronic machine, although of lower precision, specially developed at CERN for digitizing spark-chamber photographs.

With the sonic spark chamber, the position of the spark between each pair of plates is deduced from the time intervals between its occurrence and the detection of the sound by each of four microphones. Arrays of such devices can be connected directly to the computer, thus dispensing with the taking, developing and examination of photographs.

Particle optics

The study of dynamics of particles in magnetic and electric fields gives rise to another important family of computer programmes. The electron storage ring, or beam-stacking model, required the writing of a programme that followed the motion of individual batches of particles during their acceleration and stacking in the ring. A previous study by the same group resulted in a series of programmes to examine the behaviour and stability of a proposed fixed-field, alternating-gradient stacking device. Various aspects of the performance of the linac (the linear accelerator that feeds the PS) have been studied and improved using the computer, and the later stages of the design of the PS itself involved a detailed computer simulation of the beam in the ring, including the various transverse or ' betatron ' oscillations to which it is subjected.

There also exists a series of particle-optics programmes used for the design and setting up of particle

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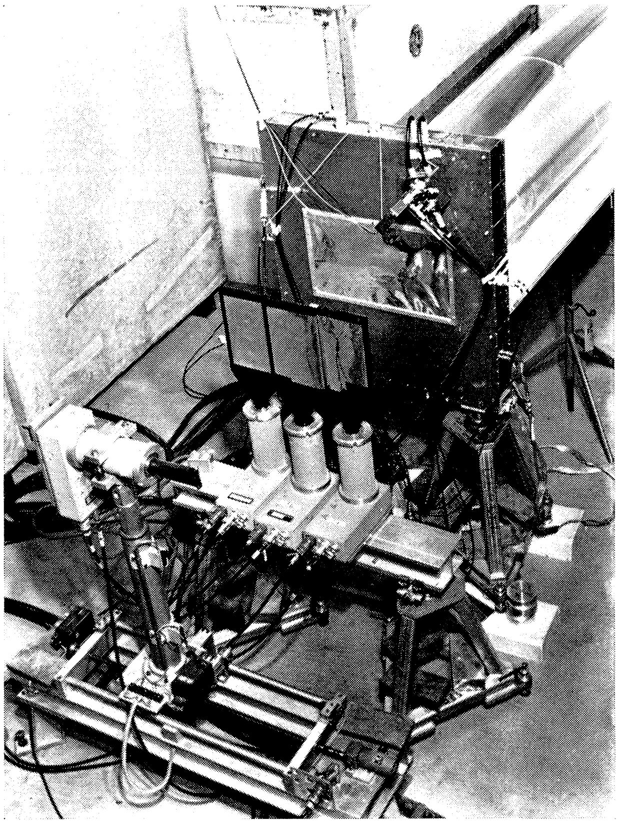
* Rumour once had it that IEP stood for ' instrument for the elimination of physicists ' !



CERN/PI 7.5.64

Sonic spark chamber, with associated scintillation counters, in the East hall of the PS. The use of this technique is making possible for the first time the measurement of proton-proton scattering at extremely small angles. Signals representing the positions of proton tracks in this and four similar chambers are recorded on magnetic tape, which then goes to the 7090 computer for calculations of the direction and momentum of each proton, before and after scattering. Use of a small computer (now being installed at CERN) between the chambers and the magnetic tape will enable up to ten times more events per accelerator burst to be recorded.

beams, particularly the ‘separated’ beams producing particles of only one kind. These are ‘production’ calculations, in the sense that the programme is run with new parameters every time there is a major change in beam layout in any of the experimental halls.

Computer language

At first, a major bar to the use of computers for small, but important, calculations was the difficulty of programming them in their own special ‘language’ to solve the specific problem in hand. What is the use of a machine that can perform a particular calculation in a minute, the would-be-user asks, if it will take a month to provide the programme for the calculation ? Given a hand calculating machine, a pencil and paper and a quiet room, I can do it myself in three weeks ! This valid argument limited the use of computers to two kinds of calculation: those too long to be performed by hand, and those that had to be carried out so often that the original effort of producing the programme was justified.

