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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, more typical of the season than of high-energy physics, is nevertheless part of CERN. It shows the winter's first covering of snow on the lawns and some of the trees in front of the restaurant, enhancing the view across the Geneva countryside towards Mt. Salève.

CERN COURIER

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Last month at CERN

The proton synchrotron

The second of the major **shut-down** periods planned for the proton synchrotron this year was from 1-26 November. As usual, this time was devoted to work on the accelerator that, in general, cannot be carried out conveniently during the three-and-a-half days each fortnight between each run for experiments. Such work includes modifications to the machine, installation of new equipment and major changes of beam lines, in addition to routine maintenance. Unfortunately, space and time do not allow a full account of the activity during this latest period; suffice it to say that the programme issued in advance ran to more than thirty pages.

Among the **beam changes** carried out this time were the dismantling of the o_3 and d_{17a} beam lines, the construction of d_{18} and d_{18a} (in the South hall), w_1 (in the East hall, for the 2-metre bubble chamber) and part of o_7 (also in the East hall) and the installation of a new 3-metre separator instead of the former 6-metre one in the k_4 beam line.

During this time, also, the Lagarrigue group and their **1-m heavy-liquid bubble chamber,** from the **Ecole Polytechnique, Paris,** left CERN for Saclay, where they will carry out experiments at the 3-GeV accelerator 'Saturne' during the next few months. Since its arrival at CERN in July 1960, this chamber has provided some 3 million photographs for many different experiments. It is expected to return here in the second half of 1965.

On 24 November the whole of the MPS Division fêted the **fifth anniversary** of the first successful operation of the synchrotron at its design energy of 24 GeV (see *CERN COURIER* no. 4, November 1959). Included in the programme were speeches by J. B. Adams, under whose guidance the accelerator came into being, P. Germain who became leader of the Division in 1961, and Prof. V. F. Weisskopf, CERN's Director General. A fascinating display involving three slide projectors, a ciné projector and synchronized tape commentary presented the history of the PS from the days when cows roamed the fields on which it now stands to the current projects for storage rings and other additions and improvements.

The same day saw a reunion of the former 'parameters committee' of the PS, the senior scientists responsible for the major points of its design, providing an occasion for those now scattered in various institutions throughout Europe to meet again with their former colleagues at CERN.

It was presumably only a coincidence, but the jubilation was cut short in the following two weeks by a succession of breakdowns and other difficulties that reduced by more than a quarter the time that could be used for physics experiments during the first period of running after the shut-down.

Nevertheless, good use was made of the time that was available, particularly by groups setting up or testing new apparatus. In the East hall, the experiment on proton-proton elastic and inelastic scattering, now running with the **SDS 920 computer** 'on-line' (see *CERN COURIER*, vol. 4, p. 104, August 1964), continued to collect data at a much faster rate than previously.

The editor and assistant editor of CERN COURIER, and everyone else in the Public Information Office, send their best wishes for 1965 to all readers.

Health Physics contributions to International symposium

From 23 to 27 November a number of members of the CERN Health Physics Group, led by its Head J. Baarli, took an active part in the **International symposium on the dosimetry of irradiation from external sources,** held in

Paris under the auspices of the French section of the Health Physics Society. The Congress brought together several hundred specialists in dosimetry from all parts of the world, the discussions being divided into three main sections covering theoretical aspects of dosimetry, methods and apparatus, and the results of dose measurements carried out under various conditions.

The participants from CERN presented a number of papers in all three sections, dealing mainly of course with the special problems arising in the dosimetry of high-energy radiation. A. H. Sullivan spoke on the theoretical aspects of possible methods for the direct measurement of 'dose-equivalent' for different kinds of radiation. During a session on special problems, at which the chairman was J. Baarli, J. Dutrannois spoke on the particular problems of using nuclear emulsions for personnel dosimetry at high-energy accelerators, T. Overton presented a paper by K. Goebel on the role of activation detectors in high-energy particle dosimetry, and S. Charalambus reported on a study of the dose-rate at the surface of materials activated by the CERN accelerators. Finally, in the session dealing with radiation control, A. Rindi spoke of the risks arising from the activation of the CERN 600-MeV synchro-cyclotron, and J. Baarli discussed the radiation protection of the CERN laboratory and its surroundings during operation of the accelerators.

CERN/PI 175.11.64

Scene in the main control room of the proton synchrotron during the shut-down. With the development of new techniques in recent years, the adjoining counting room has been used less and less whilst the amount of control equipment for the accelerator has grown. A convenient solution has been found by removing a partition and incorporating one bay of the counting room into the control-room area.

CERN FORTRAN

As mentioned in the article on CERN computers last June (*CERN COURIER*, vol. 4, pp. 73-77), various 'automatic programming languages' have been developed in recent years to simplify the preparation of the sets of instructions (or 'programmes') required for the solution of each specific problem on a computer. These languages were a big step towards simplifying the task of preparing long programmes, but a change of computer, especially to one from a different manufacturer, still meant that a considerable number of alterations had to be made to the programme. In particular, this left a number of problems in the exchange of computer programmes between CERN and other laboratories collaborating in the same experiment.

In November, however, 'CERN Fortran' was announced by CERN's Data Handling Division. This is a new programming language, developed as a result of discussions within CERN and a meeting of representatives from various bubble-chamber groups held at the Weizmann Institute of Science, in Israel, last May. It is a version of the Fortran series, allowing programmes to be run with only minor modifications on computers that otherwise use Fortran IV (IBM 7090/94, IBM 360 series, Univac 1107) or Fortran 63 or 66 (CDC 1604, 3600 and 6600). Considerable work has been done in CERN in recent months to convert large programmes into the new language and test them on both IBM and CDC computers. This experience has shown that, correctly used, CERN Fortran goes a long way towards making programmes easily interchangeable between these computers, and it has been adopted for all programmes to be used on CERN's new computer, the CDC 6600.

