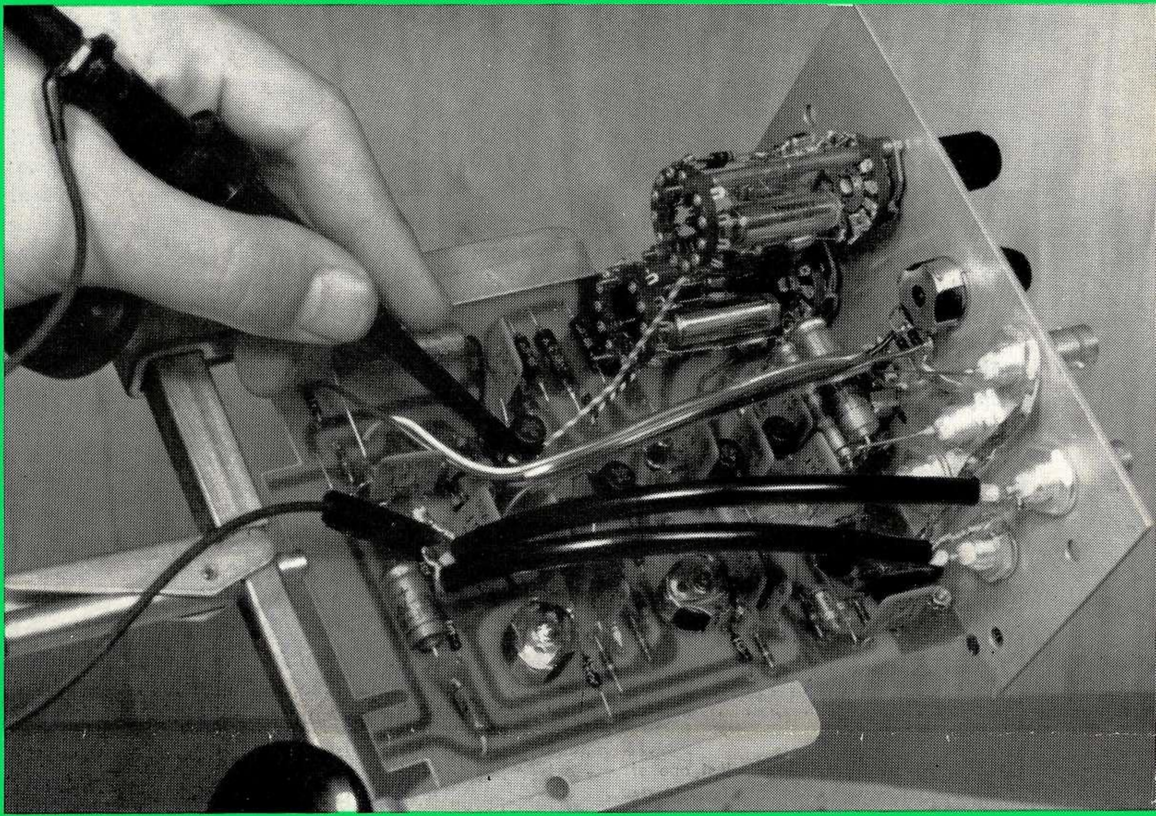
CERN COURIER



CERN/PI 212.11.63

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November 1963

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 (1.92 %), Belgium (3.78), Denmark (2.05), Federal Republic of Germany (22.47), France (18.34), Greece (0.60), Italy (10.65), Netherlands (3.87), Norway (1.46), Spain (3.36), Sweden (4.18), Switzerland (3.15), United Kingdom (24.17).
Contributions for 1963 total 92.5 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.'

Last month at CERN

On 11 October the **25th Session of Council** was held at CERN. This was a special meeting, held between the normal ones in June and December, primarily to allow further consideration of two matters of vital importance to the Organization's future outlook.

The first of these concerns a so-called '**supplementary programme**' for CERN in 1964. In its report earlier this year, the European Committee on Future Accelerators recommended that further thought should be given to the design of storage rings for the CERN proton synchrotron and of a synchrotron with an energy of the order of 300 GeV. Proposals for continuing the study of these projects next year have been set out in the form of a supplementary programme which would be financially independent of CERN's normal activities. At the October Council Session a resolution was adopted approving this programme in principle, in the sense that it is compatible with the purpose of CERN, as laid down in the Convention, and would not interfere with CERN's basic programme. The supplementary programme was, at the same time, submitted to Member states for consideration and for appropriate decisions at the December Session of Council by those states that agree to contribute financially.

Contents

The cover photograph shows just one of the many kinds of electronic instruments used at CERN. This piece, constructed from transistors and modern miniature components and using a circuit printed photographically on the rear of the card, produces a standard output pulse when triggered by a suitable input signal. It is one item in a comprehensive range of fast ' nucleonic ' devices produced by the electronics group of the Nuclear Physics Division. An article on the group begins on the opposite page.

CERN COURIER

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The second item for discussion was the CERN **budget** itself over the next three years. By its adoption of the 'Bannier Report' in October 1962, Council accepted the fact that it was necessary for CERN to continue to expand over the next few years, and consequently that the Governments of the Member states would need to provide increasing amounts of money each year to finance this growth. However, the budget agreed for 1964 was only 11 % more than that for 1963, instead of 13 % which the report recommended. For 1965, the figure proposed was only 10 % more than for 1964.

At the October meeting a number of Council Members, as well as members of the Scientific Policy Committee and the CERN Directorate, spoke in support of a greater increase. Among the points stressed was the fact that the major difficulty now is to satisfy the growing demand by physicists in Member states to use these facilities. Because of new ideas and new techniques, the amount of money required per physicist tended to increase each year rather than remain constant (as assumed by the Bannier committee), and on the present forecasts it is likely that the number of physicists employed must remain constant for the next few years. Any increase in the already much greater number of ' visitors ' in the same circumstances could only lead to a decline in the support made available to them in the laboratory.

No decision was called for at this Session, but the overall sum for the 1965 budget will be voted at the next Session in December.