This situation was rectified by the use of ‘programming languages’, which make it possible to express one’s problem in a form closely resembling that of mathematics. Such languages, if defined rigorously enough, express the problem unambiguously, and they can be translated automatically (by the computer) into the instructions for a particular computer. Two such languages have been used at CERN : Mercury Autocode, and Fortran. The use of Mercury Autocode has recently been discontinued, but until a short time ago many physicists used both languages with great success to express their computational problems in a form directly comprehensible by a computer. Courses in the Fortran language, given both in English and French, are held regularly, and usually last about three weeks. Such ‘compiler languages’, as they are called, used to be considered a rather inferior method for programming computers, as the translations obtained from them often used the machine at a low efficiency, but it is now recognized that the advantage of writing programmes in a language that can be translated mechanically for a number of different computers far outweighs a small loss in programme efficiency.

In the Theory Division, computer programmes are often written by individual theorists to check various

CERN/PI 2.10.63

Part of the Mercury computer at CERN, now being used for tests with ‘on-line’ experiments, in which the measuring equipment is connected more or less directly to the computer, so that the results can be worked out as the accelerator run progresses. Gildaz Auffret is at the control console, with Mrs. Peggy Minor (left) and Mrs. Ursula Franceschi in the background.

mathematical models. Having devised a formula based on a novel theory, the physicist computes theoretical curves for some function that can be compared with experimental results.

Operation

The Data Handling Division, which actually has CERN's central computers under its charge, contains a number of professional programmers, mostly mathematicians by training. Some of these are responsible for the 'systems programmes', that is, the Fortran compiler and its associated supervisor programme. Some have the job of disseminating programming knowledge, helping individual users of the computer, and writing programmes for people in special cases. Others are semi-permanently attached to various divisions, working on particular experiments as members of the team.

A small number of mathematicians are also engaged in what might be called 'specialist computer research', covering such things as list-programming languages and methods of translating from one programme language into another. Such work might be expected to yield long-term profits by giving increases in computing power and efficiency.

As at all large computing installations, computer programmers at CERN do not operate the machine themselves. Data and programmes are submitted through a 'reception office' and the results are eventually available in a 'computer output office', leaving the handling and organizing of the computer work-load, and the operating of the machine, to specialist reception staff and computer operators in the Data Handling Division.

What of the future of computers at CERN? In a field as new as this, predictions are even more dangerous than in others, but it is clear that the arrival of the new computer at the end of the year will cause a great change in the way computers are used. Having ten peripheral processors, each of which is effectively an independent computer, the machine may have many pieces of equipment for data input and output attached to it 'on-line'. The old concept that a computer waiting for the arrival of data is standing idle, and that this is therefore wasteful and expensive, need no longer be true. With the new system, a computer that is waiting for new data for one problem is never idle, but continues with calculations on others. Every moment of its working day is gainfully employed on one or other of the many problems it is solving in parallel. Even so, there will still be a need for a number of smaller computer installations forming part of particular experiments.

As M.G.N. Hine, CERN's Directorate Member for Applied Physics, pointed out at a recent conference*, even with the growth of such facilities, the amount of computing time available may one day dictate the amount of experimental physics research done at CERN, in much the same way as the amount of accelerator time available dictates it now ●

News from abroad

'Nimrod' inaugurated

Friday 24 April saw the inauguration of 'Nimrod', the 7-GeV proton synchrotron at the Rutherford High Energy Laboratory at Chilton, U.K., and the official opening of the Laboratory itself, by the United Kingdom Secretary of State for Education and Science, the Rt. Hon. Quintin Hogg. Among many distinguished guests from the field of high-energy physics was our own Director General, Prof. V.F. Weisskopf, who, in particular, welcomed the new accelerator as part of the world effort to penetrate into the secrets of nature.

The Rutherford High Energy Laboratory is the first establishment of the National Institute for Research in Nuclear Science, which was set up in 1957 by the British Government to provide for common use by universities and others the expensive research facilities required in areas such as high-energy physics and nuclear physics and which are beyond the resources of individual institutions. In this sense it does for British universities what CERN does on a wider scale for the European ones (including the British, of course). The laboratory, with Dr. T. G. Pickavance as Director, is situated in Berkshire, next to the Atomic Energy Research Establishment at Harwell.