The language has been described in the **CERN Fortran Manual,** which can be obtained from the Computer Documentation Service, Data Handling Division, CERN, 1211 Genève 23, Switzerland ●

Because English and French are the official languages of CERN, and because the translation of every item in CERN COURIER *from one language into the other already leads to sufficient trouble, many readers have unfortunately to be content with a journal that is not of their own tongue. As a very slight recompense for some of them, the following contribution, alluding to the litteral translation of the word 'antiparticle', is included in its original German form; others may like to amuse themselves by producing their own English or French versions.*

DIE GROSSE LAMENTEI

Schönheit vergeht :
Denn neben jedem Veilchen
wächst schon sein Gegen-Veilchen.

Zeit auch verweht :
Denn neben jedem Weilchen
bläst schon sein Gegen-Weilchen.

Raum auch zergeht :
Denn neben jedem Meilchen
läuft schon sein Gegen-Meilchen.

Ding auch zerweht :
Denn neben jedem Teilchen,
Ach Gott, da hockt sein Gegen-Teilchen.

Gegenteilchen
enteil-chen
Teilchen
Eilchen...

Gertrude Weisskopf

Saclay / CERN polarized - proton target

Early in November the first run was carried out at CERN's proton synchrotron on an experiment to determine the parity of the negative xi hyperon. This experiment relies on the success of an important and interesting new piece of equipment, the polarized-proton target that has been brought into use through the fruitful collaboration of groups at Saclay (Centre d'Etudes Nucléaires) and CERN. Although in use for the first time for the experiment for which it was designed, the target itself had, in fact, previously been tested in a proton-scattering experiment at the synchro-cyclotron last July.*

One of the fundamental properties of both atomic nuclei and sub-nuclear particles is their 'spin', a quantum-mechanical concept that can be best imagined as the amount of rotation (that is, the angular momentum) about an axis in the particle. Spin is related to 'parity', another quantum-mechanical property that determines whether a particle is or is not indistinguishable from its mirror image, and measurements of both play an important role in high-energy physics research.

Such measurements essentially involve the interaction between a beam of incoming particles and the nuclei (at low energy) or nucleons (at high energy) of a target. It is a fact of everyday experience that the direction taken by a ball after bouncing from a flat surface depends on the way it is spinning. Similarly, a non-spinning tennis ball bounced off a revolving globe will have a preferred direction of flight, and repeated throws of an arbitrarily spinning ball will show a specific pattern according to the sense and speed of rotation of the globe. In most of the corresponding experiments with particles, although both the beam and target particles have a specific magnitude of spin, the direction is in both cases arbitrary and the resulting patterns (whether of scattered incoming particles or of secondary particles produced by nuclear interactions) are correspondingly more difficult to analyse. For this reason attention has turned in recent years to the production of both sources and targets of polarized particles 'Polarized', in this context, means that an enhanced proportion of the particles not only have their spin axes parallel to a given direction but also spin in the same sense.

The new target uses the principle of 'dynamic polarization'**, in which a paramagnetic crystal is cooled to below liquid-helium temperature in a strong magnetic field and subjected to radio-frequency radiation of a particular (very high) frequency.

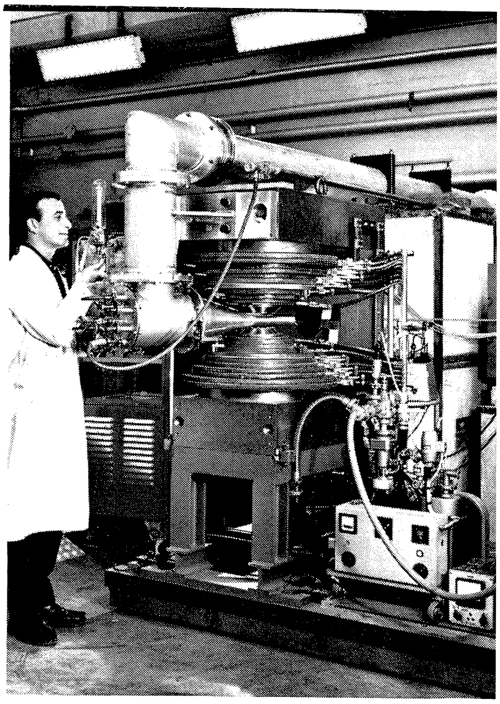
The crystalline substance used is lanthanum manganese nitrate (known as LMN) containing about 1% of neodymium-142 (which has zero nuclear spin). The precise mode of operation is rather complicated and depends on an accurate knowledge of the laws of quantum mechanics as applied to this substance but, briefly, the action is as follows. Under the influence of the magnetic field the outer electrons of the neodymium atoms, having a large magnetic moment, become polarized. Each molecule of LMN is associated with 24 molecules of water in the crystal, and magnetic interaction between the neodymium electrons and protons in the water provides a mechanism whereby the protons become aligned, that is, their spin axes become predominantly parallel to each other, and acquire a small degree of polarization. This 'thermal equilibrium polarization' is increased by increasing the strength of the applied magnetic field or by decreasing the temperature, but is always too feeble to be useful. Very low temperatures are necessary to prevent the atoms from being jostled out of alignment by purely thermal motion and to allow a high degree of orientation of the neodymium electrons.

At this stage most of the electrons are spinning about their axes in the same sense; conventionally they are said to have spin 'up' ($\uparrow$). By contrast, half the protons have spin 'up', half spin 'down' ($\downarrow$). If the crystal is then irradiated with very-high-frequency radio waves of just the right frequency, simultaneous 'flipping' of the coupled axes of an electron and a proton can be produced. Depending on the frequency selected, the flipping may be in the same sense, giving a 'flip-flip' effect ($\uparrow\uparrow$ becomes $\downarrow\downarrow$), or in the opposite sense, giving 'flip-flop' ($\uparrow\downarrow$ becomes $\downarrow\uparrow$). Because of the particular properties of the LMN crystal, the electron flips back quickly to its original state, where it is ready again to reverse another proton, whilst the proton stays in its new state for a long time. In the flip-flip transition, only protons with spin 'up' are effected, being changed to spin 'down', so that, in principle, all the protons become polarized 'down'; in the flip-flop case they become polarized 'up'. The polarization can, thus, in practice, be enhanced by factors of a few hundred with respect to the natural value.

