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Contents

The cover photograph was taken on 1 March and shows a bulldozer in action on the intersecting storage rings site. This earth moving operation is part of the preliminary site work. The major construction work, including excavations for the magnet rings themselves, is scheduled to begin in the summer.

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

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

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

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

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

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

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

Two large particle accelerators form the basis of the experimental equipment :

— a 600 MeV synchro-cyclotron,
— a 28 GeV proton synchrotron,

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

The CERN staff totals about 2200 people.

In addition to the scientists on the staff, there are over 350 Fellows and Visiting Scientists, who stay at CERN, either individually or as members of visiting teams, for periods ranging from two months to two years. Although these Fellows and Visitors come mainly from universities and research institutes in the CERN Member States, they also include scientists from other countries. Furthermore, much of the experimental data obtained with the accelerators is distributed among participating laboratories for evaluation.

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

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

Poland, Turkey and Yugoslavia have the status of Observer.

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

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

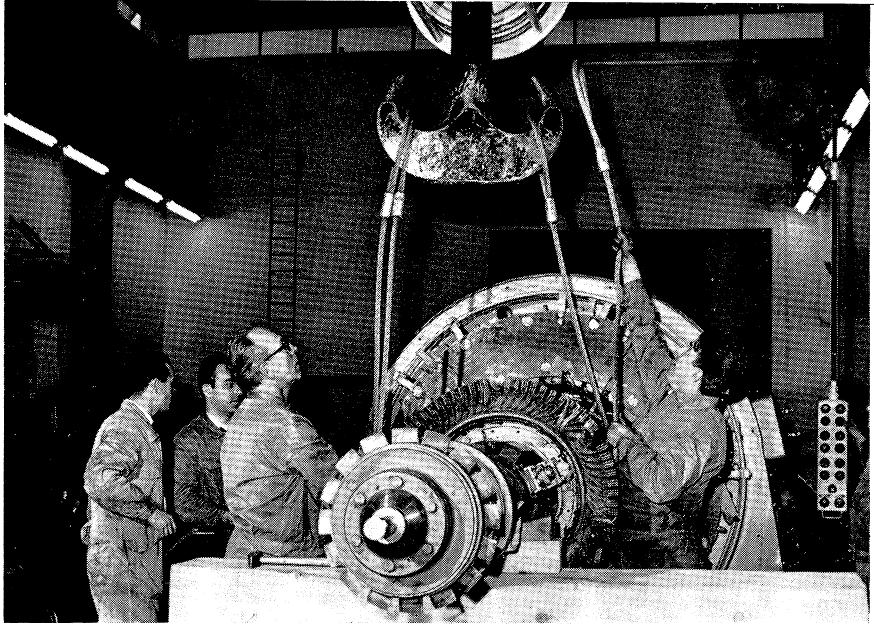
CERN News

PS and SC

The repaired magnet power supply motor of the proton synchrotron is scheduled to return to CERN on 16 May. The synchrotron would then begin operation on 25 May, the date originally planned as the end of the Easter shutdown. Information on the work carried out during the extended shutdown will be given in a future issue of CERN COURIER.

The first of three test r.f. cavities for the synchrotron was completed at CERN in March. It now goes to the manufacturers who are developing the amplifier and power supply systems for delivery in October of this year. The other cavities will be used for tests at CERN when they are completed. (Three additional accelerating cavities are to be installed in the PS as part of the first stage of the improvement programme, which is designed to increase the repetition rate of the machine.)

After the Christmas shutdown the synchro-cyclotron began operation on the 18 January. Since the demand for experimental time has increased, it has been decided to reorganize the machine schedule on a trial basis so that, from the end of February, one maintenance period out of two is not taken and the machine continues with its experimental programme.



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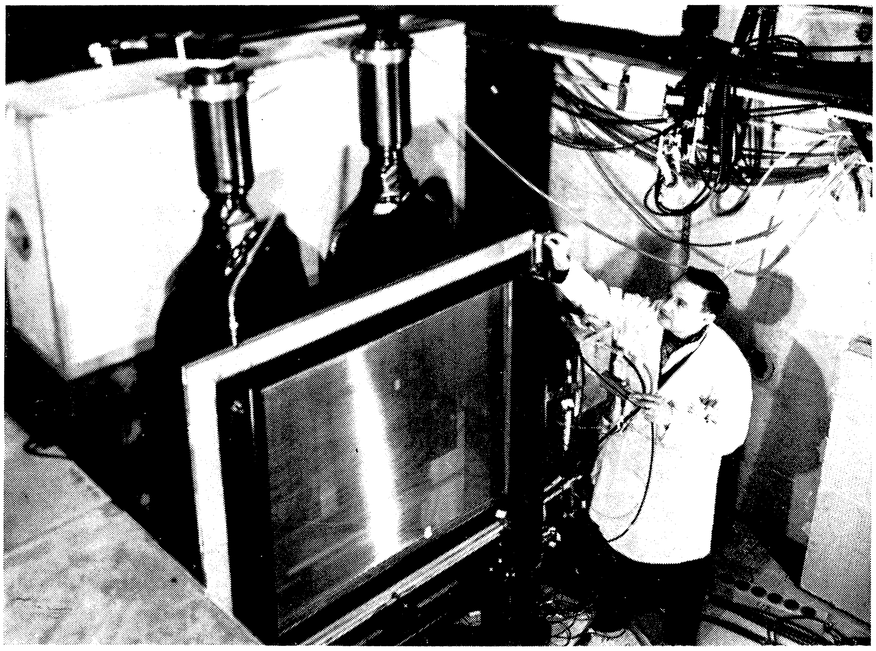
The damaged rotor of the PS magnet power supply being removed for dispatch to the manufacturers. The repaired rotor is due back at CERN on 16 May.



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The first wire spark chamber installed in a PS experiment. Behind the chamber stand the two black shapes of scintillation counters which trigger the spark chamber when they themselves have recorded the passage of a charged particle. Behind them, below the concrete support, the block of iron (see below) is visible.

Wire chamber

The first wire spark chamber to be used in an experiment at the PS was installed on the b8 beam line at the end of December. The experiment, being carried out by a group led by M. Vivargent, R. Mermod and K. Winter, is one of the investigations into CP violation (see CERN COURIER, vol. 5 no. 9 (September 1965) p. 131). It is concerned with the 'interference' between the decay amplitudes of K^0_1 mesons, regenerated in a block of carbon, and K^0_2 mesons. The experiment studies this effect in the two pion decay mode. The theoretical description involves a phase term which is the sum of a 'nucleon phase shift' (introduced by the regenerator) and a 'CP violation phase shift' (the main item of information wanted from the experiment).

Data has already been taken on the decay into two pions which involves CP violation. In June, it is intended to look at the leptonic decay (into pion, muon and neutrino) which involves only the nucleon phase shift. Thus the two different phase shifts can be determined.

The wire spark chamber is part of the detection equipment to differentiate between pions and muons. A system involving conventional optical spark chambers and a magnet, defines the direction of a charged particle approaching the wire chamber. Between the system and the chamber is placed a block of iron. A muon, which does not interact with the nuclei in the iron will pass through and emerge travelling in virtually the same direction (suffering a small deviation due to coulomb scattering). A pion, however, interacts strongly with nuclei and can suffer a major deviation. The wire chamber records the position of the particle passing through it and it is then possible to distinguish the pion from the muon.

A conventional spark chamber could be used, but it was decided to gain some experience in the operation of a wire chamber. This is a recent development in the technology of particle detection, which holds considerable promise for the future. Its great advantage is that it can detect and record the passage of several charged particles at once and provide the required data directly in electronic form.

The chamber which has been installed has a sensitive area of 80 x 100 cm. It consists of two planes of parallel wires ; one pulsed at a high voltage (5 kV) and the other earthed. When a charged particle passes through, it causes ionisation along its path in the gap between the planes and a spark is formed, on application of the pulse, at the track of the particle. Currents then pass in the wires where the spark occurs.

This chamber detects the currents using 'magnetostrictive read-out' — employing the magnetostrictive property of a ferromagnetic wire (in this case nickel). The wires of the parallel plane cross at 90° to the nickel wire. When there is a current in one of these wires, it passes over the nickel wire and the magnetic field associated with the current causes a distortion in the nickel wire which travels along it at the velocity of sound. At the end of the wire the distortion is detected by a 'pick up' coil, thus giving the time between the creation of the distortion and its detection, which is proportional to the position of the spark. (Another method, called core read-out, is also being pursued in connection with wire chambers.)

Work on wire chambers of the magnetostrictive read-out type was initiated at CERN by G. Brautti who carried out some tests with a chamber on the SC. Development of the chamber and the electronics to be used in the PS experiment was done by M. Bott-Bodenhausen and B. Friend, members of the Vivargent group.

Appointments

At a meeting on 8 March, the Scientific Policy Committee elected Professor G. Puppi to the post of Chairman of the Committee in succession to Professor L. Leprince-Ringuet. The SPC is the major authority which makes recommendations to the CERN Council on matters of scientific policy. It consists of a small number of members (11 in 1966, plus 4 ex-officio) selected for their scientific merit.

After the election of Professor B. Gregory as Director-General of CERN, Professor Leprince-Ringuet informed the CERN Council that he would not seek re-election as Chairman of the SPC since he considered it better that the Director-General and the Chairman should not come from the same scientific background. The two Professors had been in close association during their scientific careers (See CERN COURIER, vol. 6, no. 2 (February 1966) p. 28).

Professor Gianpietro Puppi was born in Bologna in 1917. In 1950, he was appointed to the chair of theoretical physics at Naples University. From 1953, he has been Professor of higher physics and Director of the physics institute of Bologna University. In September 1962, Professor Puppi was appointed Directorate Member for Research at CERN, a post he held until the end of 1963. A detailed biography can be found in CERN COURIER, vol. 3, no. 10 (October 1963), p. 129.

Professor J. S. Bell has been appointed Deputy, ad interim, to the Leader of the Theoretical Study Division.