Nimrod was begun in 1957 and was intended from the beginning to be a complementary machine to the CERN PS, giving lower energy but higher intensity. Its design energy was chosen as 7 GeV so as to be reasonably far above the threshold for the production of antiprotons, and the well-established 'weak-focusing' principal was used as there was much doubt then whether the required intensity could be reached with a 'strong-focusing' design, at that time still unproved. Some brief details of the machine were given in *CERN COURIER* last September (vol. 3, no. 9, p. 113), shortly after its successful operation at full energy on 27 August 1963.

At the time of its inauguration, Nimrod was operating regularly for $3\,{}^1/_2$ days per week and achieving beam intensities of 3 or 4×10^{11} protons per pulse at 7 GeV. Apart from work aimed at increasing both the beam intensity, towards the expected 10^{12} protons per pulse, and the operating time, a major effort was being made to develop the external proton beam, first extracted from the accelerator on 24 March this year. Six experiments were set up around the machine, and among the team leaders involved were a number of physicists who had been working at CERN during recent years. Among other experiments in preparation are some to be carried out by a collaboration between the 'Centre d'Études Nucléaires' at Saclay, French and British universities, and the Rutherford Laboratory itself. A new liquid-hydrogen bubble chamber will be used, belonging to Saclay and developed from their successful 81-cm chamber at present in use at CERN.

Nimrod is now the second most powerful proton synchrotron in Europe and the first in Britain to be capable of producing kaons, hyperons and antiprotons. Its cost, including buildings was just under £ 11 million (or rather more than that of the CERN PS). The Rutherford Laboratory also has a 50-MeV proton linear accelerator, operating since 1959, other divisions for applied physics, engineering and administration, and a separate group working on a novel

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* Informal meeting on filmless spark chamber techniques and associated computer use, CERN, 3-6 March 1964.

20-MeV electrostatic-generator project for Oxford University. It has a permanent staff of about 1000, and a budget (for 1963-64) of about £7 million, three quarters that of CERN.

(From information obtained by courtesy of the editor of 'Orbit'.)

Experiments at 'DESY'

Europe's largest electron accelerator, the German Electron Synchrotron, DESY, at Hamburg, is also in operation, having accelerated its first beam to full energy at the end of last February.

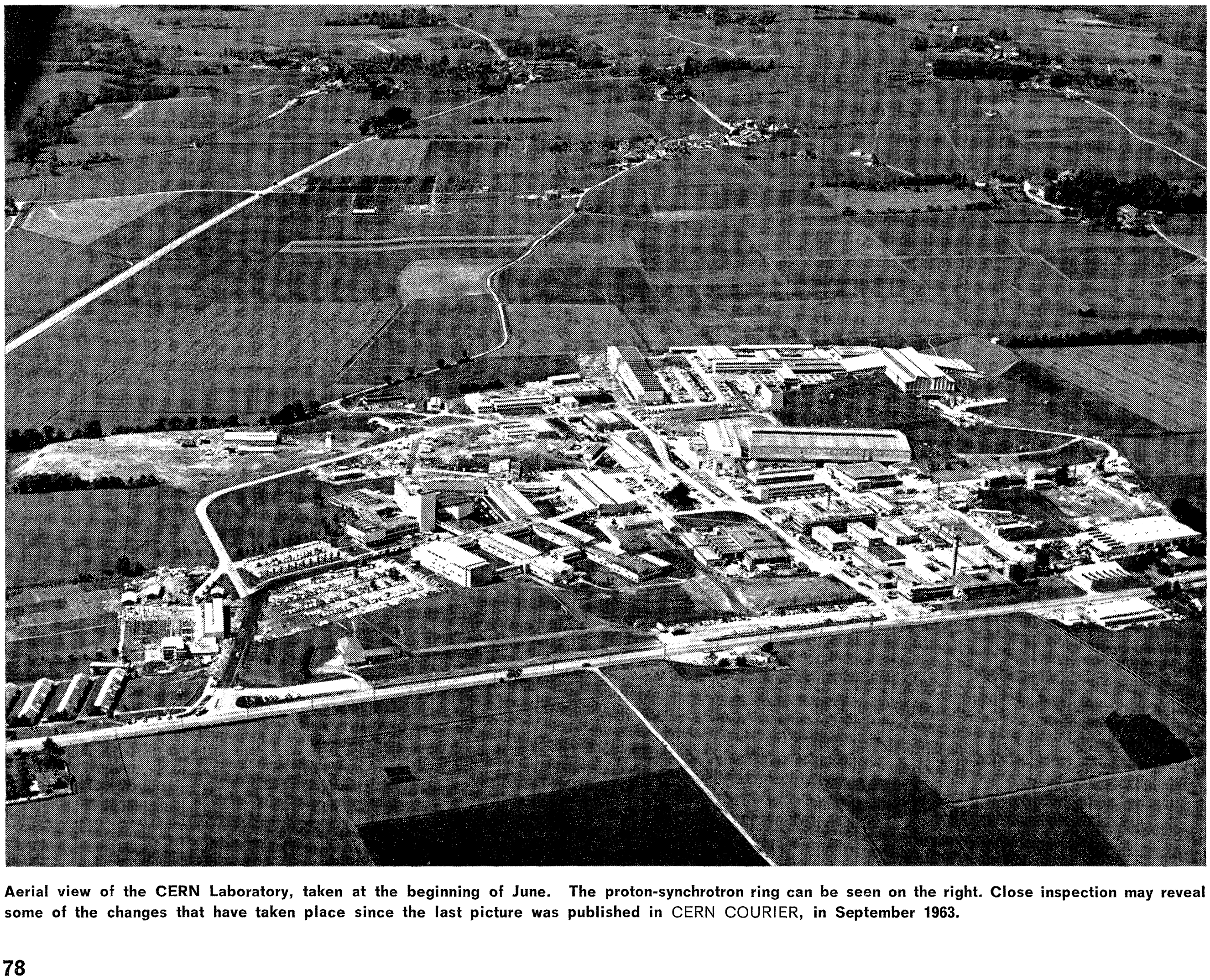
During last summer the high-frequency system was operated at full power, and the magnet power supply was completed after incorporating additional filter circuits to overcome some difficulties that had shown up in earlier tests. Assembly of the accelerator parts, with the exception of the vacuum system, was completed in October 1963, and component tests gave satisfactory results.