Thus the following situation exists: vibrations of the atoms and electrons in the crystal are reduced by the low temperature, neodymium electron spin axes are polarized by the magnetic field and protons are pulled into line by the electrons; the microwave radio field then repeatedly flips electrons and protons simultaneously so that a large fraction of the latter spin in the same sense on parallel axes.

The target in use at CERN consists essentially of four main parts: the cryogenic apparatus for producing the low

Continued on p. 172



CERN/PI 1.5.64

The polarized-proton target during assembly in the proton room of the synchro-cyclotron at CERN. The conically shaped pole pieces of the C-shaped magnet, and their water-cooled windings, can be clearly seen, with the crystal holder and microwave cavity in the cryostat extending between the pole faces. Liquid helium is fed through one of the passages in the flange on the left, and helium gas is pumped away through the large pipe leading off overhead.

* M. Borghini, M. Odehnal, P. Roubeau and C. Ryter; G. Coignet, L. Dick and L. di Lella: A test of a polarized-proton target by 600-MeV p-p scattering – to be published in Proceedings of the International conference on high-energy physics, Dubna, 1964.

** See for example : A. Abragam and M. Borghini, 'Dynamic polarization of nuclear targets', chapter in 'Progress in low-temperature physics', North-Holland Publishing Co., 1964.

The eleventh anniversary
- some unscientific recollections

by **R. W. PENNEY**

CERN has recently celebrated its official tenth anniversary, but for a few of us the first CERN decade ended already a year ago. Indeed, it is difficult to say when CERN really started. Was it in 1949, when Louis de Broglie put forward the idea in a message to the European Cultural Conference in Lausanne? Was it in the following year, when Prof. Rabi sponsored a UNESCO resolution encouraging regional research? Or was it in 1952, when the European Council for Nuclear Research (in French the 'Conseil Européen pour la Recherche Nucléaire', hence CERN) first came into being? The choice is there, but for some twenty scientists and engineers and a sprinkling of others like myself, CERN began in the autumn of 1953 when we first set up house in Geneva. By that time, individual groups in many parts of Europe were working on plans for the future machines; for instance a Synchro-cyclotron group, under the late Professor Bakker, already existed in Amsterdam with offshoots in Paris, Uppsala and Liverpool, a Theory group had formed around Niels Bohr and his Institute in Copenhagen, and the Secretary General (Professor Amaldi), with his office, was in Rome. But from September 1953, Geneva was the focal point of the Organization's activities.

What was life like in those early days? Exhilarating, certainly; uncomfortable also, and for some offering little security. Salaries were for the most part geared to national conditions, and Geneva was already one of the most expensive towns in Europe; health insurance and pension schemes, housing and welfare services, were to come only later. Still the disadvantages were more than discounted by enthusiasm and a faith that the Council would see us through. In the event, I don't think we were disappointed. We had plenty to grumble about then, but somehow we never got round to doing so seriously, probably because we were all too busy thinking and living CERN. We talked shop all day and a good part of the night, at first to the despair of our wives but after a time they too joined in.

We often did not know from one month to the next where we would be working or living — the Meyrin site then was a ploughed field and few of us were able to take on long-lease flats or houses. The main contingent, the PS group, led by Odd Dahl of Norway, had benefited from the hospitality of the 'Institut de Physique' in Geneva, but they soon outgrew the few offices and laboratories that could be spared for them. The first of the ubiquitous CERN barracks made its appearance alongside the Institut, and before the PS group finally moved to Meyrin it looked as if the Swiss Army had taken over. The 'Administration' started life as part of the Laboratory group under Lew Kowarski, who was then leading a peripatetic existence between Paris and Geneva. It consisted of a Purchasing Officer and myself with one secretary between us, all sitting together in an office next door to the Geneva Unemployment Office in Glacis de Rive (we were not inspired). R. Christinger was also among our number but he was kept busy looking after the needs of PS at the Institut and trying to keep good relations with the local authorities.

It should be remembered that, at that time, CERN was looked upon by Geneva and its inhabitants as a very strange animal indeed. Many of the local people quite sincerely thought that they were in imminent danger of atomic disintegration, or at the very least, that mysterious radiations would produce a flock of two-headed babies around the town. Shortly before our arrival, a popular referendum had been organized against the establishment of CERN in Geneva, and it was only thanks to some intensive campaigning by certain of the more enlightened citizens (among whom we shall always remember CERN's very good friend, the evergreen Albert Picot) that CERN was finally accepted. It took many years for CERN to reach its present level of comparative respectability, and in the early days we got a little tired of having to disclaim any connexion with atom bombs.

During 1954, the Laboratory group took over the 'Villa de Cointrin' (next to the airport) and was joined

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CERN in 1954. On the site of the future synchro-cyclotron a notice forbids entry. Nowadays CERN is open to all, and regularly each Saturday parties of visitors are shown round the laboratory, led by staff members who exchange their normal jobs in various Divisions during the week for that of guide on this day. The total number of visitors during 1964 was over 7500.

Training and Education 1964-65

During November the Education and Training Section at CERN issued the first details of the new session's lecture courses, under the two general headings of Technical Training and Academic Training. Some of the courses began during the month and others will follow during the winter and spring.

TECHNICAL TRAINING

Taking advantage of the experience gained in the past two years,* a few changes have been made both in the composition of the programme and in the way the technical training courses are organized.

Thus from now on courses will be given at three different levels : elementary, intermediate and advanced, and at each level the courses will be spread over two or three years.

Because of the wide range of abilities and knowledge among those at CERN wishing to follow the courses, it is not always easy to allocate people to a class of the right level, so that for some courses a classifying test has been introduced. In all courses, great importance will be attached to sessions of exercises and practical work and these will also give the teachers the opportunity to check how well each student is doing.

* See CERN COURIER, vol. 2, no. 12, p. 10, December 1962 ; vol 3, p. 154, December 1963.