News from the USA

The USA Atomic Energy Commission asked the National Academy of Sciences to investigate 85 sites from the more than 200 put forward for the proposed 200 GeV accelerator. Using eight teams, this investigation was completed by 3 December 1965 and the results were presented to the NAS Site Evaluation Committee (under the Chairmanship of Dr. Piore). Five or six sites are expected to emerge shortly from this stage of the decision and the AEC Commissioners themselves will take part in the examination of the last few sites. The final choice is expected to be made in a few months' time.

The AEC has asked the Berkeley design team to look again at the possibility of reducing the costs of the machine (the present design estimate is $ 348 million). Several suggestions, based on developments at lower energy machines, such as the Brookhaven AGS, have been put forward but the idea of building the accelerator in this way was rejected in the Ramsey Report which recommended the 200 GeV machine. However the Joint Congressional Committee on Atomic Energy has asked the AEC not to present its case for authorization until the cheaper possibilities have been explored again. A decision about authorization of the project seems to have been put off for a further year.

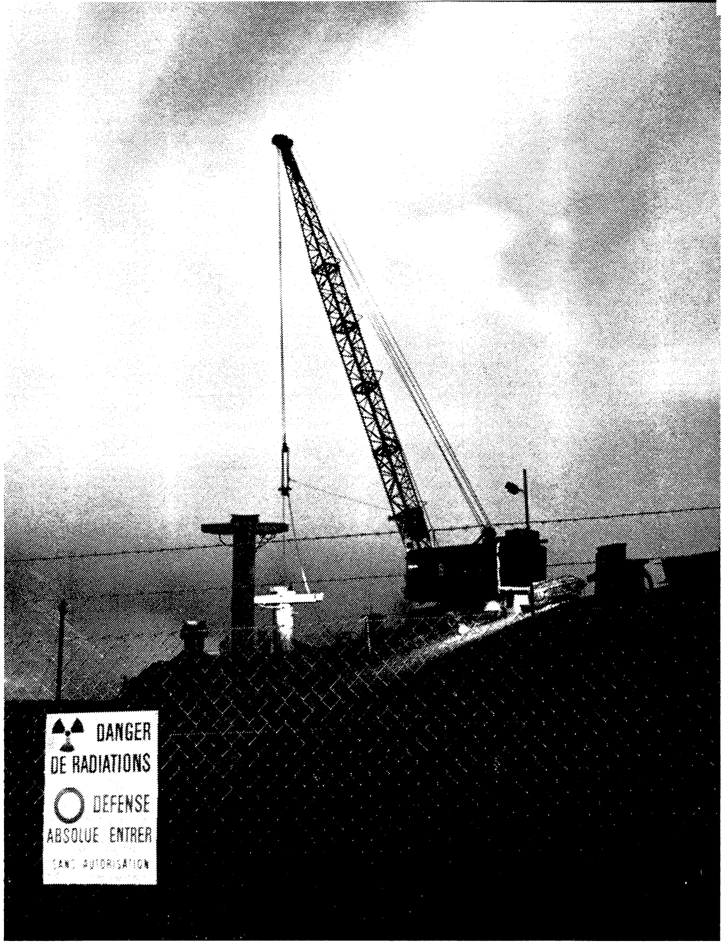
The Universities Research Association Inc. (URAI), which was set up in the summer of 1965 by 34 University Presidents, has offered its services to the government as 'contracting agency' for the construction and operation of the 200 GeV accelerator. This is an extension of the principle of University management of very large government supported projects which has worked well at Brookhaven (operated by Associated Universities Inc. — an association of 9 Universities).

Construction of the 2 mile long, 20 GeV electron linear accelerator at Stanford is nearing completion. Manufacture of the beam tube, a 4 in diameter copper pipe which is installed 25 ft underground, is complete. The original estimate of funds for the project, $ 114 million still appears to be adequate. It is hoped that the first electron beams will be achieved in May.

$ 450 000 has been made available to the University of Utah by the National Science Foundation for a natural neutrino research project. J. W. Keuffel leads the research team. The detection equipment will be located in a laboratory 1000 ft underground and construction is now under way.

Money has been provided for design work on a 'meson factory' at the Los Alamos Scientific Laboratory. The eventual project involves a linear accelerator 2000 ft long to provide a proton beam at 800 MeV with an average intensity of 1 mA. The cost of the project is estimated at $ 55 million.

A radiofrequency separator, developed by H. Hahn and H. Halama, has been brought into operation at the Brookhaven 33 GeV synchrotron. The separator is used in a beam line which supplies kaons at a momentum of 12.8 GeV/c to the 80 in hydrogen bubble chamber. On average 10 kaons reach the chamber together with one unwanted muon. The separator consists of two 10 ft r.f. deflectors separated by a drift space of 130 ft. The beam line will be used for studies using kaons, antiprotons and pions in the momentum range 7 to 18 GeV/c. (For information on the principle of operation of r.f. separators and of the separator first used at CERN at the beginning of 1965, see CERN COURIER, vol. 5 no. 3 (March 1965) p. 35.)



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In 1957, a 'Health Physics' Group was formed at CERN, attached to the Scientific and Technical Services Division[1]. At that time the radiation problems posed by the high-energy accelerators were not well understood and were only just beginning to be recognized at CERN. The group grew slowly and it took on new life in 1961, when it was given wider powers and attached directly to the Directorate. Under the leadership of J. Baarli it tackled the increasingly complex problems posed by the exploitation of the two accelerators[2]. This article gives an account of the progress achieved since then. The author wishes to acknowledge the assistance of Dr. Baarli in the preparation of the article.

Health Physics

by **J. Dutrannois**

Health Physics Group

There are radiation sources of all kinds on the site. Some are classical, such as the radioactive isotopes used to calibrate detectors, and those arising from the induced activity created during the operation of the accelerators. The latter, however, are rather different from those encountered in conventional nuclear industry, because complex families of isotopes are formed by the spallations due to high-energy particles, and the activity may be distributed inside the activated materials.

Finally, there is the radiation which comes directly from the machines when they are in operation, through the shielding, or from the experimental areas where there are secondary beams or extracted proton beams. The nature and energy distribution of this radiation varies from place to place and varies with the mode of operation of the accelerators. Moreover, the situation is a very special one, since the types of radiation encountered, and their energy, are found only at high-energy accelerators ; this radiation is emitted in the form of low-frequency pulses in the case of the PS, which further increases the problems of detection. If one remembers in addition, that it is necessary to monitor the possible radioactivity of all machine components from the region of the beams, and also that there is a staff of over 2 000 to be monitored, it is easy to understand the increased importance of the work of the Health Physics Group.

At present it has 30 members, including seven physicists and many specialized technicians, and has 'feelers' at various crucial points in CERN. Its essential task is to know at all times the radiation level all over the CERN site, which entails constantly making a whole series of measurements. This exact knowledge of the situation is communicated to the various responsible people and assessed by the group, which then gives advice as to the precautions to be taken to reduce the irradiation of staff, and the contamination of laboratories, to a minimum. A check has then to be made to ensure that these precautions have been taken and that they are as effective as predicted ; the actual dose received by each member of the staff also has to be checked.

Methods and instruments

In order to estimate the radiation hazard, the radiation level must first of all be measured. The possible danger is of a type which man cannot feel or even suspect.

For classical radiation (from radioactive sources, whether natural or artificial, and from induced activity which is mainly found in the vacuum chambers of the accelerators during shut-down for maintenance or repairs) use is made of instruments and techniques which have been known for a long time (ionization chambers for on the spot measurements, and Geiger-Muller, proportional, or scintillation counters for measuring samples, dust, etc.) But, since the radiation produced when the accelerators are working is complex and of very high energy, it has proved necessary to develop new methods and instruments.

Measurement of the energy absorbed by living tissue can be made independently of the energy or type of radiation, by using the tissue-equivalent (TE) ionization

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1. 'The Health Physics Group'. B. Wheatley, CERN COURIER 1960, 13-14.
2. 'Radiation Safety at CERN', J. Baarli, CERN COURIER, vol. 2 no. 1 (January 1962).

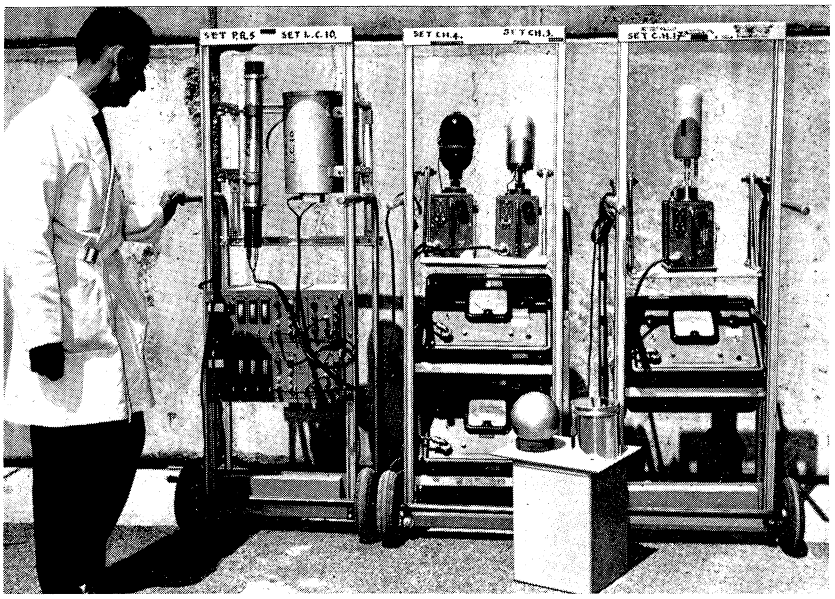

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Figure 1. A complete set of the instruments used in routine radiation survey measurements. The rack on the left is equipped with counters ; the other two racks contain ionization chambers. In front of the racks is an indium bowl moderator and a large plastic scintillator.

chamber. But, although this gives the total dose in rad* it does not enable us to interpret this dose in rem** and thus to evaluate the hazard. One solution would be to apply to this TE dose an average quality factor QF, corresponding to the flux of mixed radiation measured, but there is not yet any practical apparatus capable of measuring this QF. Another way would be to use a maximum value of the QF which leads to over-estimation of the dose. A better method would be to obtain data on the type and energy spectra of the components of the radiation and weight them according to biological effectiveness.