The linear accelerator, already delivered in 1961, also performed satisfactorily, and the first electron beam was injected into the magnet ring in December 1963. First attempts to accelerate electrons in the ring were made on 7 February 1964, and late on 26 February an energy of 5 GeV was reached for the first time. This was soon raised to 6 GeV, the maximum design energy.

At present the accelerator is operating at about 4.8 GeV, with an intensity of between 10^{10} and 3×10^{10} electrons per pulse ($5 - 15 \times 10^{11}$ electrons per second). Using a preliminary target, bremsstrahlung (gamma-ray) pulses up to 1.6 milliseconds long have been attained with an intensity of about 3×10^{8} effective quanta per 10^{10} electrons. A pair spectrometer is being used to measure the spectrum of the bremsstrahlung. The first experimental results on the scattering of electrons by protons have also been obtained, using the internal electron beam. Measurements have been begun on the recoil protons arising from the nuclear production of gamma rays.

An 80-cm liquid-hydrogen bubble chamber has been built at the French laboratory at Saclay, with the help of French physicists and engineers, and was operated successfully there in the middle of June. This chamber, also a development of the one at CERN, is expected to be installed at DESY at the beginning of August, 1964. As further examples of the international nature of high-energy physics research, it is worth noting that the linear accelerator for DESY was supplied by an English firm, and that the whole synchrotron is closely similar to the 6-GeV Cambridge Electron Accelerator in the U.S.A., put into operation two years ago. Close co-operation has been maintained between the two laboratories concerned, and one of the senior staff of the Cambridge machine spent six months in Hamburg to see the younger one safely into service.

(Based on information kindly supplied by Prof. W. Jentschke.) ●



CERN/PI 23.6.64

Aerial view of the CERN Laboratory, taken at the beginning of June. The proton-synchrotron ring can be seen on the right. Close inspection may reveal some of the changes that have taken place since the last picture was published in CERN COURIER**, in September 1963.**

BOOKS

MHD—Magnetohydrodynamic generation of electrical power, edited by R. A. Coombe (London, Chapman and Hall, 1964 ; 30 s.), is one of the first volumes in a new series entitled *Modern electrical engineering*, intended to provide a number of inexpensive monographs at postgraduate or final-year student level covering topics of interest in all branches of electrical engineering.