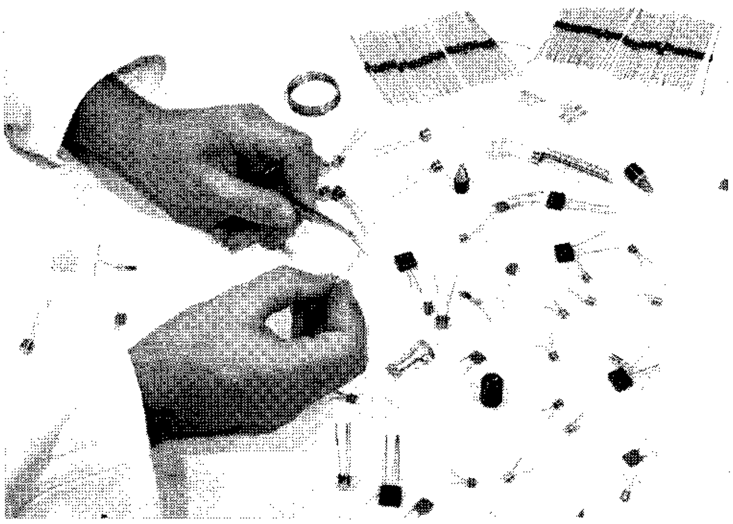
Among other business dealt with by the Council was the appointment of the United Kingdom Government's Exchequer and Audit Department to audit the CERN accounts for the next three to five years, in place of the 'Contrôle fédéral des Finances' of the Swiss Confederation, which is no longer able to undertake this work.

At the **proton synchrotron** the first week of October was devoted to phases of the same **counter** and **spark-chamber experiments** that were mentioned in last month's account, namely investigations of the production of electron pairs in antiproton annihilation, the electron decay of the lambda particle, 'peripheral' production of gamma rays, and the operation of spark-chambers in a strong magnetic field.

The rest of the month was oriented more towards bubble-chamber exposures. In the m_3 beam in the South hall, which incorporates two 10-m electrostatic separators, the **81-cm Saclay/École Polytechnique liquid-hydrogen bubble-chamber** provided 135 000 photographs of interactions by antiprotons with a momentum of 5.7 GeV/c, 135 000 of 3.5-GeV/c positive kaons, 110 000 of 3.5-GeV/c negative kaons and 45 000 of 3.0-GeV/c negative kaons. Antiprotons

Continued on p. 146

The NP Electronics Group



CERN/PI 36.11.6

Some of the components used for electronic instruments.

There are probably few fields of research today where electronic instruments are not found in some form or other, and in high-energy physics they are vital. Many people at CERN, both individually and as groups, work on the design, development, construction and servicing of electronic equipment, which is used extensively in experiments at both accelerators and for many other uses.

We are pleased to be able to present an account of one of the electronics groups, that belonging to the Nuclear Physics Division, which gives an idea of its history, some of the people who have been and are connected with it, and the kind of work that it does.

The electronics group which now forms part of CERN's Nuclear Physics Division came into existence in 1955, under the leardership of Guy von Dardel, as part of the former STS (Scientific and Technical Services) Division. In its early days it was associated with work on the two multiplate cloud chambers, constructed for the cosmic-ray group at Cointrin, and the preparation of basic electronic, equipment for experiments using the accelerators which were then still under construction.

As the synchro-cyclotron neared completion in 1957 it was realized that this experimental preparation had to be intensified. The electronics group was therefore transferred to the SC Division and located in the SC laboratory building, to work more closely with the physicists concerned.

These were hectic days. There was considerable controversy as to what the group should be doing and where the greatest emphasis should be placed — which cable impedance? — whose coincidence circuit? — which connectors? — what voltages? — which scalers? But finally, when particles were accelerated, there was adequate equipment available.

One 'panic' over, another larger one loomed — the PS would also soon come into operation and equipment would be needed for experiments of a completely new character. Guy von Dardel transferred his activities to the preparation of some of these experiments, and the leadership of the electronics group passed to Ian Pizer. It was at about this time that the foundations of the present organization were laid.

The SC electronics store was initiated by 'Nic' Nicolaysen and taken over by Jean Maier, who still runs it. Various people, from all over CERN, had a hand in the sordid but useful subject of standardization, from whence came the choice of 125-ohm cables, 75-ohm cables, 'Berkeley' connectors, 'C' connectors, valve-type power supplies, and the origins of the CERN versatile chassis-building system.*

The instrumentation was strongly influenced by two American experimental physicists — Clyde Wiegand and Oresti Piccioni. The fact that they were from opposing camps and had diametrically opposite ideas sometimes added to the confusion, but at other times added the spice that made it all worth while. Wiegand's influence was particularly strong. He showed us with his own hands how to do nanosecond things, and thanks to Henk Verweij who was his willing pupil, we soon had the foundations of a usable set of basic fast nucleonic instruments.

We were also building up 'logic' devices, under Fred Iselin, and we produced (with Arne Lang) a print-out system for 'Dekatron' scalers which was used over a long period in an experiment at the synchro-cyclotron. Pulse-height analysers were also present in those early days, and John Lindsay constructed several analysers of the type using nickel-wire delay lines as 'memories'.

Let us now telescope several years — years of hard work, criticism, turmoil —, and what emerges? The present electronics group, which in 1961 became part of the Nuclear Physics Division in the new organization of CERN, consists of sections dealing with instrument development, manufacture (wiring pool), and instrument repair and maintenance, as well as two smaller units. The store is now a separate entity. The group provides most of the nucleonic equipment for counter and spark-chamber experiments and also produces other items which can be found in all parts of CERN.

The development side continues under the same section leaders, Fred Iselin, John Lindsay and Henk Verweij. There is now a whole range of transistorized fast nucleonic instruments, currently used in large quantities in all the experiments at the CERN accelerators, and many other laboratories in Europe and the U.S.A. have shown great interest.** The widely used

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* This system enables electronic 'boxes' of many shapes and sizes to be built up from a small number of standardized components. It has been fully described by B. Sagnell in a CERN report, 62-69, issued last year.

** Condensed catalogue available.

25-Mc/s scalers, with print-out and punch-out, are now produced commercially on both sides of the Atlantic.

Various pulse analysers are maintained, modified for special requirements, and provided with specially developed peripheral equipment as needed. Other subjects are dabbled in as well, leading to such things as scanning-and-measuring tables for spark-chamber photographs and the transfer of experimental data (particularly from acoustic spark-chambers) to magnetic tape for computer analysis.

The maintenance section handles much of the electronic equipment in CERN. One part is in the SC building, under Hans Schroot, the other in the PS with Jean-Pierre Tribolet. This section also receives newly manufactured instruments from the wiring pool and checks and adjusts them before they are delivered to the physics groups.

The wiring pool is closely integrated with the development section. They manage, by some miracle (chief magician Roger Dupuis), to produce in large quantities the most difficult circuits with quite short delivery delays, and they are an important and vital link between the development engineer and the experimentalist.