Unfortunately, it is impossible in practice to obtain such complete data and it has proved necessary[3] to develop a series of instruments (based on conventional detectors) to cover, as far as possible, the whole range of types and energy. The following components are measured :

— gamma radiation and direct ionization of charged particles,
— thermal neutrons,
— fast neutrons (between 0.2 and 15 MeV)
— nuclear interactions of high-energy particles ($>$ 20 MeV).

The ionization chambers normally used operate with enriched BF_3 and CO_2 which together with a third chamber, because of the different degree of sensitivity to neutrons and gamma particles, make it possible to distinguish between the first two components.

The third component is obtained by measuring the flux density of fast neutrons by a 'Long Counter' and the corresponding energy flux by a recoil proton counter. It is possible to find the mean energy and to convert the flux density into the dose. The fourth component is deduced by measuring the density of the high-energy particle flux by C^{11} activation of carbon in plastic scintillators. In order to convert this into the dose, the nucleon cross-section is assumed to be constant at more than 20 MeV and a conversion factor (which has been established as a result of tests at CERN) of 0.1 mrem/h per particle/cm^2/sec is used.

Certain modes of operation of the accelerators, involving very short pulses, inhibit the satisfactory operation of the counters. The flux densities are then deduced from the overall activation of bare indium foil placed in a polyethylene moderator, which in turn is covered with cadmium. Figure 1 shows the types of instruments used regularly for radiation survey measurements.

The same types of instrument are found in the site monitor stations (Figure 2) where the radiation level is

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* The rad is the unit of absorbed dose and corresponds to 100 ergs/g of tissue.

** All radiation does not produce the same biological effect for the same dose absorbed ; the latter must be multiplied by a quality factor, QF, which among other things takes account of difference in biological effectiveness : $D_{rem} = D_{rad} \times QF$.

[3] 'Health Physics survey methods for the measurement of stray radiation around the CERN high-energy accelerators', J.Baarli and A. Sullivan, 1965, DI/HP/82.

CERN/PI 5.8.65

Figure 2. One of the permanent radiation monitoring stations installed on the site. It is equipped with a 'Long Counter' and an argon ionization chamber. Four of these stations have been set up on the site (the one in the photograph is close to Adams Hall) and four more are to be erected this year.

of the same order as natural radioactivity. The characteristics and the limitation of all the apparatus and methods in use have been closely studied[4].

Present situation

The systematic use of these various instruments has given measurements of the levels of activity all over the site, including the accelerator areas, under the most varied operating conditions. An attempt will be made to sum up the present situation, now that the machines have been running for five years.

First, let us consider the case of the accelerators when they are shut down. The radiation then comes solely from the radioactivity induced during operation and is limited to the machine enclosures (PS ring and SC hall) and to the equipment located there during operation and afterwards removed. Figures 3 and 4 give typical examples of the levels of induced activity in the accelerator enclosures. Obviously these levels vary, and fall off from the time that the machine is stopped. Their value and the rate of decrease depends on many factors, such as the duration of the run, the age of the machine, the type of operation (ejected beam or internal targets, etc.). These levels give the external doses received by staff while working at the machines. Moreover, attention has to be paid to the additional hazard of internal contamination by the radioactivity of the air and dust when machining activated parts, and of shavings which may be breathed in or swallowed. In order to keep a check on these special hazards, the technicians of the Health Physics Group carry out a large number of tests. Air is drawn through a filter and the radioactivity deposited is counted; surfaces are rubbed with filter paper and the radioactivity of the smears is counted, etc. Attention is paid mainly to detecting any possible β and α radiation.

So far the activities found are generally far below the maximum permissible levels, but, as far as possible, machining is limited to parts with a low specific activity (targets are therefore excluded) and only in unavoidable cases. Beta doses on the surface are also measured by means of extrapolation chambers. The results so far accumulated seem to show that in most cases the external dose predominates under present conditions; however the dust and surface activity cannot be neglected in areas of high beam loss and in the target areas. Attention has also to be paid to possible contamination which might spread and affect the ultra-sensitive detection instruments used by the physicists in their experiments.

When the accelerators are operating, radiation comes through the shielding and the secondary or ejected beams in the experimental hall create a hazard on the whole site. Measurements are constantly being carried out to keep the Health Physics Group aware of the radiation levels existing all over the site, to decide what steps they call for. These levels vary also according to the mode of operation of the machines, and they have therefore to be constantly repeated. The data has allowed us to divide the site into different areas. First of all, it was noted that over large areas the radioactivity was not high enough to require special precautions, apart from constant monitoring by means of the fixed stations. The mean activity measured in these stations is two or three times that of natural radiation (cosmic and natural radiation)[5]. They have been suitably placed to monitor also the

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[4] 'The calibration of HP instruments used to measure high energy radiation', J. Baarli, K. Goebel and A. Sullivan, Health Physics Journ. 1963, 9.

[5] 'The radiation protection of the CERN Laboratory and its surroundings when operating the CERN accelerators', J. Baarli, 1964, DI/HP/59.

Figure 3. Typical radiation levels, recorded inside the proton synchrotron ring, 30 hours after the machine is shut down. The figures (in mrem/h) relate to the levels measured at fixed distances from the synchrotron vacuum pipe (underlined figures at 1 m, other figures at 8 cm). The expanded view seen inside the ring is of the 'isodose' curves at an internal target region.

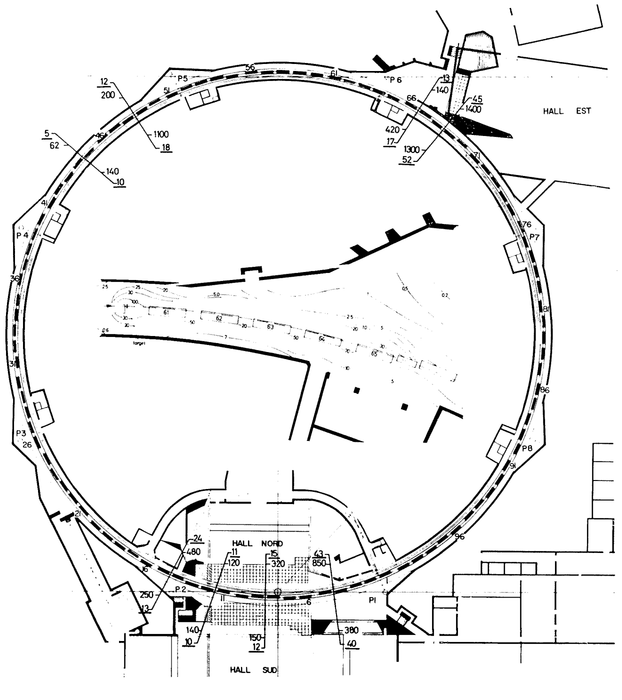

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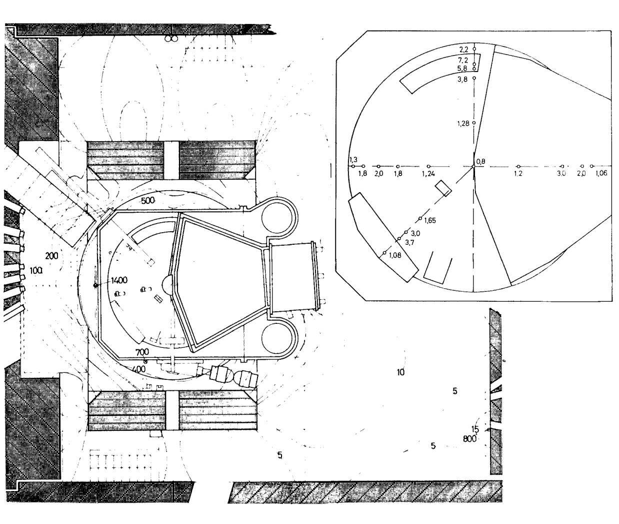
Figure 4. Typical isodose curves around the synchro-cyclotron, eight hours after the machine is shut down. The figures are again in mrem/h. The expanded view gives the levels inside the vacuum tank of the machine. Here the levels given are in rem/h and it can be seen why special precautions are necessary when work has to be carried out in the tank.



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radiation level outside the CERN site, to ensure that the limit fixed by Swiss Federal law (5 rem/30 years for the population as a whole) is not exceeded.

In the areas near the accelerator, in particular on top of the external shielding of the PS ring, measurements made under the most unfavourable conditions (when targets receiving most of the beam are below the measuring point) showed dose rates of the order of several mrem/h. The shielding moreover is always constructed so that the dose rate outside the shielding is less than 2.5 mrem/h, the maximum permissible hourly average for staff exposed to radiation in their work. In the experimental halls, the dose rates vary according to the beams extracted, and the space distribution of the radiation is very varied in intensity and energy. Accordingly, each case is a special one which has to form the subject of large number of measurements at many points.

The radiation encountered in the radiation areas, in the experimental halls and close to the accelerators is of very varied composition : Table 1 shows several typical examples of distribution between the various categories of radiation. In particular, the quality factor varies considerably. The high dose rates in the radiation areas automatically entail a series of precautionary measures. These are taken by the Divisions according to results communicated by the Health Physics Group, which also acts as an adviser. In order to avoid radiation hazards to the staff, access to certain areas is seriously restricted, but most of the precautions taken are to make people aware of the hazards and impose only the measures which are locally necessary (increasing the shielding, limiting the time during which access is allowed, etc.) in order to give the physicists the greatest possible flexibility in their experimental work.

In this respect, the Health Physics Group has evolved a Radiation Safety Code which is now in draft form. It covers all the recommendations which seem necessary in the light of experience.