Although for a reviewer to quote the ' blurb ' or preface of a book is to invite a charge of laziness, in this case it seems justified, for the editor has provided an excellent description of his book in the preface, which reads as follows :

> ' The intention of this book is to provide for the interested scientist a survey of the principles and problems of MHD generation. It is designed so that a non-specialist may start with no previous knowledge of the subject but finish with the ability to read and understand the latest research papers.
>
> When writing an introductory account of such a subject it is difficult to proceed in a strictly logical way. Many arguments can only be understood fully when their end product is appreciated. For this reason Chapter 3 has been written as an introduction covering the whole field of MHD generation. It is non-mathematical and is intended to survey the MHD scene so that the subsequent Chapters 4-8 can be better understood. Chapter 1 is a short chapter to show how MHD fits in as a specific method of Direct Conversion, and Chapter 2 gives a brief review of the history of the subject. The first three chapters are thus of an introductory nature.
>
> The specialist Chapters 4-8 have been contributed by six scientists engaged on work relating to MHD generation, all of whom are recognised authorities on the subject-matter of their respective chapters...
>
> Due to the form adopted, some repetition of ideas does occur from chapter to chapter. This is not seen as a disadvantage, however, for each consideration of a particular topic is usually made from a different point of view. As far as possible symbols have been kept distinct, though occasionally the same one is used for two quantities when there is no possibility of confusion. Units are in the MKS system throughout except for one or two exceptions where units of a special nature are used e.g. Angstrom unit. Also, in some places, the temperature is quoted in degrees Kelvin instead of Centigrade.
>
> The text is based on a series of lectures given at the Royal College of Advanced Technology, Salford, in the latter part of 1962...'

Magnetohydrodynamic (MHD) generation is a method of converting heat energy into electrical energy without the use of the conventional steam (or gas) turbines that perform the conversion via the intermediary of mechanical energy. Instead of the metallic conductors of the conventional electric generator (dynamo), the MHD generator uses a stream of ionized gas. Passage of this gas through a strong magnetic field produces an electric current exactly analogous to that produced in the metallic conductor. The advantage is that the stream of ionized gas can be a direct product of the primary heat source (furnace or nuclear reactor) and that the generation efficiency can be much higher because the gas can be used at a temperature far above that which is ever likely to be possible in a turbine. MHD generation is the most promising method of ' direct conversion ' for power levels exceeding 100 MW, and the most likely use for the system is as a ' topper ', placed between the primary heat source and the steam turbine of an otherwise conventional generating system. It appears likely that such a combined system would have an overall conversion efficiency of 55 % or even 65 %, instead of the 45 % which seems to be the limit for the conventional station alone.

There are many difficulties — high temperatures, problems of ionization, current collection, the disadvantage that direct current, instead of alternating current, is produced and conversion equipment is expensive. It is an interesting commentary on this book, however, that the problems to be solved are covered as adequately as the advances already made and the hopes for future successes.

To return to the editor's preface, the present reviewer has not actually tried to read the latest research papers on the subject, but he is pretty sure that he could : the authors' aims are fully realized. The introductory chapters in particular are concise and clear. They have been written by the editor, and their style can be gathered from the preface quoted. As a good lecturer repeats his salient points several times in an hour's talk, so the repetition of ideas from chapter to chapter in this book serves to remind the reader of unfamiliar topics and to co-ordinate the different sections of the subject. A creditable point of detail is the conversion of Wb/m^2 into gauss for those who are more familiar with c.g.s. units ; symbols are consistent and listed alphabetically in 4 ½ pages at the end.

This is perhaps a convenient point to begin mention of the defects of the book, since many of the units quoted do not conform to the recognized standards : for example, $/m^3$ instead of m^{-3}, $Joules/m^2/^\circ C$ instead of J/m^2 deg C, $kg/sec/m^2$ instead of $kg/m^2\,s$. Standard forms have also been ignored in the lists of references, given at the end of each chapter ; the explanation that (for example) ' Pennsylvania, 1961 ' refers to the published proceedings of the 2nd symposium on the engineering aspects of MHD, at Pennsylvania in March 1961, would have been more helpful on p. 16 than on p. 204. The index is not very useful, considering the large amount of information that the book contains.