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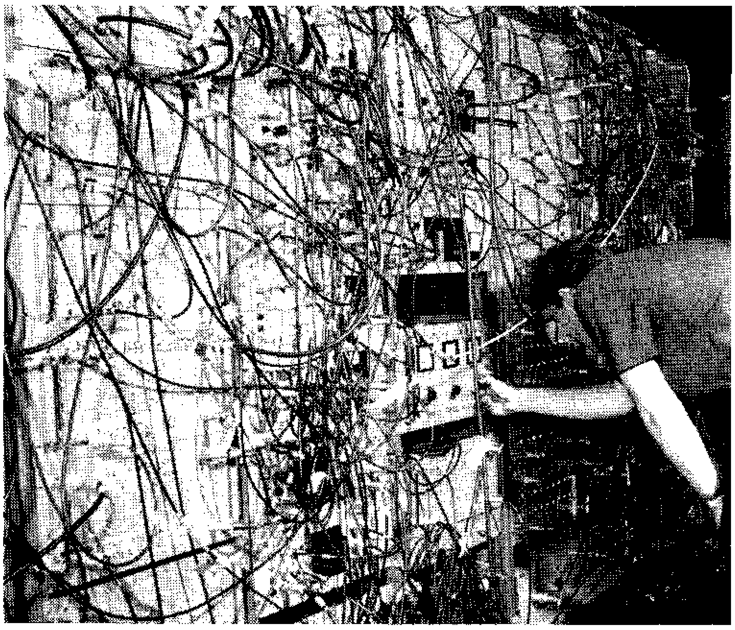


The complexity of a physics experiment demands many instruments and numerous interconnexions. Nearly all the 'nucleonic' instruments in this photograph (forming part of the equipment for the lambda decay experiment at the PS) were designed by the electronics group.

One of the 'smaller units' mentioned above consists of Hans Haeubi, who serves as the source of all semiconductor information, edits the 'Laboratory Handbook—Electronics', and deals with problems of work sub-contracting. The other has 'Nic' Nicolaysen, dealing with purchasing and distribution of commercial instruments and producing (with one draughtsman) all circuit drawings.

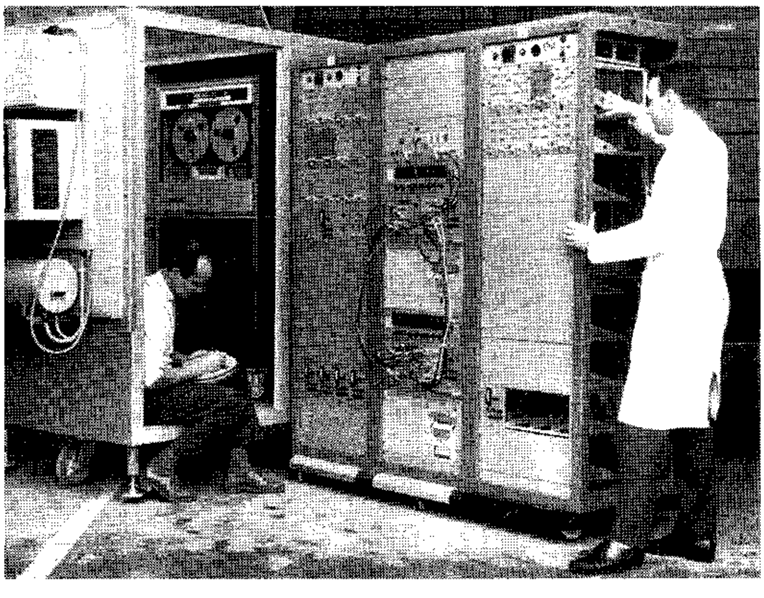
The activities of the NP electronics group are recorded and distributed irregularly by means of *The Electronical Mirror,* read avidly by all, but mostly (it is said) because of the jokes it contains. Close contact is maintained with other laboratories doing similar work in Europe and the U.S.A. Recently Henk Verweij spent three months at the Lawrence Radiation Laboratory, Berkeley, and this will be followed by a return visitor from there.

Do not be misguided by this article into thinking that all CERN electronics is centred in the NP electronics group. Only a specialized part of it is conducted there. Electronics, in fact, is a widespread occupation, both 'amateur' and 'professional', in the CERN laboratories — probably more widespread than most other technical disciplines. It ranges through audio systems, for the auditorium and elsewhere, television, radiofrequency systems, accelerator electronics, computer and film-scanning devices and many other activities in practically every Division.

More power to the electron !

I. P.

CERN/PI 155.11.63



One of the NP electronics group's latest creations is a complete system for recording directly on to magnetic tape, ready for transfer to the computer, the data collected from an array of sonic (or acoustic) spark chambers. With this type of spark chamber the position of the spark in each gap is computed from measurements of the time taken for the sound of the spark to reach each of four microphones placed at the edges of the gap. On the right of this photograph, which shows the first part of the system being prepared for tests in the PS South hall, Arne Lang inspects one of a row of four scalers used in the measurements of the time intervals. (These scalers are counting instruments which can each register up to a million counts at a maximum rate of about 25 million per second.) The central rack contains 'logic units' controlling the transfer of the data to the tape. To the left, Albert Maurer is seated inside the air-conditioned cabinet specially designed to keep the tape in a controlled, dust-free atmosphere.

Dubna — 1963

21-27 August

International conference on high-energy accelerators

Last year CERN was host when the International conference on high-energy physics *, was held here, under the auspices of the International Union of Pure and Applied Physics. This year it was the turn of Dubna, the Joint Institute for Nuclear Research, where the companion International conference on high-energy accelerators took place from 21-27 August.

The accelerator conference was founded by CERN in 1956, and held here again in 1959. In 1961 it took place in the U.S.A., at the Brookhaven National Laboratory. Like the conference on high-energy physics, with which it alternates, it is now held every other year, successively in the U.S.A., U.S.S.R. and Western Europe (CERN).

Twenty-one physicists and engineers, including the Director-general, went to Dubna from CERN. This article has been compiled from the accounts they gave afterwards of the conference and the visits that were made to other laboratories.

The conference brought together some 300 participants, of whom about a quarter were from the U.S.A. and a quarter from Western Europe. Its purpose was to review the developments in the design, construction and operation of high-energy particle accelerators (generally those giving energies of about 1 GeV and above) during the two years since the last conference, at Brookhaven, and to survey the future possibilities.