Monitoring

One of the duties of the Health Physics Group is to ensure that the doses received by the staff are kept to a minimum and in any event below the maximum permissible levels. The latter are those recommended by the ICRP (International Commission of Radiological Protection). The Commission recommends that the personal dose accumulated by an individual should not exceed D = 5 rem × (N-18), where N is the age in years ; and further that in any period of 13 consecutive weeks the accumulated dose should not exceed 3 rem. In practice this corresponds to a total annual dose of 5 rem, or an average of 100 mrem per week, or an average hourly dose of 2.5 mrem/h for a 40-hour working week.

As seen above, the measurements carried out make it possible to divide the site into areas according to the radiation level encountered. The greater part of the site is not a radiation area, and the results show that staff receive 15 % or less of the permitted dose for a radiation worker. This explains why about half of the CERN staff are not in this category and are not therefore subject to regular individual radiation monitoring.

At present about 1200 people are considered to be radiation workers*. The dose received by each of them is monitored by means of films which are sensitive to γ and β radiation, and, when appropriate, also by means of fast neutron films; the latter are used when radiation other than β and γ has been detected during monitoring measurements. In view of the variation in nature and energy of the radiation encountered in the radiation areas, it may be considered that the γ films record the dose due to γ and to the ionization of charged particles of any energy, while the neutron films record the fast neutrons and to a certain extent the spallation effects of high-energy particles.

Calibration is carried out with conventional Ra and PuBe sources, and numerous experiments have shown the limits of validity of these films in certain extreme cases (p or π beam) encountered at CERN ; the dose range covered with satisfactory accuracy is from 10 mrem to 600 rem for the γ films and 10 mrem to 3 rem for the neutron films. A new holder has recently been developed which contains both types of film as well as a series of filters to measure the dose due to slow neutrons and to give more information on the composition of the dose.

The average annual dose received by the staff is of the order of 450 to 520 mrem of γ radiation and 100 to 150 mrem of fast neutrons[6]. The maximum annual doses received are normally less than 5 rem (the dose distribution in 1964 is shown in Figure 5).

TABLE I **Distribution of Radiation Dose near the CERN PS Accelerator**

	Thermal Neutrons %	Fast Neutrons %	High-energy Particles %	Gamma Radiation %	Apparent Quality Factor
PS North Exp. Hall	14 - 22	55 - 76	2 - 14	2 - 9	4.4-14
PS South Exp. Hall	12 - 22	54 - 62	10 - 14	7 - 19	2.8-5.3
PS Bridge	11 - 16	50 - 70	9 - 25	6 - 9	3.8-5.9
PS muon Region	1	15	1	83	1.2

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[*] 'Radiation workers' are those who work regularly in the presence of radiation so as to receive an accumulated dose of over 1.5 rem per year.

[6] 'Personnel radiation control 1964', J. Baarli and J. Dutrannois, 1965, DI/HP/75.

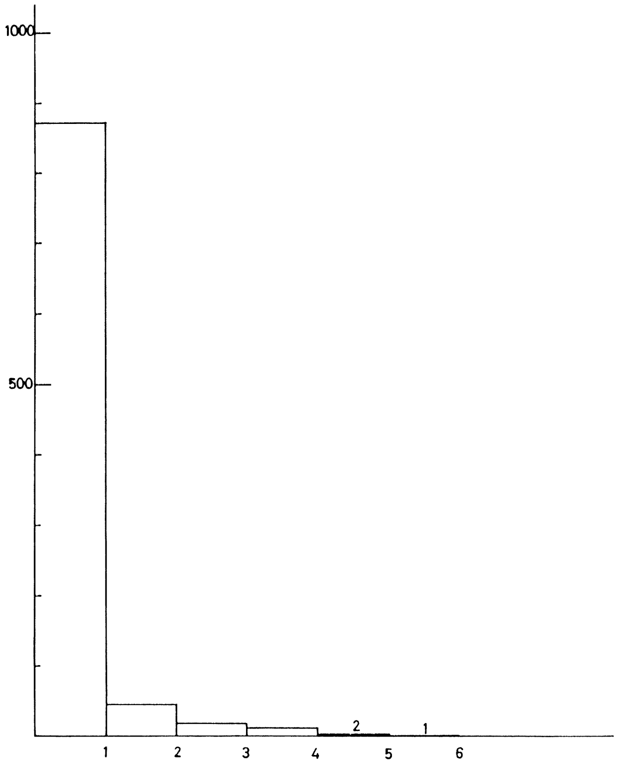


Figure 5. **The histogram shows the number of monitored people at CERN (vertical scale) falling within the different dose levels in rem/year (horizontal scale).**

Obviously, staff who are professionally exposed to radiation undergo medical examinations and in particular regular blood tests, which in recent months have been carried out by the CERN *Medical Service.* This Service decides whether the person examined may or may not work in the presence of radiation. Furthermore, every year staff exposed to fast neutrons undergo an opthalmological examination.

Future problems

The Health Physics Group still has many problems and their number will grow still more. They can be divided into three main categories.

The first concerns the progress necessary in interpreting measurements and translating them from rad into rem. The work of CERN and of a few other high-energy physics laboratories is of a pioneering kind. The biological effects of these high-energy particles are to a certain extent unknown ; the actual data and the provisional estimates of the ICRP are based on the extrapolation of results obtained at lower energy, and it is desirable to have direct information about the biological effects of high-energy particles in order to check these extrapolations. Attention needs to be given not only to the energy dissipated per unit volume but also to the distribution of this energy in the volume on a microscopic scale.

This is an important problem of fundamental dosimetry which is very difficult to study. It would be worth while to develop methods and instruments capable of giving information about the space distribution of ionization, since it would lead to a better solution of the problems of protection against radiation around the large accelerators and also to better estimates of the necessary shielding. Already studies closely linking the dosimetry of beams of known type and energy with biological studies in the same beams have been carried out in co-operation, on the biological side, with specialist organizations outside CERN.

A second problem is that of better measurement of the radiation. There are two main possibilities : either to develop techniques and equipment which will give better differentiation between the various components of the dose — in energy spectrum and type of radiation — or, on the other hand, to develop instruments and methods which will measure the energy transmitted (in rad) and the corresponding quality factor, at the same time.

Finally, there is a practical problem connected with the development of CERN. The increase of the beam intensity in the accelerators results in an increase of the radiation coming through the shielding and in an increase of induced activity. Even now the working time per hour has to be restricted to a few minutes in certain places (tank 50 on the PS for example) since a dose equivalent to the average monthly dose is received there during that time. One can imagine the difficulties which will arise. Furthermore, the radioactivity of the air and the dust is likely to become great and to require the use of special techniques. The storage rings project will extend the radiation areas geographically and probably pose problems connected with measurements at very high energy. The growing number of buildings makes it necessary to install them in places which, owing to the increase of the current in the machines, will be classified as radiation areas.

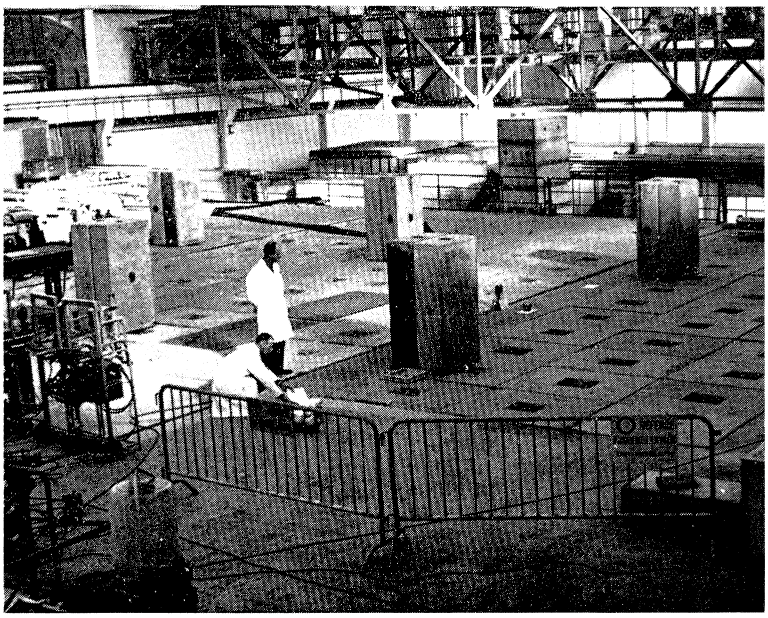
Conclusions

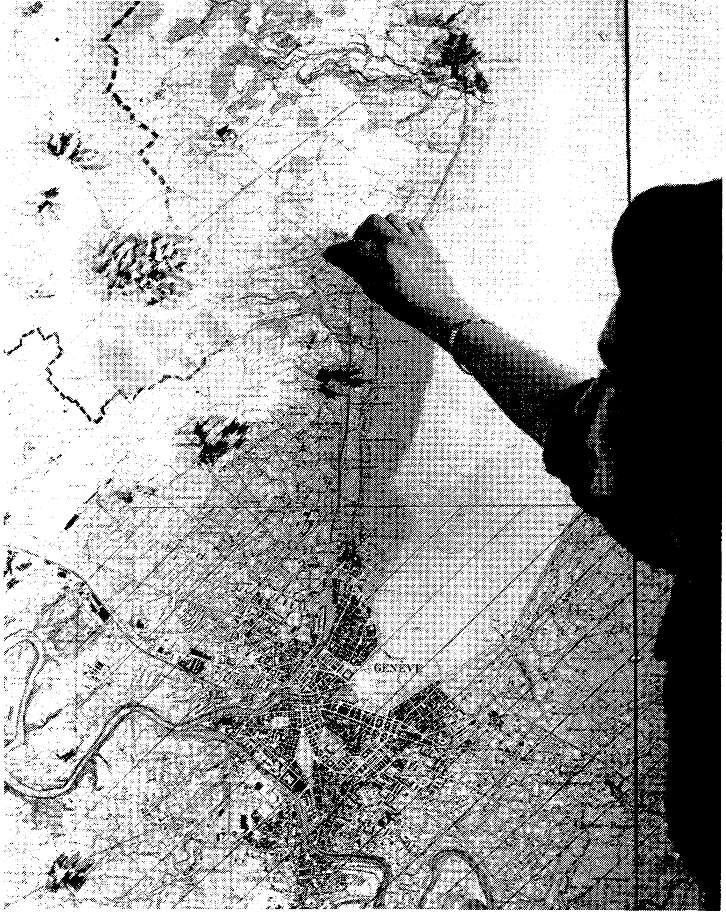
The health physics problems posed at CERN are of a special nature, often completely different from those encountered in conventional nuclear industry in the reactor field.