The printing has been carried out directly from ' varityped ' sheets and the book has thus inherited most of the defects of normal typewritten reports, particularly in the layout of mathematical equations. This may also explain, though not excuse, the large number of misprints — mostly simple typing errors. In a more expensive, or less well-written book, these would have been unforgivable: as it is, they distract from the pleasure of reading, and if this system of printing is to be used for the other books in the series it is to be hoped that more care will be taken over this point.

Such defects make the present volume less than perfect, but in spite of them, as was remarked earlier, the text provides a first-rate introduction to a comparatively new subject. As well as the students for whom it is intended, anyone interested in future developments of science and engineering could read it with profit.

It is, by the way, worth noting that this promising method of producing electrical power is based on principles formulated in the days of Faraday and Maxwell, around a hundred years ago. Also, although ideas for practical systems date back sixty years or more, it was the study of plasmas for thermonuclear research and the development of rockets and heat-resisting materials that led, albeit indirectly, to the present successful experiments in MHD generation. There is scope for reflection, in this book, on the interactions of academic research and technological progress.

A.G.H.

Effect of ionizing radiation on high polymers, by T. S. Nikitina, E. V. Zhuravskaya and A. S. Kuzminsky (New York, Gordon and Breach Science Publishers Inc., 1963 ; $ 4.95) has been translated from the Russian by Scripta Technica, Inc. It forms volume 13 of the publisher's *Russian tracts on advanced mathematics and physics.*

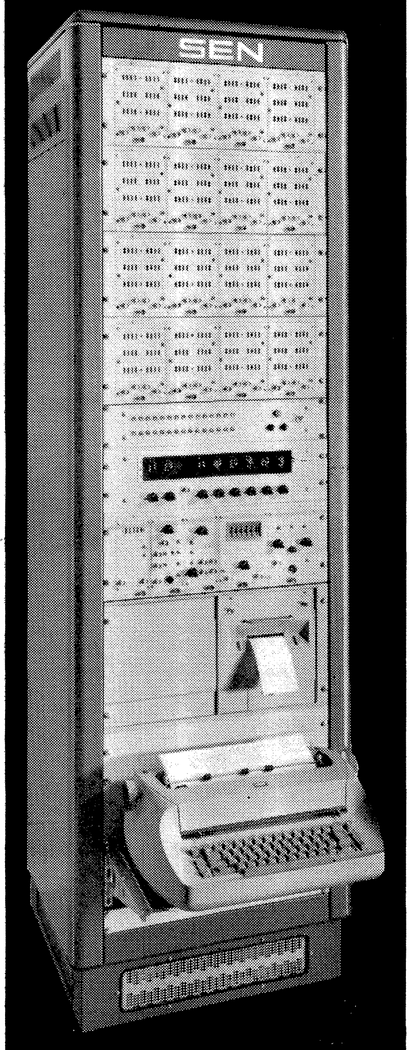
The book represents a thorough literature survey of the subject, although the facts are unfortunately mentioned in a very brief way. After a short first chapter, where the various types of radiation and their units of measurement are listed, chapter two describes the radiochemical processes occurring in polymers as a result of irradiation, mainly by gamma rays. The most important processes are'cross-linking', in which parallel macromolecules are joined to each other by cross bonds to give a kind of vulcanization, and 'degradation', in which the main molecular chains are split in a random manner and finally reduced to their constituent monomers. In addition, gas liberation and oxydation occur in the second case as a consequence of the bond rupture. As a result of these chemical changes, alterations are brought about in the physical properties of the materials, such as mechanical strength and electrical insulation.

Chapter three gives actual experimental data for various highly polymerized materials, which are classified under the two headings mentioned above, namely those that are cross-linked by irradiation (polyethylene, polystyrene, carbon-chain rubbers, polysiloxanes, p.v.c.) and those that are degraded (polymethyl methacrylate, polyisobutylene, fibres). It has been found that the aromatic structure of styrene, as well as the naphthalene and methyl ring structures, are around a hundred times less sensitive to radiation than are the cyclic chains. If introduced into a polymer of the latter kind they even reduce its rate of cross-linking. Sulphur also inhibits the rate of radioactive vulcanization of rubber.

Tables giving the measured effects of gamma radiation on the properties of elastomers and plastics are added in an appendix.

Taken as a whole, this is a useful first reference book for those faced with having to make a particular choice of organic materials to withstand the effects of irradiation.