No doubt because there are so few secrets among the scientists and engineers working in this field, much of the material presented at the conference was already known. In addition, the large number of papers submitted (169 distributed among 11 sessions) produced a heavily loaded programme that unfortunately allowed little time for discussion. However, in a developing field it is always worth while to survey progress occasionally and the 'proceedings' of the conference will certainly become a highly useful source of reference. Moreover, valuable personal contacts were possible between experts from many laboratories, which is, in any case, one of the chief reasons for holding any conference. For the Americans and Western Europeans in particular, there was the added interest of being able to hear of the Soviet work at first hand and to visit their major laboratories afterwards.

Development of existing accelerators

From the status reports presented on the principal accelerators already in operation, it could be seen that beam intensity, always an important feature from the experimenter's point of view, had in most cases been improved. For instance, the 6-GeV Bevatron at the Lawrence Radiation Laboratory, Berkeley, U.S.A., had reached 2.3×10^{12} protons per pulse, following the extensive modifications carried out the previous year. The Cambridge Electron Accelerator, also in the U.S.A., had an intensity of 5×10^{10} electrons per pulse, but with a repetition rate of 60 per second this represented 3×10^{12} electrons per second. As previously mentioned in *CERN COURIER*, the achievement by the CERN PS of an intensity of 0.9×10^{12} protons per pulse was announced to the conference shortly after the event. For the first time, it seems that fundamental intensity limitations are being encountered, so that in the two American machines mentioned it is now mainly interactions in the beam itself, or between the beam and the accelerating system, that hinder further increases in intensity. Formerly of lesser importance practically, these interactions will now require closer study if further gains are to be made.

Since the beam can be used more efficiently outside the accelerator, a complementary approach to higher intensities is given by the development of good extraction systems. Here the most noteworthy results were presented by speakers from CERN, who gave details of the 'fast' system, an invaluable component of the neutrino experiment then in progress, and of the 'slow', resonant extraction system, operated for the first time a fortnight before the conference.

Accelerators recently completed

Information was presented on three new accelerators, all completed this year, two of them just in time for the conference. These are the Princeton-Pennsylvania Accelerator, at the Forrestal Research Centre, Princeton, U.S.A., 'Nimrod', at the Rutherford High Energy Laboratory, Chilton, England, and the 'ZGS', or Zero Gradient Synchrotron, at the Argonne National Laboratory, Chicago, U.S.A. The first two of these are conventional weak-focusing synchrotrons, accelerating protons to 3 GeV and 8 GeV respectively ; the third is a unique form of the same general type giving protons of up to 12.5 GeV. All three have been discussed briefly in recent issues of the *CERN COURIER.*

Accelerators under construction

Of the accelerators now under construction the one that attracted most attention, certainly among the visitors, was the 70-GeV proton synchrotron being built at Serpukhov, about 100 km South of Moscow (in other words, some 230 km South of Dubna). The design has evolved to some extent since it was first discussed in 1956, and this accelerator is now essentially a conventional strong-focusing synchrotron, that is, a larger version of the CERN PS or the Brookhaven AGS. As injector it will have a 100-MeV strong-focusing linear accelerator, fed in turn by a 700-keV pre-accelerator equipped with a 'duoplasmatron' ion source of remarkably improved design. This pre-accelerator is already in existence and was reported to give quite well defined beams of up 400 mA of protons. The site itself, in pleasant wooded surroundings, was visited by a number of the conference participants. Civil engineering work is well under way and two thirds of the tunnel, the

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* *CERN COURIER*, vol. 2, no. 8, August 1962.

linac zone, and a vast experimental hall 160 m × 90 m in area have been covered. The accelerator is expected to come into operation in about three years' time.

The other machines under construction are all for accelerating electrons. The largest is the Stanford Linear Accelerator (sometimes known as 'the monster'), in the U.S.A., which will initially give electrons of energy 20 GeV. Another linear accelerator, for 2 GeV is being built at Kharkov, in the U.S.S.R. At Hamburg, Federal Republic of Germany, 'DESY', an electron synchrotron designed for 6 GeV, is now nearing completion, and a very similar machine is well under way at Erevan, in Armenia. Finally, there is the new British machine, 'Nina', for 4 GeV, to be built at Daresbury, Cheshire. At the time of the conference, building of this had not actually begun, but an announcement in November from the National Institute for Research in Nuclear Science stated that construction of the laboratory, had been started. It will be known as 'The Daresbury Nuclear Physics Laboratory'.

Accelerator projects

The demand by the experimental physicists for higher-energy projectiles has resulted in a number of new design studies for larger proton synchrotrons, and although these are all far from complete their presentation formed one of the focal points of the conference.

In the U.S.A., two projects have been proposed. One of these, by a group at the Lawrence Radiation Laboratory, Berkeley, is for a machine giving an energy of 200 GeV. The magnet ring would be about 1.6 km in diameter and the injector a synchrotron of 5 GeV, not much less than the energy of the Bevatron. A group at the Brookhaven National Laboratory is working on the design of an even larger machine, in the range of 600 to 1000 GeV.

Western European work in this field is centred at CERN, where the outline of a 300-GeV synchrotron has been produced. This would be about 2.4 km in diameter, contain some 27 000 tons of steel plate in the magnets and consume about 20 MW of power. The accelerator would be located entirely underground and the site, including space for the experimental areas and supporting services, would have to be over 20 km^2 in area.

All three of the above machines represent fairly straightforward extrapolations of the present PS and AGS designs. Also in this category is a 500-GeV synchrotron under consideration at the Institute of Theoretical and Experimental Physics in Moscow. A second Russian group, however, is working on plans for a machine operating on so-called 'cybernetic' principles, to give 1000 GeV. The aim is to take better advantage of the alternating-gradient principle by considerably reducing the beam fluctuations that are normally set up by the slightest misalignment of the magnetic field, and thereby to reduce the size of the vacuum chamber and hence that of the magnets required. Not just the radiofrequency supply but also the magnet currents would be continuously adjusted automatically by measurements on the beam itself. The forces that accelerate the particles and also those that keep them on their approximately circular path would thus be continuously related to the beam position, and the otherwise severe effects of slight misalignment of the magnets and other small irregularities in the magnet field would be reduced. Whether the extra complexity in the control equipment would be worth the saving in magnet steel seems rather problematical to many, but the Russians are planning a 1-GeV 'model' to test the system.

In the more conventional energy range, an unconventional design for a 10-GeV electron synchrotron is being worked on at Cornell University, U.S.A. This would have the magnet, complete with its coils, inside the vacuum tank instead of outside. It should still be possible to maintain a sufficiently good vacuum with such an arrangement and it is claimed that the overall cost would be considerably reduced.