The lack of accurate information concerning the biological effects of high-energy radiation has a great influence on the safety factors to be used. Furthermore, the very nature of the research work done at CERN calls for an unprecedented degree of adaptability and flexibility. Accordingly, the Health Physics Group has to treat almost every case as a special one, which means considerable extra work. But this results in increased freedom of access (albeit sometimes with restrictions) with the assurance of working in safety, which is of great importance for the work of CERN.

A radiation survey taking place on the bridge between the North and South experimental halls of the proton synchrotron while the machine is in operation. The measurements are being taken using an indium bowl moderator.

CERN/PI 141.2.65





CERN/PI 192.2.65

On this map of Geneva and the 'Pays de Gex', each flag represents the home of a member of the CERN staff. This information is very useful to the Welfare Section, especially for examining social facilities together with the communes. The section is available to all staff on problems concerning residence, housing, education, social integration, mental health, cultural and sporting activities in collaboration with the Staff Association.

The role of Welfare Section

In April 1964, CERN COURIER introduced Pierre Zumbach who had been appointed Head of the newly created Welfare Section at CERN. He then said why he was interested in this type of work and what would be the guiding spirit behind the various tasks he intended to undertake. Now, after two years, Mr. Zumbach answers a few questions about the progress of this work.

What is your most essential task and why ?

There is a great variety of tasks and it is difficult to say which is the most essential. We are, however, at a turning point in the development of the Section. Since 1960, CERN has had a **Welfare Service** run by a Welfare Officer. Now, I co-operate with her in this work which has thus been intensified. It consists of single or repeated consultations examining individual and family problems to try to find solutions. To give you some figures : during 1965, 253 people, 102 of whom were new staff, were seen in the course of 483 consultations which led to 765 actions of various kinds and 204 visits to homes. The problems raised can be divided as follows : 50 % psychological and medico-social problems treated in co-operation with the medical officer ; 16 % welfare problems which it was possible to deal with quickly ; 14 % problems of accommodation for children and adults (for convalescence or for special schools) ; 11 % family and marital conflicts ; 9 % economic difficulties.

This is perhaps a rather delicate question : are there more marital conflicts at CERN than elsewhere ?

No. But the uprooting of a family to come to CERN, poor integration in community life, language difficulties (especially for the wives) or sometimes the working time-table of the husband tend to bring out, perhaps sooner than elsewhere, difficulties of adjustment and discord between husband and wife. CERN is not the basic cause of the problems, but may have an influence on the intensity of the reactions. It is therefore preferable to consult us before the tension becomes too great so that any measures we advise may have a better chance of success. While bound by professional secrecy (an indispensable prerequisite in welfare work and confidential matters) we are in contact with a number of psychologists, doctors, vocational guidance experts, educationalists and lawyers who co-operate with us. Our role is to clarify the situation and to give advice, leaving, of course, the liberty to decide what to do, to those who consult us.

What are the facilities you have set up ?

I attach the greatest importance to the problems of integration in community life. I feel that if, in one way or another, more attention had been given to these questions we would not have experienced in Geneva the xenophobia which arose during the election campaign last year, or at least not with the same intensity. Integration in community life has many psychological and social aspects. I feel that CERN's efforts should be directed at very precise problems. Since January 1965, a university-trained person, who can speak a number of languages, has been in charge of the **Information and Reception Office** in our section.

Have you been able to draw any conclusions from the experience of running this office ?

Yes. I can give you the first statistics which show that this service is valued and therefore useful. 773 newcomers have been told in a short interview of the existence of the office which is there to give information, advice and guidance to any member of the staff and, where necessary, to members of his family, about any kind of problem with the exception of professional questions concerning his employment at CERN. 963 consultations were held with both newcomers and CERN staff of more than one year's standing. All levels are represented — 10 % in the lower grades, 52 % and 38 % in the medium and higher grades. We might add that 34 % of these people are English-speaking.

The most significant statistics are those covering the nature of the problems raised — 28 % problems of education and schooling ; 19 % information on legal and administrative matters (including addresses to be contacted and formalities to be coped with) ; 18 % information on formalities concerning relatives, home-helps, etc. ; 14 % cultural problems and hobbies ; 10 % help in such things as finding baby sitters, etc., 9 % miscellaneous information.

Documentation is gradually being accumulated on the basis of these requests to enable us to forecast future needs. The aim is to be able to give precise, useful information and to draw attention to the possibilities which exist but which are not known of in many cases. The accent is always placed on finding a solution based on what is available in Geneva or in the 'Pays de Gex' in order to create a starting point for integration in the local community.

Do wives come for information ?

Of course, that is only natural. 50 wives of new staff and 108 wives of existing staff have consulted the office. 60 of them were English-speaking.

What is your conclusion from this initial experience ?

Perhaps not a conclusion, but at least a general trend : the experience encourages us to develop the service. Of course, we know that the job of welcoming newcomers rests on all the staff and particularly certain people who put colleagues in contact with the new-arrivals. This especially concerns personnel officers, divisional secretaries, heads of administrative services, etc. But experience has shown that an office with the specific task of reception and of giving information complements or augments these other forms of welcome. Families already established here should be encouraged to welcome newcomers and to share with them their own experiences on first arriving at CERN. However, and this is an important fact appreciated by the users, an office specializing in this work can, when it is necessary, guarantee that such matters will be treated in confidence.

This task of reception and information will become, with experience, a watchtower for recognizing the long-felt wants of CERN staff and their dependents. The Planning Office of the section could then undertake thorough research to provide, if not always completely satisfactory solutions which unfortunately do not exist in every case, at least the outlines of better solutions and some indication of how to achieve them through a complete knowledge of existing possibilities. This is at present the case with schooling problems, in particular at secondary and university levels. We would like to point out that integration in the local community life begins with a knowledge of the language of the country in which one lives. Therefore, we warmly encourage all newcomers to get an elementary knowledge of French as soon as possible. The programmes of the language schools in town are available and we keep in touch with the person in charge of the language courses organized by the Staff Association.

Are there other services in your section ?

The most important is the **Housing Service.** As you know, this service tries to find for the staff, furnished or unfurnished houses or flats in Geneva, the 'Pays de Gex' and (less frequently) the Canton of Vaud and Haute-Savoie. To give you an example of the amount of work — 220 unfurnished and 330 furnished flats were found in 1965.

Hotel bookings are also made for visitors (418 in 1965). 30 flats furnished by CERN are sub-let at cost price to visitors with families and to staff arriving in Geneva without having found permanent accommodation ; this service is very much appreciated. This project should also be developed. The Housing Service also gives advice and helps staff when they have difficulties with housing agents and landlords.

At present our section supplies the Chairman of the Joint Housing Committee, a task which becomes more and more time-consuming, since it aims at creating a co-operative housing scheme and involves numerous contacts in France and in Switzerland to improve present housing conditions. Moreover, the whole CERN policy on housing might well be the subject of a further COURIER interview as the topic is so complex and difficult.

What about Canteen problems ?

In conjunction with the **Restaurant Management** and with the support of the Joint Management Committee we are extending the available space and providing more efficient storage facilities. We are studying plans for setting up a restaurant of similar size on the new extension of the CERN site. The night service providing hot meals, which was started in 1965, has been very satisfactory. The total out-put of the Canteen amounted to 260 000 meals and 770 000 cups of tea and coffee during the year !

Can you mention any other activities ?

Within CERN itself, we co-operate with the **Staff Association,** especially in connection with club activities, and take part, in a consultative capacity, in the recently established Club Co-ordination Committee. Together with the Staff Association we organize the 'Midday Lectures'. Our section is also concerned with the definition and establishment of personnel policy in general, particularly with regard to the welfare and social security of the staff. For example, we are co-operating in an ad hoc study group on the retirement age.

Outside CERN we try to increase contacts in social, cultural and recreational spheres and with the authorities of the Communes around CERN. The members of our Section personally belong to a number of clubs and groups which keeps us well-informed on a variety of matters.

A final question : for those who doubt the usefulness of a welfare section, what have you to say about the future prospects of your work ?

Any tendency towards 'empire building' would be useless. Welfare work must not artificially inflate demand by offering excessive supply. On the contrary, the real needs should be judged by a realistic assessment of the facts and the solution should be sought using reasonable means. It is the moral duty of any large undertaking, and we feel that CERN, which is a focal point in the scientific world, has also to accept responsibility for the well-being of its staff. Moreover, their well-being may have a direct influence on the quality of the scientific work done. We shall welcome with great interest any advice, comments or criticism.

BOOKS

The Feynman lectures on physics, vol. I — mainly mechanics radiation, and heat, by Richard P. Feynman, Robert B. Leighton and Matthew Sands (Reading, Mass., Addison — Wesley Publishing Co. Inc., 1963; $ 8.75).

In recent years physicists, first in the United States and then in Europe, have been taking a very hard look at the way in which their subject is taught in schools and universities. Indeed, one of the things that has come under scrutiny is the very idea that physics is a 'subject', somehow separate from mathematics, chemistry, or biology, or from history, economics or foreign languages. A new idea (which, after all, is only a very old idea in modern form) has arisen, seeking not only to remove the rigid sub-divisions into which the study of physics has been split but also to present physics as a part of the knowledge that we all ought to have of the world we live in, something essential to a full education and not as an esoteric subject for a relatively few specialists. Specialists there must be, of course, and they will study physical phenomena in much more detail, but even specialists should remember that what they discover are explanations for human experience. As such, this knowledge has at some stage to be fitted into the everyday context of life, together with that of other sciences and of the arts, and not kept separate. Even at the frontiers of knowledge, in sub-nuclear research as at CERN, for example, where the behaviour of the 'things' we study seems so far from normal life, physics cannot be shut off from the various aspects of engineering, chemistry, biology, economics, languages, politics, and so on, that are all involved.