Carrying over the experimental method to a new field, for the elementary physics instruction, the organizers will be trying out a newly devised course of 'programmed instruction', in English or French, enabling students to work on their own most of the time with periodic meetings for demonstration experiments. showing of films and practical classes.

The courses announced during November are as follows :**

Elementary level

— designed for those who wish to learn, or revise, the basic elements of subjects connected with the work at CERN, particularly in mathematics and physics ; a necessary preparation also for the courses at intermediate level.

Mathematics, by F. Louis.

Physics, a 'do-it-yourself' course under the direction of G. Vanderhaeghe, using a specially written, 'programmed' instruction manual in conjunction with the 'Physics' text book of the U.S. Physical Science Study Committee (beginning early next year).

** Apart from the elementary physics, which is also available in English, all courses in this series are given in French.

Intermediate level

— for those wishing to acquire a basic knowledge and practical experience in fields of current use at CERN.

Mathematics ('b' and 'c'), by F. Louis, continuing last years' courses 'a' and 'b'.

Electronics, by F. Ferger, continuing last year's course (beginning in January 1965).

Advanced level

— designed for specialists in the various branches who wish to increase their knowledge or keep up to date with new developments.

Electronics, by G. Amato, continuing previous years' courses (beginning in January 1965).

Mathematics, by F. Louis, continuing last year's course.

Mechanics, by L. Solinas, following the course on 'Strength of materials' given last year (beginning in January).

Vacuum technique, by E. Fischer, following previous years' courses and concentrating on ultra-high vacuum (beginning early in 1965).

Other courses may be organized also this year, if suitable opportunities arise.

The eleventh anniversary (cont.)

in September/October by the Secretary General and the Synchro-cyclotron group. Here too, the inevitable barracks were not long in appearing.

On the home front, we had even greater accomodation trials. Admittedly the 'crise du logement' had not then hit Geneva in its full fury, but it was already building up, and we had little experience of flat hunting in those days. I remember my own family having to endure no less than four moves in that first year, and I remember also the arrival of the bailiffs' men from the 'Office des Poursuites' who on a cold winter's day, proposed to remove all the furniture from the apartment we had rented temporarily from an I. L. O. lady on home leave. Our halting French was stretched to its utmost to avoid this tragedy and it was probably only the sight of our squalling 10 month-old infant that finally softened the invaders' hearts. In fairness to the lady in question, let me add that it turned out to be a misunderstanding all round.

By the end of 1954, the formal European Organization for Nuclear Research had come into being, a Director General (Prof. F. Bloch) had been appointed, the CERN full-time staff had grown to 146 members, the Groups (apart from Theory) were centralized in Geneva, parameters for the proton synchrotron had been settled, working conditions had been sorted out, and a first budget of 25 million Swiss francs was on its way to adoption. The pioneers could look back on a year of solid achievement ; they had had their difficulties and their frustrations but I doubt if any of them would not want to do it all over again if they had the chance. Perhaps some of them will ! ●

Probable subjects are *elementary electricity, elementary* and *intermediate electronics* and *intermediate vacuum technique.*

ACADEMIC TRAINING

During the academic year 1964-65 the two traditional courses in theoretical and experimental physics will be continued, but in addition there will be lectures on applied physics and some basic courses in physics and mathematics at the academic level. The latter courses are regarded as something of an experiment and their future will thus depend on their success this year.

The courses so far announced are as follows :

Theoretical Physics

Strong interactions at high energies (Part IV), by L. Van Hove (completed).

Weak interactions, by N. Cabibbo and M. Veltman.

Relativistic description of spin, especially helicity formalism, by R. Hagedorn.

Experimental Physics

High-energy neutrino interactions, by C. Franzinetti (from 11 January).

Radiogalaxies and high-energy physics, by G. Cocconi (date to be announced later).

Some methods of spin determination of elementary particles and resonances, by W. Koch (probably in March).

Experimental methods in the physics of unstable particles (continued), by B. Maglic (probably in April).

Applied Physics

Subjects under consideration for this year are :

Beam optics.

Superconductivity.

Basic Courses in Physics and Mathematics

Group theory and the classification of the elementary particles, by L. C. Biedenharn.

Like other seminars and lecture courses organized at CERN, the lectures in the Academic and Technical Training programmes are open to any qualified person from outside as well as to the people working at CERN. Fuller information can be obtained from Dr. G. Vanderhaeghe, Education and Training Section, CERN, 1211 Genève 23, Switzerland ●

Vacation students in 1965

During the summer vacation in 1965, there will again be opportunities for a limited number of European university students to gain practical experience of high-energy physics research at CERN.*

Candidates must be nationals of the CERN Member States and have completed at least two years of university training. The appointments will last from two to four months, during which time the students will assist in the day-to-day work of the groups to which they are assigned. A special series of lectures will be arranged, describing activities at CERN and including courses on theoretical physics and computer programming.

The principal vacancies for summer 1965 are as follows :

Participation in experiments

— In research teams using bubble chambers, spark chambers, electronic counters or nuclear emulsions.

Development and operation of experimental facilities

a) The two particle accelerators (28-GeV proton synchrotron and 600-MeV synchro-cyclotron) :

— linear accelerator, ion source and pre-injector,
— radiofrequency measurements and developments,
— target measurements and developments,
— preparation of information on beams for experimenters.

b) Experimental apparatus

— high-voltage systems,
— particle detection devices,
— particle-beam separators and ejection equipment,
— design and setting-up of beam lines,
— electronic circuits and equipment for counter experiments,
— equipment for the automatic analysis of data from bubble-chamber and spark-chamber experiments.

c) Computer

— programming an electronic digital computer (CDC 6600) for solving scientific and technical problems.

d) Health Physics

— radiation measurements and dosimetry.

Research into the design of future accelerators

— all aspects of the design of high-energy proton synchrotrons ;
— design of a proton linear accelerator ;
— experimental and theoretical studies of storage-ring problems ;
— ultra-high-vacuum techniques.