Storage rings and colliding beams

By arranging for two beams of particles to collide more or less head-on, certain reactions can be investigated at energies much higher than would otherwise be practicable. To obtain a useful collision rate however, means have first to be found to create beam intensities

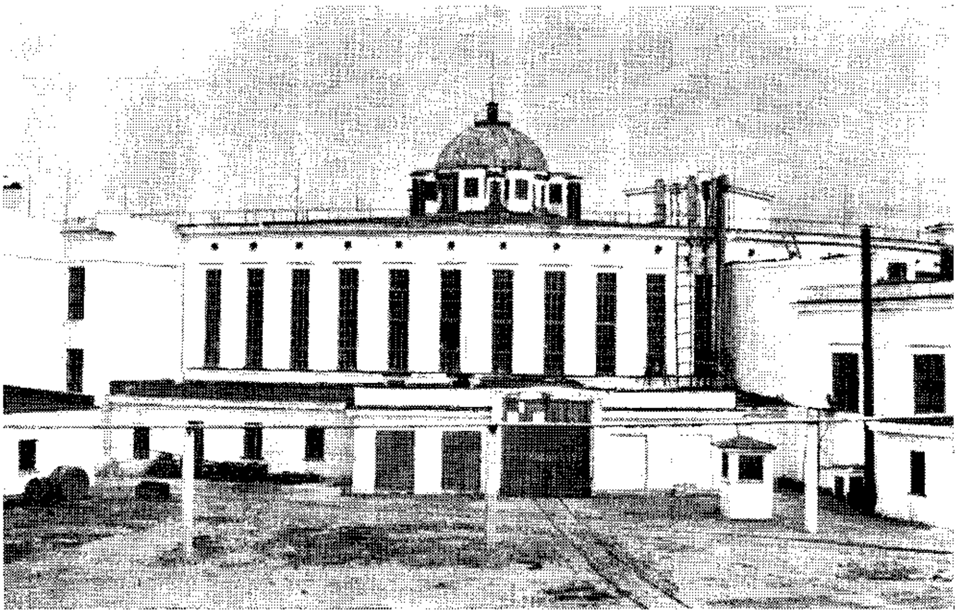
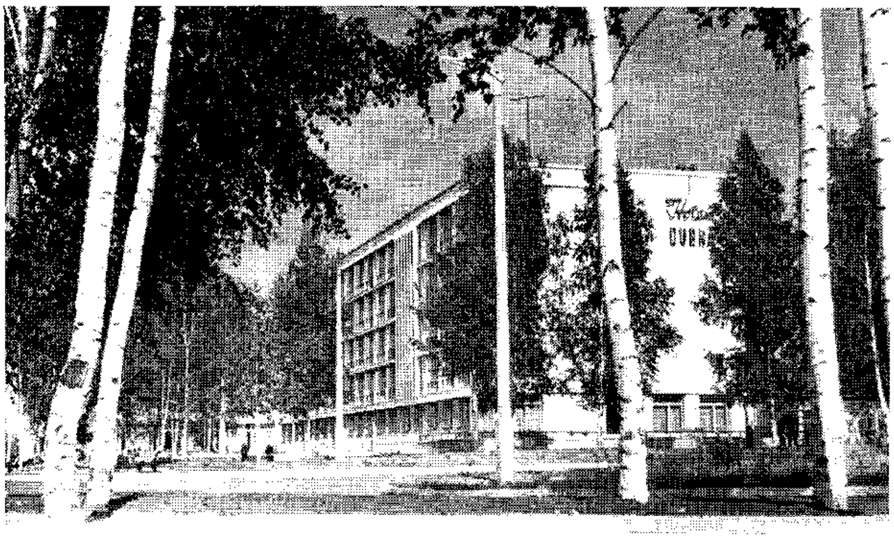


Photo : JINR

The building housing the 10-GeV proton synchrotron (synchrophasotron) of the Joint Institute for Nuclear Research at Dubna, U.S.S.R.

Photo : JINR



Arriving foreign delegates found the brand-new 'Hotel Dubna', built specially for the conference, as a symbol of hospitality to come. Among evening entertainments were performances by the Moscow Symphony Orchestra and prize winning soloists, the head of the Moscow Puppet theatre, and variety artists. On the Sunday there was a boat trip up the Volga to the Moscow Sea. Visits were arranged to the accelerator laboratories at Dubna itself, and to other laboratories in Erevan, Kharkov, Leningrad, Moscow, Novosibirsk and Serpukhov.

many times higher than are possible with present accelerators, and one way of doing this is to inject successive pulses of particles into two intersecting 'storage rings' in which each beam is accumulated until the required intensity is reached. A number of papers on the CERN design for a pair of rings to be fed by the 28-GeV proton synchrotron were read at the conference.

Several storage rings have already been built for electrons, although the energies involved are much lower and the rings are still being used to study the problems involved in the use of this technique rather than for physics experiments.

At Stanford, U.S.A., in conjunction with Princeton University, a pair of rings has been constructed for 500-MeV electrons. Early operation revealed that a limit of 15-20 mA was being imposed on the intensity of the stored beams by vertical oscillations of the electrons, but a number of studies have revealed the probable causes and it is hoped that the instability can be overcome. Trouble has also been experienced with a pair of rings designed by the Frascati Laboratory, Italy, and being tested with the aid of the linear accelerator at Saclay, France. These rings are meant for storing a beam of electrons and a beam of positrons. An increasing loss of electrons with increasing beam intensity has been traced to mutual interactions between electrons in the beam.

In the U.S.S.R., the Institute of Nuclear Physics at Novosibirsk has a pair of storage rings in which 50-100 mA of electrons can be stored for up to about 1 hour at 100 MeV. The injector is a rather interesting air-cored synchrotron, of 40 MeV, capable of accelerating enough electrons to give a current of this order in a single pulse. Also at Novosibirsk is a pair of electron-positron rings, for 700 MeV, fed by another air-cored synchrotron of 350 MeV, in an advanced state of construction. A pair of rather more conventional rings for 100 MeV, is being built at Kharkov.

An interesting experiment is in progress at the Lebedev Institute in Leningrad, using their 280-MeV electron synchrotron, constructed with the aid of the magnet from the former model of the Dubna 10-GeV accelerator. It has been found possible to keep the beam in the machine after it has been accelerated, during the decelerating half of the cycle, and to accumulate several successive pulses in this way. The aim is to inject positrons and electrons simultaneously and to build up the two beams, circulating in opposite directions, before allowing them to collide.