Nevertheless, at any level of teaching, not only historical inertia and the dictates of a workable timetable but also a certain natural grouping ensures that 'physics' will still be treated independently, though its relationships with other disciplines will be emphasized more than in the past. To this end a number of good text books have appeared which contrast strongly with even the best of those that were current, say, twenty years ago.

One of the most compelling must certainly be this one, edited under the direction of Profs. Feynman, Leighton and Sands and recording in vivid fashion the lectures given by Prof. Feynman to the first-year students of the California Institute of Technology in 1961-62.

As explained in the Foreword, this volume (the first of three) covers the first year of the two-year introductory course taken by all incoming students at the Institute and constitutes a major part of a fundamenal revision of the course, carried out over a four-year period. Prof. Feynman prepared and delivered the whole series of lectures, which were tape-recorded, and the text-book for future use was prepared from the recordings — after an editorial revision that turned out to be much more arduous than was (perhaps somewhat naively) originally expected !

A study of the contents list, giving the titles and subtitles of the 52 lectures which have become the 52 chapters of the book, shows immediately that this is no ordinary text-book of physics. As one slowly reads through the book (and it takes a long time because there is a year's instruction in its pages) this first impression is reinforced again and again. The physics is certainly that which has been taught for many years in the last terms at school and the first at university, supplemented by more recent knowledge. But the topics are in a different order, which gives the physics a new shape, there are examples and cross references that give it a new clarity, and the language is of a kind that separates the more important from the less important and compels a new enthusiasm for parts of the subject long since dismissed as dull.

The tone of the book is set in the first two pages. In these opening paragraphs, Prof. Feynman explains that physics cannot be taught as a set of axioms like Euclidian geometry; firstly we do not know all the basic laws and secondly the statement of those we do know requires a knowledge of advanced mathematics as well as some very unfamiliar ideas. Physics has to be learnt gradually, and everything we learn is only an approximation to the truth so that corrections will be needed later. Stressing that the test of all knowledge is experiment, he points out that it is *imagination* that is needed to create the great generalizations that are moulded into the laws of physics*.

Then he puts the proposition, that if all of scientific knowledge were to be destroyed and only one sentence passed on to the next generation, then the statement that would contain the most information in the fewest words would be the following: 'All things are made of atoms — little particles that move around in perpetual motion, attracting each other when they are a little distance apart, but repelling upon being squeezed into one another'. All through the book this fact is not lost sight of. Even though many of the topics dealt with do not involve the idea of atoms explicitely, always the question is asked: 'Is what we have said consistant with what we know about atomic behaviour; if not, why not ?

To begin with, the first three chapters are of a general nature: atoms in motion, basic physics, the relation of physics to other sciences (chemistry, biology, astronomy, geology, psychology). Here there is no mathematics to put anyone off and this section in particular can be thoroughly recommended to anyone, not just the physics student, who would like to know what physics is.

Next comes a chapter on the conservation of energy, again a touchstone to be used many times to gauge the sense of a statement or derivation. Having often sought to define 'energy' for the sake of non-physicists, it was something of a relief to find here the confirmation that it does not exist in little blobs and in fact we have no knowledge of what energy is ! 'Time' is a similar abstract notion, impossible to define specifically ('how long we wait', says Feynman) yet essential in our thinking and therefore needing to be measured in an accurate and agreed fashion. Both time and distance are dealt with in chapter 5, and the chapter following is devoted to a discussion of probability, not forgetting its relation to atomic structure and the Heisenberg uncertainty principle.

The next eighty pages or so develop the topic of Newton's laws of motion, beginning with the theory of gravitation, discussing what we mean by motion and how it is described

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* Since this review was written, the selection of Prof. Feynman as one of the Nobel Prizewinners for 1965 has given recognition to his own eminence as a theoretical physicist.

by the mathematics of the calculus (differentiation and integration), the components of velocity and force, the conservation of momentum, vectors and vector algebra, different kinds of forces, including (already !) nuclear forces, and ending with the ideas of work and potential energy.

Next, and this is another surprise for someone brought up in the old tradition, come chapters on the special theory of relativity, relativistic energy and momentum, and space-time, the latter including a clear treatment of four-vectors and four-vector algebra — the logical extension into the four dimensions of space-time of the three-dimensional vectors already discussed. It seems obvious that this is the place to introduce these ideas. As presented by Prof. Feynman, they are not so terribly difficult and they show how Newton's laws have to be modified when the velocities involved approach those of light. Even Einstein's equations are still approximate, since they do not take account of the uncertainty principle, but they are not as approximate as Newton's equations dealing with the same phenomena.

From the mathematical refinements of essentially point-like particles, the lectures turn to the realities of solid bodies at the sort of speeds normally encountered, deriving such concepts as the centre of mass and moments of inertia and treating various aspects of rotation in both two and three dimensions, using vector notation.

The chapter entitled 'The harmonic oscillator' is introduced by the excellent explanation that the standard examples (mass suspended from a spring and simple pendulum) are to be seen as easily understood demonstrations of the properties of the highly versatile linear differential equation with constant coefficients, rather than as particularly interesting phenomena in themselves. A beautifully devised chapter on 'algebra' leads to the relationship between complex numbers and the 'geometrical' notation for oscillations in terms of sines and cosines, and thus enables such things as resonances and transients, in both mechanical and electrical systems, to be treated relatively easily in the following pages.

In the second half of the book, the first thirteen chapters deal with various aspects of electromagnetic radiation, a sort of synthesis between geometrical and physical optics and electrical wave theory that brings out the essential unity underlying these former sub-divisions of physics. Fermat's 'principle of least time' is used as the basis for a study of geometrical optics, and justified by quantum-mechanical considerations (again this cross-checking from one concept to another for consistency). Maxwell's equations introduce the topic of electromagnetic radiation, with all the phenomena of interference, diffraction, dispersion, absorption, polarization, and so on, that this involves, whilst the discussion brings in many of the ideas on the calculus, vectors, oscillations and quantum behaviour dealt with earlier. The section is brought to an end by one chapter on the relativistic effects of radiation and two that (at the moment !) are not physics at all, on the sensations of colour and the more general mechanics of seeing. Prof. Feynman rightly makes no apologies for 'these excursions into other fields'. 'Nature is not interested in our separations', he says, 'and many of the interesting phenomena bridge the gap between fields'.

There is also a sort of postscript, in which two chapters are devoted to an elementary discussion of quantum mechanics and the question of the relation between the wave and particle viewpoints. At the same time this acts as a bridge to the next section, which begins with the kinetic theory of gases, passes through the principles of statistical mechanics, Brownian movement, application of the kinetic theory, and diffusion, to the laws of thermodynamics, devotes a chapter to some of the applications of thermodynamic theory, and ends with a chapter entitled 'ratchet and pawl'. In this, a model of good teaching, Prof. Feynman takes a simple piece of mechanical equipment, known to everyone, shows that it is not so simple as it looks, and thereby derives some of the essential ideas concerning reversibility and irreversibility that are at the heart of fundamental physics.

The next four chapters deal with various aspects of sound, serving as specific examples of some more general phenomena that arise from wave motion and supplementing the earlier chapters on electromagnetic waves. Included in this section is a statement of the important synthesis given by the idea of 'linear systems', and a consequent relationship between our ways of thinking about macroscopic waves, on the one hand, and quantum-mechanical atomic and nuclear systems on the other.

In the last chapter, Prof. Feynman's clarity of exposition, coupled with humourous presentation, is again shown to the full, and this explanation of 'symmetry in physical laws' is, like the opening chapters of the book, accessible to many more readers than just the students to whom it was first delivered. After defining what we mean by symmetry in such a context, and giving some of the more obvious examples, he deals with the remarkable connexion that exists between symmetry rules and conservation laws. He then considers some of the interesting properties of mirror images, including the particularly surprising fact that many biological systems distinguish between 'left-hand' and 'right-hand' molecules, so that many substances which can be made artificially in both forms exist in nature in only one. The difference between polar and axial vectors is also clearly explained.

In his highly entertaining story of the Martian who was told by telephone how to make a model of a man on Earth, Prof. Feynman shows clearly how the symmetry laws come into play and describes the connexions between the non-conservation of parity in weak interactions, antimatter, and the so-called CP invariance (though, perhaps typically, he doesn't name the latter as such).

Finally, in the last paragraphs, he turns to broken symmetries, giving a glimpse of problems with which physicists in high-energy laboratories are now so familiar.

A really adequate impression of this lively, sometimes provocative, and very personal approach to a major part of physical knowledge would require another Feynman as reviewer. All I can really say, in summary, is that anyone who has ever reached the stage of studying physics at university level should get the book for himself and explore its contents. He will be extremely well rewarded.

A. G. H.

Introduction to radiological health, by Hanson Blatz (Maidenhead (U.K.), McGraw-Hill Publishing Co. Ltd., 1964; 99 s.).

This book forms a very good introduction to the variety of problems associated with the field of radiation protection

— or radiological health, as the author prefers to call it. It discusses radiation and radiation sources, and their properties, as well as the problems of the interaction of radiation with matter; it also deals with biological effects, related to permissible radiation doses, contamination levels, radiation measurements, and protection, including radiation accidents and the legal aspects of radiation control.

The book is written in general terms, but it gives a considerable amount of information on its subject. It would be more useful as a volume of general interest to someone who wishes to gain some knowledge of the character and scope of radiation protection, rather than as a reference book for a health physicist. It is to be recommended to those who have some background in physics, biology or medicine and who would like to learn what the problems of radiation protection really are.