Students will be paid an allowance to cover their living expenses as well as travelling expenses equivalent to the second-class return railway fare to and from Geneva. Most of them will be accommodated at centres provided for students at Geneva University.

Application forms can be obtained by sending a postcard to the Fellows and Visitors Service, Personnel Division, CERN, 1211 Genève 23, Switzerland. **Completed application forms must be returned to CERN before 1st March 1965** and it will not be possible to consider forms which arrive after that date ●

* See article in CERN COURIER, vol. 4, p. 8, January 1964.

BOOKS

Accelerators — machines of nuclear physics, by R.R. Wilson and R. Littauer (London, Heinemann Educational Books Ltd., 1962 ; 6 s.) is a volume in the *Science study series* and was first published in the U.S.A. in 1960. This series of books arose from the activities of the Physical Science Study Committee organized at the Massachusetts Institute of Technology in 1956 and is intended to provide surveys of the most stirring and fundamental topics of science within the grasp of the young student or scientifically inclined layman.

The subject of accelerators is introduced by a chapter that enquires more closely than usual into the act of ' seeing ', and shows in a convincing way how, in order to ' see ' smaller and smaller things, smaller and smaller wavelengths, that is ever greater energy, must be used for the ' illumination '. The conversion of the energy of an accelerated particle into the mass of newly ' created ' particles is also explained.

Then the development of particle accelerators is treated in a more or less historical fashion, from the early x-ray tube of 1895 to the prospects of colliding beams as seen in 1959. Successive chapters in between deal with direct accelerators — the Cockcroft-Walton machine and the Van de Graaff generator, linear accelerators, the cyclotron, the betatron, the electron synchrotron, the synchro-cyclotron, the proton synchrotron, the alternating-gradient principle and sector-focused cyclotrons. A concluding chapter deals with ideas on ' cosmic accelerators ', the means by which charged particles in interstellar space acquire energies that make man's greatest achievements seem small.

The style of writing is easy, almost colloquial ; to an English reader it is obviously American. But it has the immense advantage that the knowledge and enthusiasm of the authors is fully communicated. Diagrams are used to help explain the text and a number of interesting analogies are introduced to make things clearer. Those who are bewildered by terms such as ' phase stability ', ' bunching ', ' betatron oscillations ', and ' acceptance ', who wonder why many accelerators work in pulses instead of continuously, who would like to know why a proton synchrotron needs a linac as ' injector ', will find everything explained here in terms that are easy to understand. As the story unfolds, each new type of accelerator is seen to grow out of those preceeding it, with now and again a crucial idea that opens up a whole new field. One such idea was that of E. O. Lawrence, to whom, in effect, the book is dedicated. His cyclotron was the forerunner of all the circular accelerators since invented, including our own two at CERN, and the chapters describing Lawrence's work and the development of his Radiation Laboratory at Berkeley are among the best in the book.

In spite of the emphasis on machinery, the purpose of particle accelerators is not lost sight of, and the close relationship between accelerator builders and physicists is underlined. Rapid progress is also mentioned, and this leads to the major criticism of the book. Written at the end of 1959, it is already out of date. At that time CERN's proton synchrotron had just started to work (with a beam of 10^{10} protons/pulse !), Brookhaven's was yet to be finished, and the idea of bigger accelerators was still largely a dream. The prediction is made that beams of high-energy neutrinos might be possible at CERN and Brookhaven, and the table of 'elementary particles' looks rather old-fashioned. It seems a pity that before republishing this text in England (even

Saclay / CERN polarized - proton target (cont.)

temperature; the magnet, which must provide an extremely uniform field; the microwave system, which polarizes the protons; and the high-frequency system, which measures the sign and the amount of the polarization. Except for the magnet, the target was developed by M. Borghini, M. Odehnal, P. Roubeau and C. Ryter at Saclay, in the laboratory of Prof. A. Abragam. The cryostat is of a new type having two major advantages: it is horizontal, allowing the magnet pole faces to be horizontal also and thus permitting the disposition of spark chambers and other equipment horizontally around the target, and it is fed continuously with liquid helium. The helium comes in 50-litre insulated containers (from the liquefier operated by CERN's TC Division), each providing enough for about a day, and it takes only ten minutes or so to change from one to the next. From the container the liquid helium passes first into a 'separator' in the cryostat, where it is filtered through sintered brass. Vapour produced during the transfer is pumped away through spiral tubes which are used to cool thermal shields to about —240°C. The liquid from the separator goes through a heat exchanger, where it is cooled, and is then expanded through a needle valve into the microwave cavity holding the target crystals, where it vapourizes. With the radio-frequency power on, a temperature of about 1.1°K (—272.3°C) is obtained in the cavity. The vapour is pumped off via the heat exchanger previously mentioned.

The microwave system uses power sources of 10 Watts at frequencies around 70 000 Mc/s; a change of about 160 Mc/s is necessary to reverse the sign of the polarization. The high-frequency system operates around 80 Mc/s and consists of a nuclear-magnetic-resonance detector which can take a reading in 10 milliseconds and display the sign and the percentage of the polarization on a digital voltmeter, for photographing on the same film as the spark-chamber tracks. Polarizations ranging between 50 and 60% were currently obtained in the 5-cm³, 5-cm-long target during the first runs of the xi-parity experiment.

Two magnets have been made, designed by G. Petrucci, of CERN's NP Division, and manufactured in the MSC workshop. The first, seen in the photograph, was used in the preliminary experiments at the SC and the one now in use is of a somewhat improved design. As can be seen, the windings and pole pieces are strongly tapered, to allow for the positioning of other equipment, and in spite of the large air gap, compared to the size of the pole faces, the field of 18 500 gauss is uniform to 1 part in 5000 over an area 1 cm × 1 cm × 5 cm. This was done by carefully measuring the field and 'shimming' the poles correspondingly with small pieces or iron, a process carried out by the MSC section under E. Braunersreuther ●

in 1962) the authors were not induced to bring it up to date. In spite of some inconsistencies which have arisen in trying to adapt the text for English rather than American readers, to those at CERN who can read English and who would like to know more about the PS and the SC (and for anyone else interested in the development of modern high-energy physics) this book can be thoroughly recommended.