New ideas

Apart from the innovations inherent in some of the designs already mentioned, such as the 'cybernetic' accelerator and the placing of guiding magnets inside the vacuum chamber, various new ideas were presented to the conference as possible bases for future developments.

The most interesting of these was the 'non-linear' accelerator proposed by the Soviet physicist Orlov. This would be a circular machine with a fixed magnetic field (not varying with time), the strength of which increases and then decreases with distance from the axis of the vacuum tube through which the particles are accelerated. In this particular form of guiding field the particles execute complicated ('non-linear') betatron oscillations inside the tube, of large amplitude, which take them alternately into areas of positive and negative gradient of the magnetic field. A kind of alternating-gradient focusing in the vertical direction is thus induced automatically. Such a machine is said to be capable of accelerating protons to any energy between 1 GeV and 1000 GeV, with enormous beam intensities. The vacuum tank would need to be about 2 metres wide, however, which would entail very large magnets, and the tolerances allowed in construction are extremely small. Also, long straight sections would not be possible, a great disadvantage from the operational point of view. It remains to be seen whether such difficulties will prove to outweigh the undoubted advantages shown by this design.

Other devices reported indicate a growing link between the fields of high-energy accelerators and the plasma devices normally associated with experiments on nuclear fusion. Finally, it is worth noting that the advent of high intensity monochromatic and non-divergent light beams from so-called 'lasers' has led to the suggestion that the protons in such a beam might be considerably increased in energy as a result of Compton scattering during collision with a very high-energy electron beam, to produce a beam of high-energy gamma rays of well-defined energy and polarized with respect to a particular direction ●

BOOKS

Weak interactions, and topics in dispersion physics, edited by Christian Fronsdal (New York, W. A. Benjamin, Inc., 1963 ; cloth $ 8.80, paper $ 5.45), is the report of the second Bergen International School of Physics, held in 1962. The publication of such a report is always a good thing from the point of view of the organizers ; it is of most value to students when it provides a systematic exposition and review of a field not recently covered in such a way elsewhere. Sometimes, however, the material included in the report is simply that which has given least trouble to the available lecturers, who have reluctantly written, in a minimum number of words, a sketch of what they have said.

The present volume, unfortunately, to some extent gives this latter impression. However, it does have a main theme, namely weak interactions, and most theoretical aspects of that subject (which stands now much where it did in mid-1962) are touched on. The authors of this part of the volume are Bernardini, Telegdi, Treiman, Behrends, Sirlin, di Lella, Primakoff, and Fujii. The most lengthy and systematic article is that of Treiman on 'The structure of weak interactions'. This invites comparison with his similar work at Les Houches in 1960 ('Relations de dispersion et particules élémentaires' ; Paris, Hermann, 1960) — a comparison which shows the Les Houches article to be the more complete and better documented. Of the other articles, that of Behrends and Sirlin on the isobaric structure of weak interactions is especially notable. Their development includes as a special case the 'six-boson' scheme, afterwards proposed by T. D. Lee, and (in a footnote) the crucial observation on this theory made later by Bell, Meyer, and Prentki.

The remaining 40 per cent of the book is given to a miscellany of topics in field theory. Fubini gives a nice introduction to the small amount of dispersion theory needed for weak-interaction form factors. The other articles are individually very worthy, but it is a pity that the time and space were not devoted to amplifying and deepening the weak-interaction side. The excellent article by Mandelstam, 'Dispersion relations in strong-coupling physics', is reprinted from *Reports on Progress in Physics*, vol. 25 (1962).

J. S. B.

Nuclear and nucleon structure, edi[illegible], Robert Hofstadter (New York, W. A. Benjamin Inc., 1963 ; cloth $ 11.00, paper $ 7.65), provides an excellent collection of reprints on various subjects connected with the study and interpretation of nucleon and nuclear structure through the medium of electromagnetic interactions. Guided by the editor's comments on every article, the reader is taken on a fascinating tour through this field, in historical order, starting with Dirac's classical 1928 paper on the quantum theory of the electron. Among the 82 selected papers one notices the early probing of the neutron structure in the scattering of slow neutrons on electrons, followed by a series of later papers on the probing of protons and neutrons by high-energy electrons at high momentum transfer. The description of these experiments by 'form factors' as well as their theoretical interpretation in terms of resonances and dispersion relations are well represented. The experimental papers explicitly demonstrating the existence of the ρ, ω and η mesons are included.

Also in the collection are a number of experimental and theoretical papers on the determination of nuclear size and shape by muon x-rays and elastic electron scattering. Inelastic scattering of electrons on nuclei is, however, surprisingly little represented (with the last paper from 1956), in view of the importance that this field has acquired in the last few years.

Any collection of this kind is easily criticized on some ground. In this case, the editor has been too eager at the end of the book to include the very latest developments. Thus, the last two 'papers', dealing with nuclear structure effects on muon x-rays are, in the one case, an American Physical Society abstract and, in the other case, a private communication. While both would merit inclusion in their final form, the wisdom of presenting them as they stand may be doubted. Among the more recent papers (1960-1962) the level of selection is also not always as high as earlier in the volume. The inclusion of several important survey and review articles is, however, of great value.

As a whole, this reprint collection should be a very useful reference source for most physicists, and in addition it is an excellent place in which to become acquainted with this field. The price, however, is regrettably high for a book consisting basically of photographic reproductions of existing papers.

T. E.

Proceedings of the Eastern Theoretical Physics Conference, University of Virginia, 1962, edited by M. E. Rose (New York, Gordon and Breach, 1963 ; $ 5.00).

Nowadays it is becoming more the rule rather than the exception that to review a conference report is an arduous

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Last month at CERN (cont.)

with a momentum of more than 5 GeV/c and negative kaons of more than 3.5 GeV/c carry enough energy to create a possible new particle, known as the omega particle, predicted by the theory of unitary symmetry. Attempts to find this particle have so far proved unsuccessful, but a new search for it will be made among the photographs obtained in these latest runs. Evidence for the particle will also be sought in the **1.5-m British national hydrogen bubble chamber,** using the long separated-particle beam, o_2, in the East hall. The second electrostatic separator of this beam was put into operation during October, and assembly of the chamber was also virtually completed. Operation of the chamber was, however, confined to test runs. The synchrotron was programmed so that 90 % of the beam in each pulse hit the target for the m_3 beam and the remaining 10 % the target for the o_2 beam.