The book has a good subject index.

J. B.

Nuclear physics, by Irving Kaplan (Reading, Mass., Addison-Wesley Publishing Company Inc., Second edition, second printing, 1964; $ 15).

The first edition of this well-known book appeared in 1954, and the first printing of the second edition dates from 1962.

Part I (7 chapters) deals with the 'Background of nuclear physics', including chapters on the special theory of relativity and on atomic spectra, part II, called 'The nucleus', is devoted mainly to radioactivity and nuclear reactions, while part III (4 chapters: neutron physics, nuclear fission, nuclear energy sources, and accelerators) is a choice, as indicated by its title, of 'Special topics and applications'.

Each chapter is followed by a list of references and — with one exception — by several (6-20) problems, the solutions being given in an appendix. The references are divided into two parts: general (mostly books), and particular papers quoted in the text. Many classical books and papers are included, which — if consulted — would serve to give the student a 'feeling of history'. Generally the references stop at 1958; only in a few places are there some items up to 1961, obviously 'added' at a later stage.

Many numerical tables in the main text and the appendices enable the student both to solve the problems and to become familiar with the orders of magnitude of the quantities involved and with the most important and characteristic physical data. As a separate enclosure a chart of the nuclides, up to lawrentium 103, contains valuable information, such as abundances, activation cross sections, modes of decay and energies, some isomeric states, and masses on the carbon-12 scale. This is the only place, incidentally, in which this scale is used explicitely.

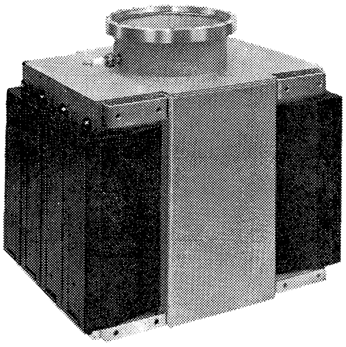
As stated in the author's preface the book is intended for an advanced undergraduate level. Generally speaking, from this point of view the choice of topics is reasonable, although the complete absence of elementary-particle physics is a limitation, even if the book is addressed mainly to non-physicists and particularly students of nuclear engineering. From the present text, in fact, it is rather difficult to guess for what useful purpose the high-energy accelerators described in the last chapter might have been built. The 'curriculum' of the book may also explain why spark chambers or solid-state detectors are not even mentioned; nevertheless, this must be seen as a serious gap today.

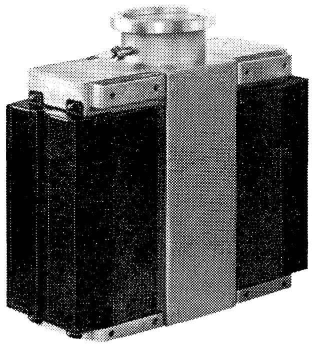
Obviously it would be quite unreasonable to provide the text with more than a rather descriptive treatment of theoretical problems involving quantum mechanics, such as (for example) alpha-decay or parity conservation, and the reader who wants to acquire a better understanding and a deeper insight must make use of the literature, to which, it is true, he is generously and judicially sent by the references.

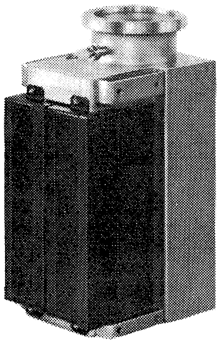
A few minor negligent formulations might give rise to erroneous understandings. For example, on p. 156 one finds: 'The spin angular momentum of the electron... could have the values $+{}^{1}/_{2}$ or $-{}^{1}/_{2}$..', when in fact, in opposition to its projections, the spin itself is characterized by essentially positive quantum numbers.

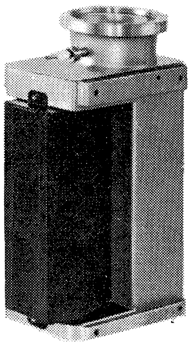
As a whole, however, the book is written in a clear-minded and attractive manner, able to stimulate the beginner's interest in nuclear physics and its applications. Its reputation as a most valuable introduction to nuclear physics is well deserved. Let us hope that a further edition, which will become necessary presumably in the not too distant future, will not only be brought up to date but will also include an elementary account of high-energy physics and fundamental particles.

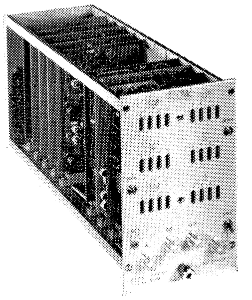
J. S. Ausländer (Karlsruhe)

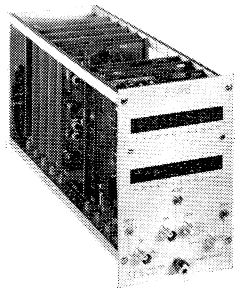


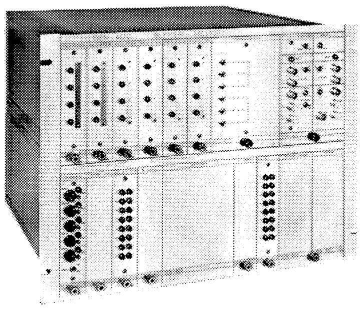












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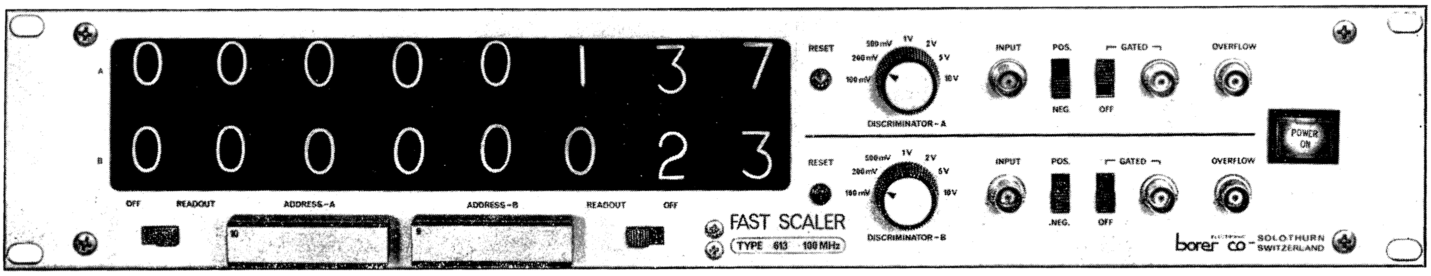

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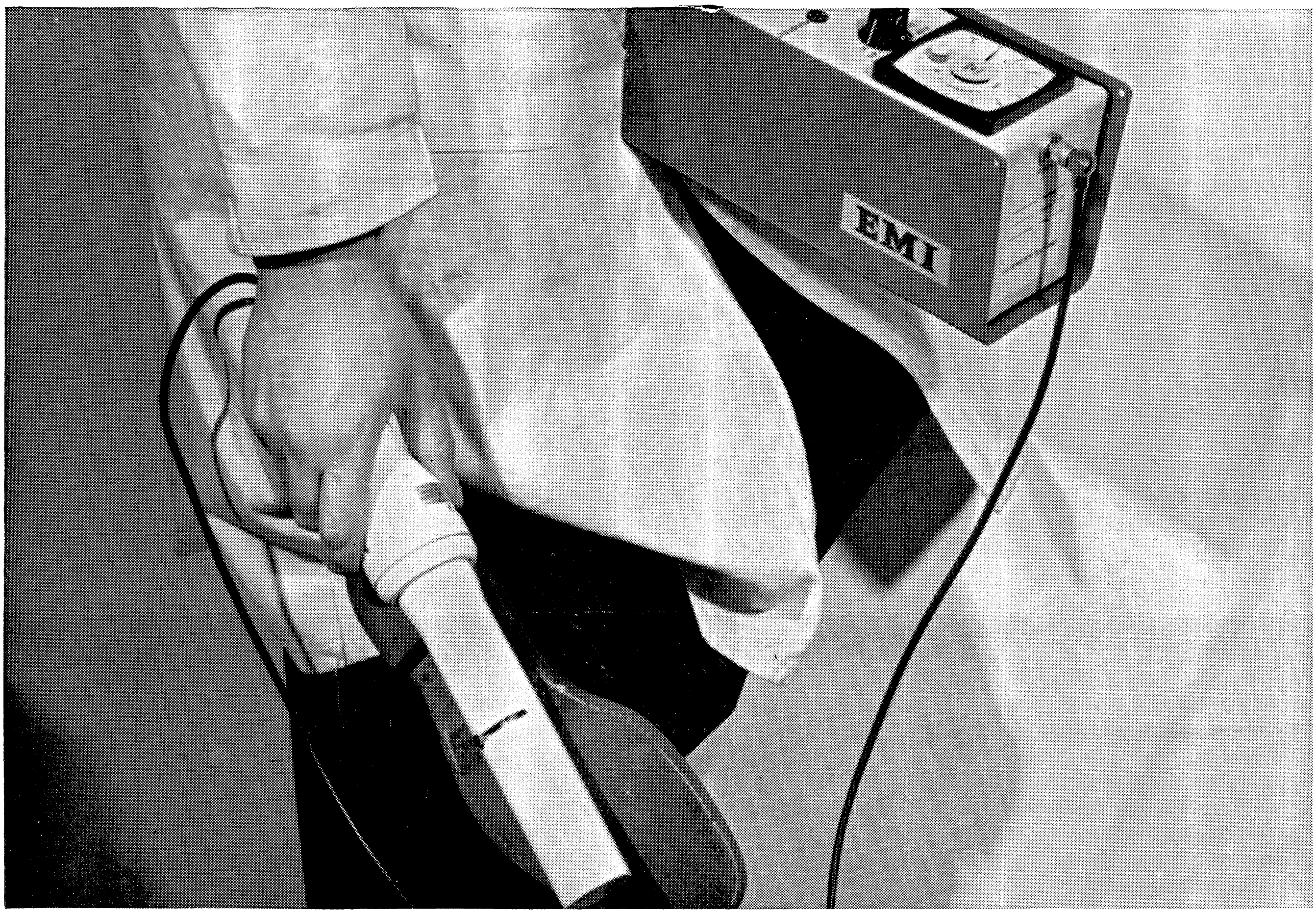

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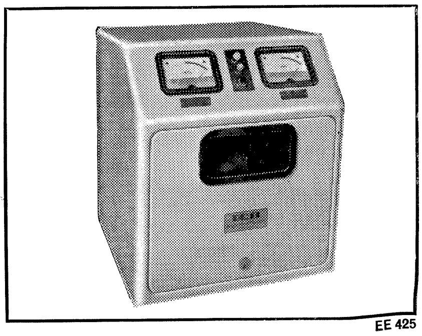
In the time that it takes you to read the first few lines of this advertisement you could be completely checked by an EMI radiation monitor. This happens every day so that thousands of people working in nuclear establishments go home safe from radioactive contamination. The new generation of EMI Nuclear Health Monitors, the largest range in Europe, includes instruments to meet the needs of establishments large or small. The monitors illustrated are but two of the EMI range which includes, Hand and Clothing Monitors, Hand Monitors, Foot Monitors, Floor Monitors, Beta/Gamma and Neutron Dose Ratemeters, and Air Monitors, as well as the Wells series of modular nucleonic instruments. If nuclear safety is your business, send now for full details of the EMI range.