M. Barbier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Staff Vacancies

at CERN in 1964

Applications are invited from citizens of CERN Member States to fill vacancies in various parts of the Organization.

There are vacancies in the three following main groups for :

— **Graduate physicists, mathematicians and engineers** with post-university experience in techniques such as computer programming, data handling, electronics, vacuum, electromagnets, radiofrequency, high voltages, electron optics and pulses.

— **Qualified technicians** to help physicists and engineers in the performance of work in the branches mentioned above.

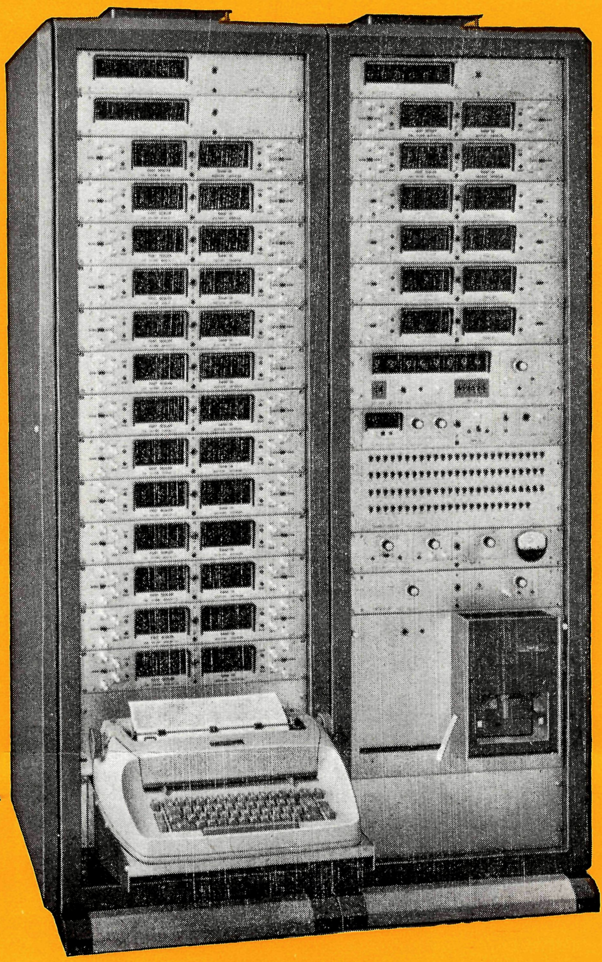
— **Secretarial staff.** There are excellent career opportunities for younger persons who already possess a good working knowledge of English and French and who have typing and / or general office experience.

CERN offers attractive salaries, generous leave, and substantial special allowances and benefits.

Present staff members are invited to bring this notice to the attention of suitable potential candidates.

Application forms may be obtained from

Personnel Division (CC/64/5), CERN, Geneva 23, Switzerland



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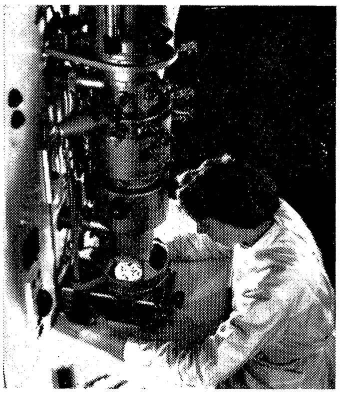

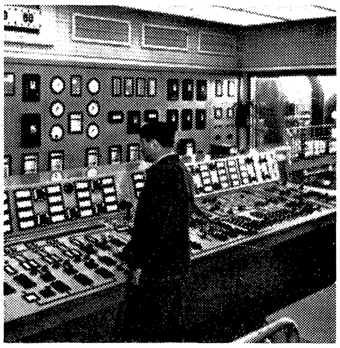

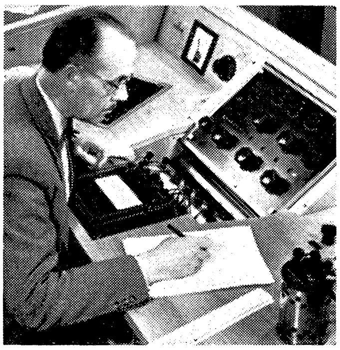

Measurement and control in
thermal and
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Electrical metrology

Electronic microscopy

Non-destructive testing
of materials

Measurement of mechanical
quantities

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