Accelerators of charged particles, by B. S. Ratner (Oxford, Pergamon Press Ltd., 1964; 17 s. 6 d.) is in a different category altogether. Translated from the Russian edition of 1960, it claims to describe 'in an easily understandable manner the history and latest developments in accelerator technology' and 'no prior knowledge of nuclear physics or mathematics is needed...'. In fact, we find the first two chapters (a third of the book) devoted to a kind of 'layman's guide to the development of atomic energy', which few layman will understand, with the early accelerators of Cockcroft and Walton and of Van de Graaff mentioned in passing. Successive chapters then deal, in what might be called text-book language, with the main types of accelerators, ending in an imaginary journey to Dubna to examine 'one of the most interesting installations of the present day'. The last chapter mentions the start-up of CERN's proton synchrotron, but nowhere in the book is Brookhaven mentioned — or Berkeley, come to that, except for Lawrence's invention of the cyclotron.

It must be admitted that the story is difficult to follow, padded with unnecessary detail, inconsistent in its references to names of people and places, misleading on a number of facts, and (in spite of the translation editor) shows obvious signs that the translator was not familiar with the subject. The bibliography mentions only Russian publications, including what appear to be Russian translations of standard American texts, and the index is meagre. The book may have been useful in its original form, but there seems to be no good reason for translating it and republishing it now in English without considerable revision.

A.G.H.

The development of weak interaction theory, edited by P. K. Kabir (New York, Gordon and Breach Science Publishers Inc., 1963; $ 4.95).

This, the fifth volume in the publisher's *International Science Review Series*, provides a very useful review of what may be called 'classical' weak-interaction theory, presented as a collection of the relevant original papers prefaced by a compact survey of the field by the editor. The timing is almost perfect. The Universal Fermi Interaction, which has proved so useful in the understanding of the weak interactions of non-strange particles, appears to have spent its force; the new approaches based on the SU_3 formalism are not yet fully developed.

The general layout of the book is excellent. Before the preface there is a block diagram, illustrating the development of the theory (upon which the selection of papers is based), which impresses upon the reader the extensive feedback between the various sub-sections. Taking the selected papers in order one can clearly see the historical development: the almost uncanny insight of Fermi, the breakthrough of Lee and Yang leading to the rapid refinement of the theory, and finally the difficulties encountered with strange-particle decays and the hypothesis of the intermediate vector boson. The fact that five of the authors whose work is quoted are Nobel laureates shows the rapidity and ingenuity with which this development was carried through.

The preface is adequate for its purpose. One gets the impression that the editor has a typical theoretical physicist's devotion to the intermediate vector boson, but as an experimental physicist one is temped to ask: if it exists, where is it? One fears that the ghosts of Michelson and Morley are once again walking the cloisters of physics, chanting penitentially the word 'ether'.

As regards the editor's selection, I feel that, although this is a review of the theory, the inclusion of a few experimental papers would have been useful — for example,

The fascinating exploration of Romanesque art in French-speaking Switzerland, made under the guidance of Prof. P. Bouffard, at that time Mayor of Geneva, had a sequel this autumn when a party from CERN was introduced to the charms of the Haute-Savoie, by Prof. P. Guichonnet, of the University of Geneva. Once again this excursion provided an opportunity to strengthen the bonds between CERN, Geneva and the neighbouring regions, and those taking part were thus particularly appreciative of the warm welcome they received from the authorities of the aptly named town of Bonneville. To end the tour, which revealed to everyone a number of previously unsuspected treasures, a visit was paid to the château at Thorens owned by the Sales family.

The CERN Staff Association continues to extend its friendly contacts with the people of Geneva, and early in 1965 an exploration of some of the lesser-known parts of the City will be arranged. Like the other outings, this will be open to everyone at CERN.

The photograph here shows Prof. Guichonnet and the party from CERN outside the Town Hall in Bonneville.

on one of the classic experiments demonstrating parity violation or the decay of a pion into an electron. Again, at a certain point in its progress the theory was considerably embarrassed by conflicting experimental data. On reading through the selected papers one sees the anxiety building up; then, at a certain moment, one must assume everything has been resolved because the discrepancies are never mentioned again. Descriptions, at the appropriate points, of the experiments which clarified the situation would have greatly assisted the continuity of the book. Apart from this criticism, however, the selection of papers is excellent.

One final comment. I stated at the beginning that I felt that the timing of the book was *almost* perfect. The editor concludes his selection with several papers describing the possibilities of high-energy neutrino reactions, but the final choice of papers was apparently made just too soon to include mention of the first astounding result in this field — the non-identity of the electron and muon neutrinos. Maybe this book covers only one chapter of the development of the theory of weak interactions, but the last page of the chapter seems to be missing.

I. M. Blair

Progress in nuclear energy, Series IV: Technology, engineering and safety, volume 5, edited by C.M. Nicholls (Oxford, Pergamon Press Ltd., 1963 ; £ 6 6 s. 0 d.)

Reviews of books dealing with nuclear engineering are appearing rather frequently in *CERN COURIER.* So much so, that the editor even wrote a short editorial (May 1964, p. 62) stressing that CERN, as an organization, is not concerned with activities in the field of the uses of nuclear energy. This editorial also gave the justification for reviewing books on nuclear engineering : firstly the subjects of the books are thought to be sometimes of interest to members of the CERN staff, and secondly it was said that readers of *CERN COURIER* have interests in other than fundamental research.

Are there indeed several subjects in nuclear engineering that are of interest to accelerator engineers ?

Before high-intensity accelerators were considered, accelerator and nuclear engineering had, as a matter of fact, very little in common. Health physics techniques, safety, and reliability of instrumentation were perhaps the main common interests. High-intensity accelerators, however, have confronted the accelerator engineer with new problems : radiation damage and activation of materials, remote handling of active components, special process measurements. All these problems are already familiar to the nuclear engineer, although the list of common interests is still a rather small one.