During the second operating fortnight, every tenth pulse was directed on to the target for the a_5 beam in the North hall. This is a beam of negative pions, of momentum 1.05 GeV/c, specially designed for high intensity (the original version, a_2 was described in *CERN COURIER* in July 1962). The beam was being used for an experiment intended to give a value for the magnetic moment of the lambda particle, by allowing lambdas, produced by the interaction of pions in a polyethylene target, to decay inside **nuclear emulsions** placed within a very high (pulsed) magnetic field. Measurements on the tracks left by the decay products of the lambda in such an arrangement show the effect of the magnetic field on the lambda as it travelled the 10-cm gap between the target and the emulsion. The effect in turn depends on the magnetic moment if not quite a thankless task. Often a great deal of partly baked material is presented and the poor reviewer has to wade through a mass of unconnected papers very carefully, searching for a nail on which to hang his notes. Fortunately this particular conference proved to be the exception : the avowed aim was to spread the subject matter over as wide a spectrum of topics as possible so that people working in one field would have the opportunity to learn of recent progress in other areas. Obviously the entire span of theoretical physics could not be covered in the course of two days, and so the discussions were loosely restricted to nuclear and particle physics and to topics in general relativity. That this limitation in no way detracted from the scope of the conference, a glance at the table of contents will show. For example, the subject matter ranged from vibrations and single-particle excitations in nuclei (G. E. Brown) to a detailed review of analyticity in particle physics (S. B. Treiman), from a reformulation of the theory of pairing correlations (M. Baranger) by way of the pion resonances (J. Steinberger) to remarks on weak interactions (C. N. Yang), the quantization of geometry (B. DeWitt) and gravitation from a field-theoretical viewpoint (R. Arnowitt).

It would be invidious to discuss certain contributions to the exclusion of others and the papers mentioned above should be regarded as being representative of topics rather than as the selection of particularly interesting talks. However, it would be a grave omission indeed not to mention Wheeler's after-dinner talk, which in a sense epitomizes this conference. He poses a very simple question : what makes a physicist, in particular a theoretical physicist, tick ? To give here a summary of his ideas would be a travesty and quite out of place, but we would suggest that those who wish to understand more deeply the philosophy underlying his question, and those who wish to forge further links in the charismatic chain, should spare a little time and give some thought to his words.

A remark concerning the discussions which follow each paper may be in order. Editors of future proceedings of conferences should take a look at the excellent example set by this book : some editing of the participants' remarks would certainly have been necessary, yet the discussions have remained extremely lively, almost personal, one could say. None of these clinical, grammatically impeccable pronouncements one usually associates more with government spokesmen than with a live debate on a very controversial subject. Full marks to the organizing committee for allowing sufficient time between talks for these verbal engagements to develop. **St. L.**

Nuclear power engineering, by M. M. El-Wakil (New York, McGraw Hill, Inc., 1962) and **Nuclear reactor engineering,** by Samuel Glasstone and Alexander Sesonske (Princeton, D. Van Nostrand, Inc., 1963).

There is a subtle difference between these two titles, which reflects the opposition of two dissimilar views presented by the authors, concerning essentially the same subject matter but seen from two different standpoints and responding to two different sets of requirements.

Dr Glasstone, Consultant to the U.S. Atomic Energy Commission, this time in collaboration with Prof. Sesonske, Professor of Nuclear Engineering at the Purdue University, presents a successor to his well-known text, *Principles of nuclear reactor engineering*, published in 1955. The new book, of 830 pages, about equal in size to its predecessor, had to cover a field in which practical knowledge and new applications had expanded enormously during the intervening eight years. But the main purpose declared in the preface is still to ' describe the fundamental, scientific and engineering principles of reactor systems '. The emphasis is on what happens in a nuclear reactor, and how the engineers contrive to put the necessary material system together and to keep it running. Various uses (production of electric power, research, space activities) then find their logical place as additional conditions imposed on the definition of the material system. About one-third of the total length of the text is devoted to fundamentals (Introduction, Nuclear reactions and radiations, Diffusion and slowing down of neutrons, Reactor theory in the steady state, Reactor kinetics, Temperature and poisoning effects). Then various practical aspects are considered : Control, Energy removal, Structural and moderator materials, Fuels, Radiation protection, Shielding, Mechanical and Structural components, Preliminary design. In the remaining hundred pages various existing reactor systems are reviewed from the points of view of uses, comparative efficiency and cost.

The declared objective of Prof. El-Wakil, Professor of Mechanical Engineering at the University of Wisconsin, was ' to cover the engineering aspects of converting nuclear fission energy to useful work ', and he sees a nuclear reactor as ' a heat source from which useful power can be produced '. The first part of his book of 556 pages covers the fundamentals : Atomic and molecular structure, Atomic and nuclear reactions, Neutron flux distribution in cores, Time variables in reactor behaviour, and occupies nearly as large a fraction of the total length as the corresponding section of Glasstone and Sesonske's book. However, since the overall

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of the particle. Another emulsion experiment during the month involved the exposure of six emulsion stacks to about 1.4 million negative kaons, of 3 GeV/c, in the m_3 beam.

With no experiment scheduled to use the fast ejected beam from the synchrotron, more extensive tests were possible on the **slow ejection system.** The external beam path was extended in vacuum nearly to the wall of the South target area, the final viewing screen being near the neutrino horn. Straightforward checks of the beam position at various points along its path were carried out with the aid of plastic scintillator screens and television cameras, supplemented by the use of ' polaroid ' film, ordinary photographic paper and x-ray film. In more detail, the average cross-section of the beam was measured, using nuclear emulsions of various kinds, arrays of small solid-state-diode radiation detectors, and aluminium foils on which the distribution of the induced radioactivity was afterwards determined. Measurements of the time structure of the beam gave promising results. These measurements were carried out with scintillation counters, solid-state diodes, and photographic paper or film on a rapidly rotating wheel perpendicular to the beam. The latter showed clearly that the beam was focused into a spot less than 1 mm wide but that it oscillated from side to side by about the same amount, in time with the slight ripple remaining on the current in the septum magnet that ejects the beam.

The ejection efficiency was measured with the aid of a secondary - emission chamber, borrowed from the MSC Division, and irradiated aluminium foils measured, like the others, by the NP Division's nuclear chemistry group. These gave values of from 30% to 60%, according to the limitations placed on the quality of the beam ●

text is shorter and the reader is approached at a more elementary level of knowledge, the whole treatment of the fundamentals is of a more introductory and auxiliary nature. The author in fact considers that 'part one may be bypassed by those with sufficient background'.