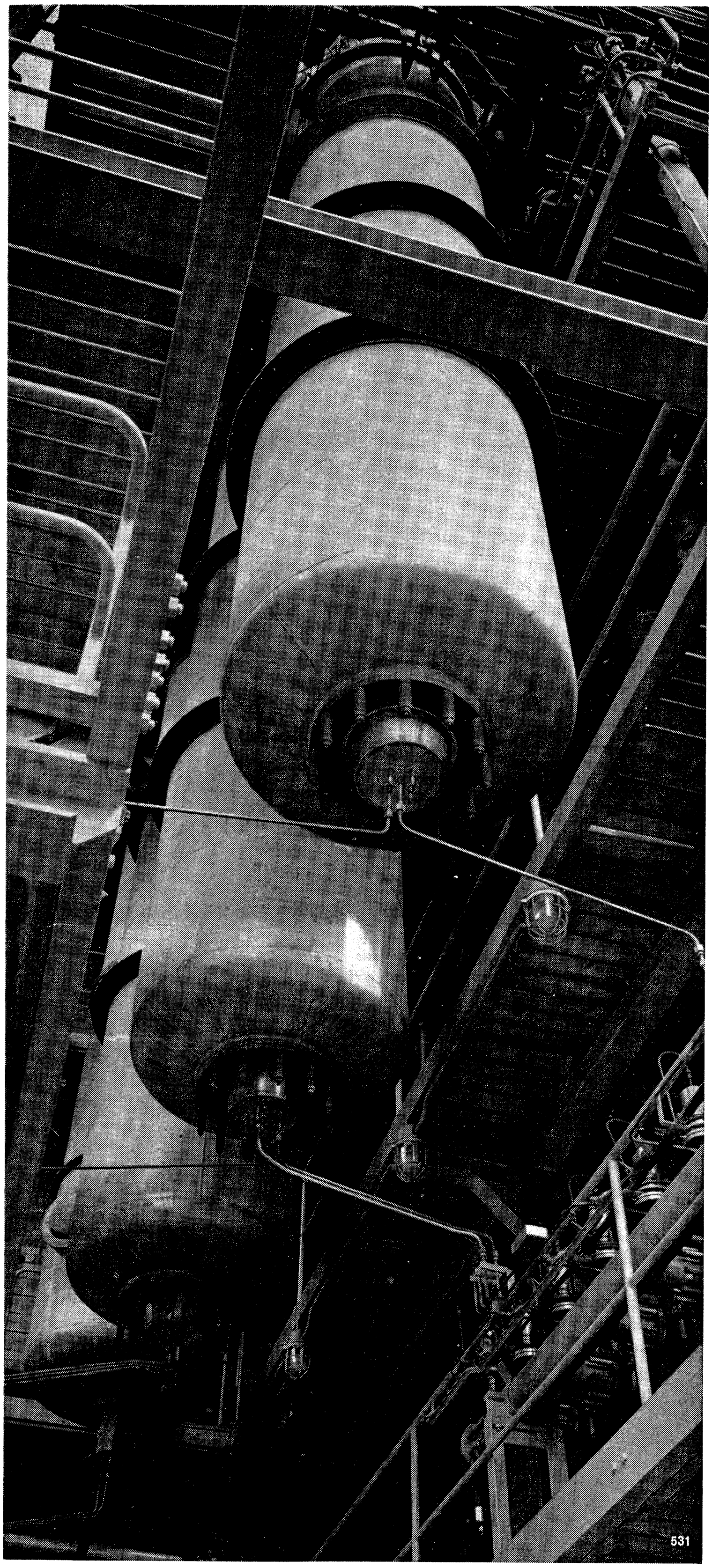
Above: Rate meter RM2 is a low cost solid state general purpose monitor for all types of radiation. It weighs only 6 lb.
Below: Single Hand Monitor Type HM2. Economical solid state instrument—ideal for universities and hospitals using radio isotopes. Has audible and visible indicating systems.



EMI

EMI ELECTRONICS LTD
NUCLEONICS DIVISION · HAYES · MIDDX · ENGLAND · TELEPHONE: HAYES 3888

EE 425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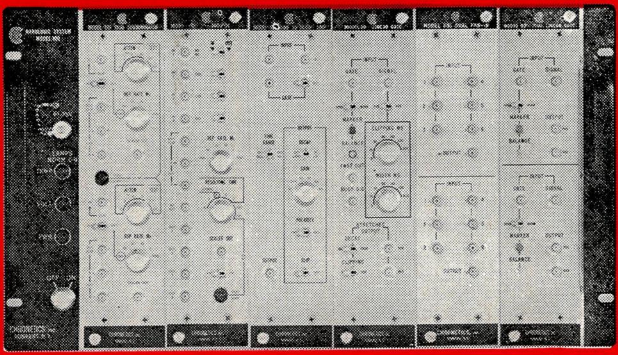
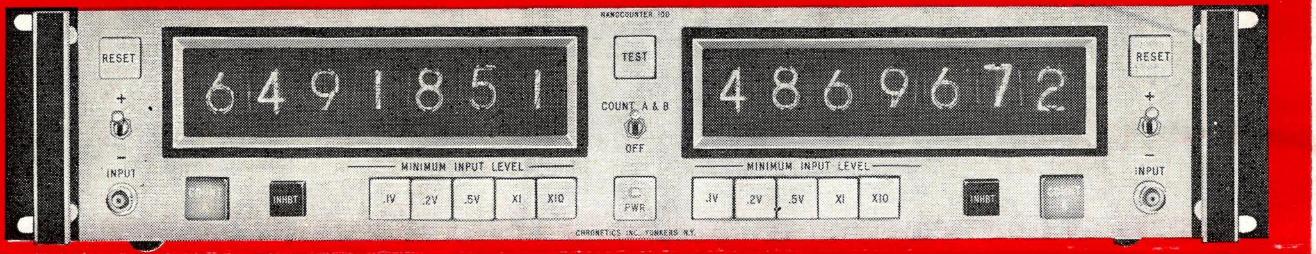
ADVANCED NUCLEAR INSTRUMENTATION





NANOCOUNTER^{tm} 100

100 MC DUAL COUNTER/SCALER

SPECIFICATIONS (Each Section)

Counting Rate: 0-10^8 counts/sec (100 Mc)
Pulse-Pair Resolution: 10 nsec
Count Capacity: 10^7 (7 decades)
Input Data —
- **Sensitivity:** 100, 200, 500 mV; 1, 2, 5V
- **Max. Input:** 100V; any sensitivity range
- **Input Impedance:** 50 ohms; DC-coupled
- **Reflection:** ±10% max.

Output Data —
- **Display:** In-line, 7-digits, long-life Nixies
- **Elec. (Printer) Readout:** On command
  - **Parallel:** 36-line 1-2-4-8 BCD; other codes special order
  - **Serial (Optional):** 4-line 1-2-4-8 BCD; other codes special order
- **Output Logic Levels:** 0V = 0, —4V = 1; 1K ohms. +4V or +8V options available
- **Reset:** Local-front panel pushbutton; Remote-ground line on rear connector
- **Scaler Identification:** BCD (00-99) via framing switches
- **OVFL:** Overflow count; —4V, 300Ω source Z

General —
- **Temperature Range:** 0°C to 60°C; all silicon, no fans
- **Power Requirements:** 105-125 or 210-240 VAC, 50-400 cps
- **Dimensions:** 3½"h x 16"d x 19"w, o/a; fully shielded
- **Price:** $2200. f.o.b. Mt. Vernon, N. Y. Slightly higher outside USA

NANOLOGIC^{tm} 100

100 MC DIGITAL LOGIC SYSTEM
FOR NUCLEAR PHYSICS

FUNCTIONAL MODULES (6 shown of 18 available):

101 Dual Discriminator • 102 AND (coincidence)/OR • 103 AND/OR with DC-coupled anti-coincidence • 105 Time to Pulse Height Converter • 106 Dual Nanoamp^{tm} • 107 Dual AND (coincidence) • 108 Dual Fan-Out • 109 Dual 100 Mc Decade Prescaler • 111 Gate Generator • 112 Dual 4-Fold Logic Fan-In • 113 Dual AND Gate • 114 Four Discriminator • 115 Dual Power Fan-Out • 116 Linear Gate & Stretcher • 118 Dual Linear 6-Fold Fan-In • 119 Dual Linear Gate • 38 Three 8-Fold Resistor Fan-In • 44 Four 4-Fold Fan-Out

NANOLOGIC 100 proven performance —in use at most of the major accelerators of the free world—advanced design, unmatched stability and reliability. Comprehensive technical literature available.

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