The situation is demonstrated by scanning the book under review. It contains many (18) contributions on different topics in nuclear engineering, each by a specialist. The largest chapter, the one on process technology, contains six contributions : 'Radiometric techniques and instrumentation of in-line process monitoring', 'The separation of plutonium isotopes', 'Development of a production process for radio-krypton recovery by fractional absorption', 'The preparation of $UO_2.PuO_2$ powders for nuclear fuels', 'Gas-solid contacting', 'Corrosion and materials of construction in chemical processing of reactor fuels'. The first of these could be useful when building a gamma-ray monitor in the circuit of a magnet ; the others describe interesting techniques (the one on gas-solid contacting in particular) but can hardly be included in the 'common list'. An article on methods of measuring temperature in nuclear reactors and the excellent review on the filtration of radioactive particulates might, however, be eligible for inclusion. At least the common interests are there ; the book satisfies a little in this respect.

The scope of the contributions is not equal, some dealing with specialized subjects, giving theoretical and practical information, while others cover a broad field and are kept in general terms only. For example, the author of 'The response of containment structures to transient pressures caused by nuclear reactor runaway' characterized his paper as a survey of the current literature on the subject (54 references included). However, some disequilibrium in a book of this kind can hardly be avoided.

In general terms, the book supplies up-to-date information on some rather specialized subjects, together with extensive reference lists. Its value should be judged also, with reference to its place in the impressive series of *Progress in nuclear energy.*

J.H.B. Madsen

Application of ultrasonics in molecular physics, by V. F. Nozdrev, translated from the Russian by Scripta Technica, Inc. (New York, Gordon and Breach Science Publishers Inc., 1963 ; $ 27.50).

The fact that it is now possible to produce very high ultrasonic frequencies, of the order of 10^9 oscillations per second, has led to a considerable expansion of the field of experimental ultrasonics. In particular, the use of small-amplitude oscillations enables an accurate determination to be made of the kinetic molecular behaviour and the thermodynamic properties of gases, liquids and solids.

In this book, the author states that he "does not pretend to generalize all the experimental and theoretical material in this field. Rather, this book represents the results of many years work by the collective of the Laboratory of Molecular Acoustics, the N.K. Krupskaya Pedagogical Institute of Moscow Oblast' (MOPI) and, in part, by the Molecular Physics Department of Moscow State University (MGU)." The results of work done by other scientific bodies have been included, but generally only as brief references.

The diagrams tend to be cramped, but the text is well presented. Although concerned primarily with the practical details of the work carried out at MOPI and MGU, care has been taken to give the necessary theoretical background and there is an extensive list of references, although most of these are to Russian publications. To avoid interference with the main text, the experimental data obtained in the laboratories are tabulated separately in an appendix, following the same sequence as the material of the book.

The first two chapters explain the theoretical bases for the optical methods and the pulse methods for studying the propagation and absorption of ultrasonic waves in liquids and gases. General techniques and various kinds of equipment used and developed at the laboratories are described and explained, together with an analysis of the possible experimental errors. The remaining four chapters deal with specific experimental results and the conclusions that can be drawn from them, as follows :

Chapter III describes the study of the propagation of ultrasonic waves in liquids from the solidification point to the critical state, using both optical and pulse methods.

Chapter IV describes the properties of ultrasonic waves in individual substances and binary mixtures in the critical region. For a large number of substances, two-phase and three-phase regions were studied, and also the single-phase region (vapour) close to the critical point. The substances used were the saturated and aromatic hydrocarbons, alcohols, acetates and formates which, in the author's opinion, present the greatest scientific and practical interest.

Chapter V describes the propagation of ultrasonic waves in saturated and superheated vapours of organic liquids. This research furthers the development of the theory of a gaseous state and also finds applications in modern technology (thermal engineering, the petroleum industry, etc.). Special attention is devoted to the computation of energy and force characteristics, specific heat, and compressibility.

Chapter VI discusses the study of the absorption of ultrasonic waves in pure and mixed organic liquids over a wide range of temperatures, concentrations and frequencies. Experiments using saturated and aromatic hydrocarbons are described and the relaxation processes in liquids are discussed.

To sum up, the author has succeeded quite well in producing a laboratory text book that is interesting to read and easy to digest. Against this, it is unfortunate that the translators did not give a little more forethought to the electronic circuits and, in a few places, to the English.

R.J. Wilton

The analytical chemistry of thorium, by D. I. Ryabchikov and E. K. Gol'braikh (Oxford, Pergamon Press Ltd., 1963 ; £ 5), has been translated by A. Norris from the original Russian text.

It is an extensive book, primarily for chemists interested in the analytical procedures for the determination of thorium. Many methods are given for use under a great variety of circumstances, and over 2000 references are quoted.

In spite of this, however, there is little on the ion-exchange behaviour of thorium, which is the basis of a rather important method today. For the specialist in radiochemistry, the corresponding booklet in the *Nuclear Science Series* published by the U. S. National Academy of Sciences and the National Research Council, *Radiochemistry of Thorium*, by E. K. Hyde, would seem to be more concise and practical.