In part two (occupying about a quarter of the total length), the author treats those basic concepts which are of particular interest to a power engineer (Thermodynamic aspects of nuclear power, Heat generation and removal, Heat transfer and fluid flow, Flow with change of phase). In the remainder of the book (nearly one-half), existing and recently proposed reactor systems are reviewed in the light of the basic ideas of part two. Practical considerations are dominant throughout and two concepts (boiling and gas-cooled) are treated in noticeably greater detail than the others (pressurized-water, organic, liquid-metal, fluid-fuel). The 'futuristic' proposals (use of heavy water for better fuel conservation, or of fast-neutron chain reactions for breeding) are, on the contrary, given less attention than, for example, in the Glasstone-Sesonske book. Neither of the two books shows much interest in nuclear propulsion for ships.

To sum up, if both power engineers and reactor specialists have to work together in a nuclear-power project, the El-Wakil approach will come more naturally to the former, and the Glasstone-Sesonske approach to the latter. Both books are excellently printed and well provided with problems and indexes.

L. K.

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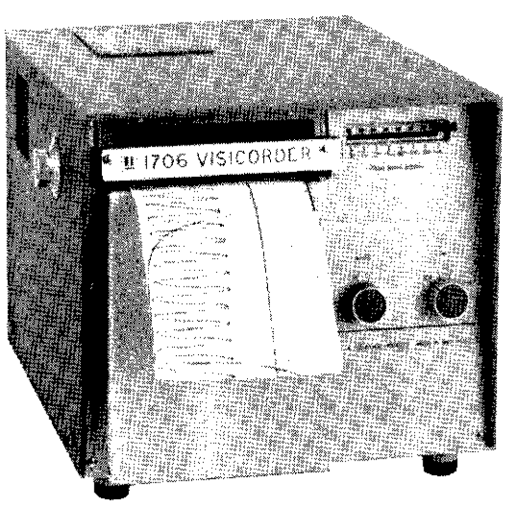

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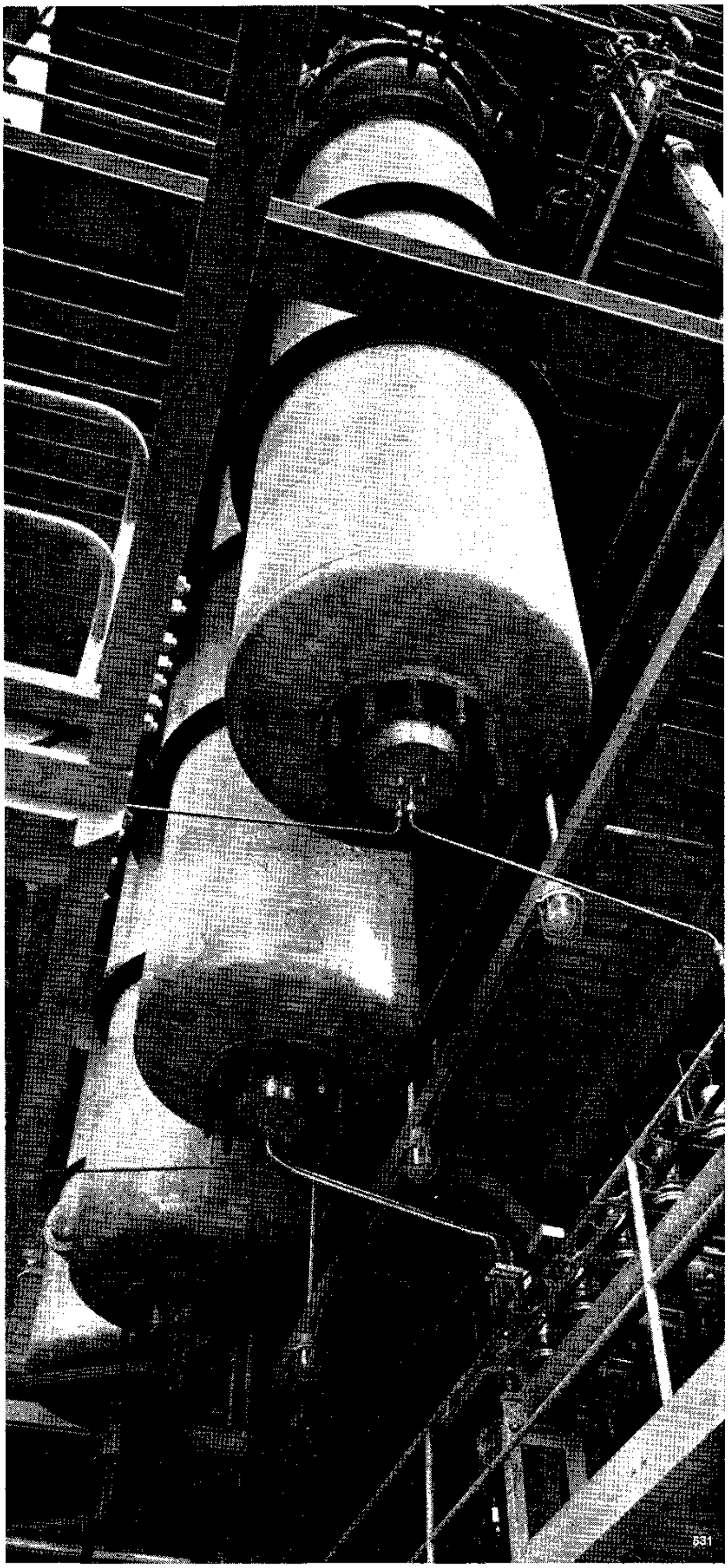

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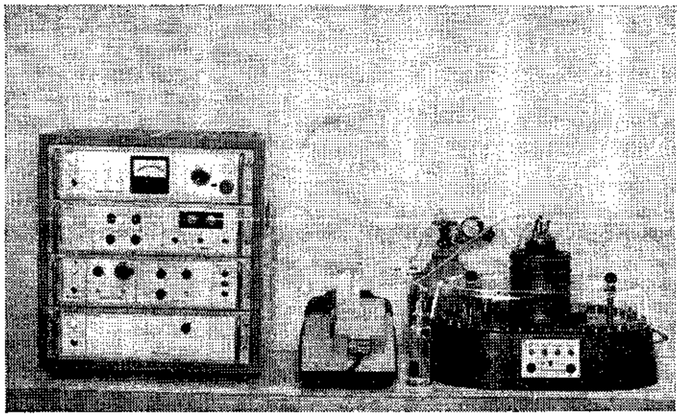

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