R. Brandt

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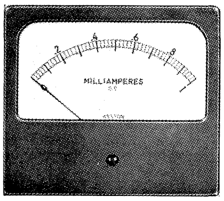

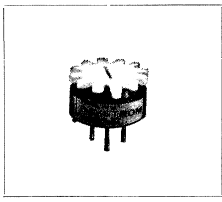
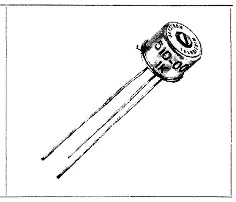

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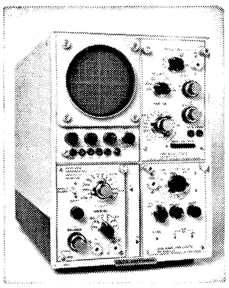
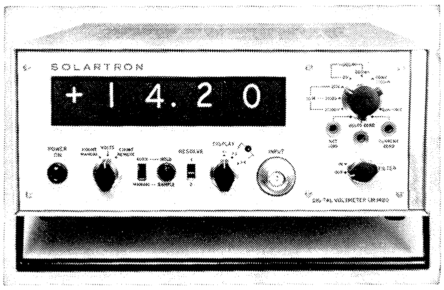

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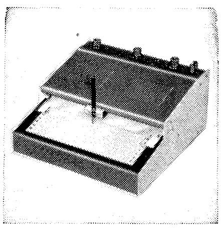
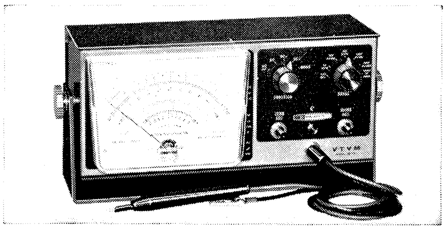

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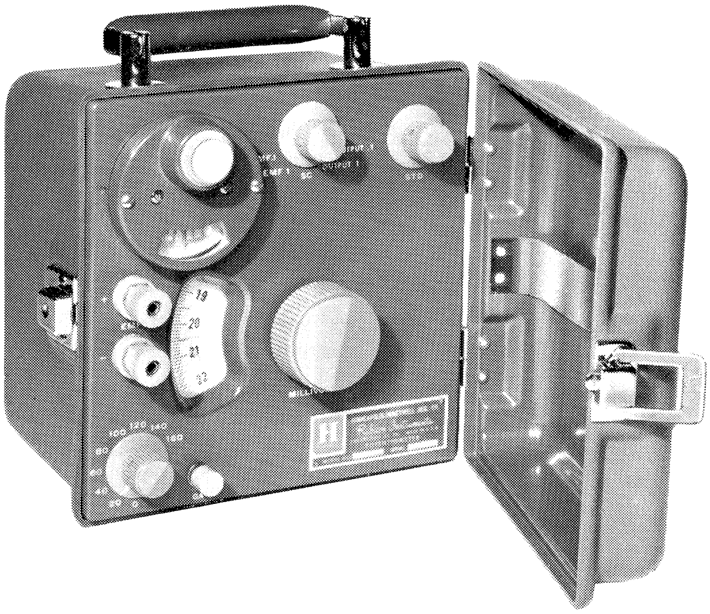

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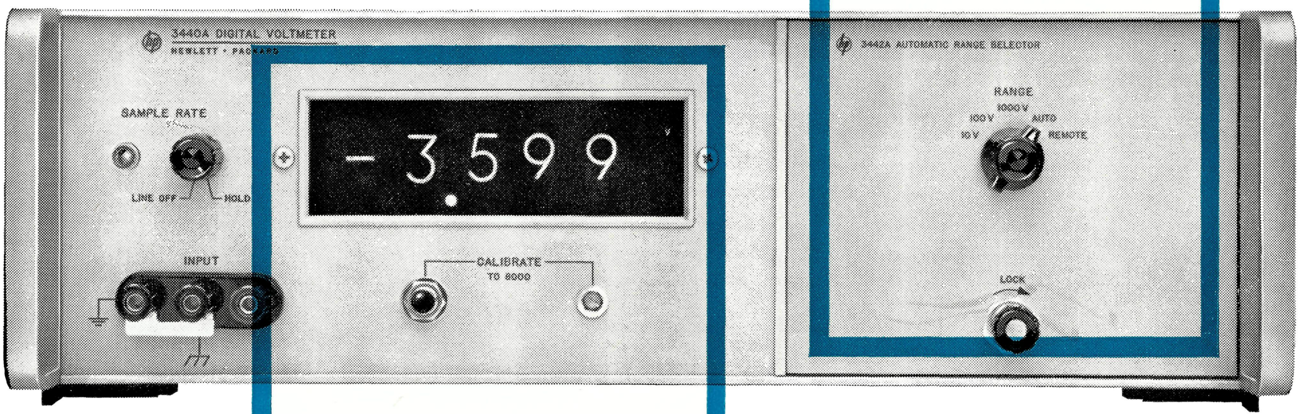

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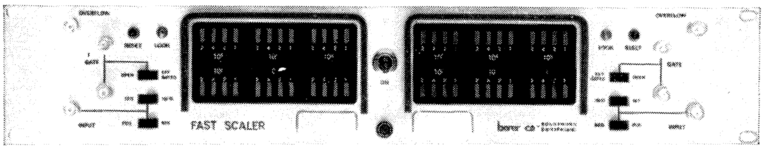

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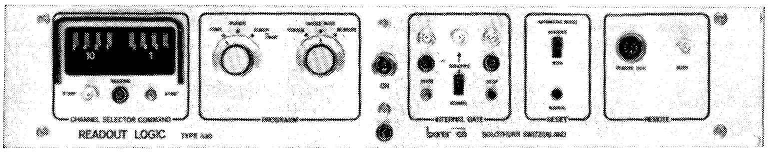

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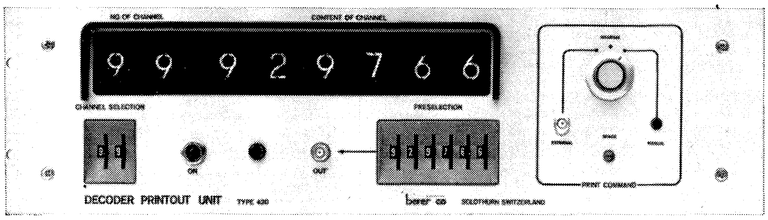

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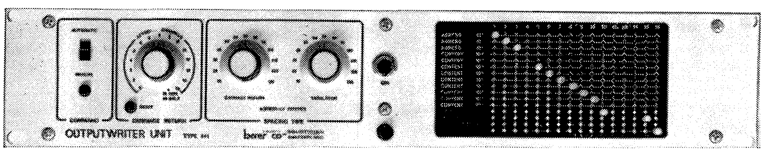

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