CERN COURIER

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European Organization for Nuclear Research

Cover photograph : Signature in Moscow of the Agreement for collaboration at the Serpukhov Laboratory, USSR. On the left, the Director General, Professor B. Gregory, signs for CERN ; on the right, the chairman of the State Committee for the Utilization of Atomic Energy, Professor A. Petrosiants, signs for the USSR.

Comment

Contents

The Agreement concerning collaboration between European and Soviet scientists at the Serpukhov 70 GeV proton synchrotron was signed on 4 July. It provides the USSR Laboratory with the technical know-how and experience on fast-ejection systems and r. f. separators developed at CERN over the past few years, and provides scientists from CERN and its Member States with access for experiments to the highest energy accelerator in the world. The machine is scheduled to receive its first beams towards the end of this year and its physics programme will probably be under way about a year later.

The French government has already separately agreed (October 1966) to send to Serpukhov a very large hydrogen bubble chamber 6000 litres in volume, called 'Mirabelle', being developed at the Saclay Laboratory. Scientists from France will participate in the bubble chamber experiments with Soviet scientists. Together with the ejection system and the separated beam to be provided by CERN, this will eventually form one of the most important experimental set-ups at the Institute for High-Energy Physics.

A few months ago, the US Atomic Energy Commission also approached the Soviet authorities concerning the possibility of physicists from America taking part in the experimental programme at Serpukhov. So far, no official statement has been made from either side about the progress of this inquiry.

Free exchange of information between high-energy physics Laboratories throughout the world has always existed. The results of the experimental work are published and are freely available. The major conferences in this field are held in Europe, the Soviet Union and the USA. Also for many years, there has been exchange of scientists between Soviet Laboratories, particularly Dubna, and CERN (and between Soviet Laboratories and other Laboratories in the Member States). Up to now, these exchanges have been on a fairly small scale and have been conducted under purely verbal agreements covered by a simple exchange of letters.

The Serpukhov collaboration is a great development of this relationship and has resulted in the drawing up of a formal Agreement. Having access to the 70 GeV machine over the next few years will ensure that European scientists can continue to use the most advanced experimental facilities for their research. In addition, collaboration between scientists from different parts of the world can have benefits which transcend the purely scientific.

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CERN, the European Organization for Nuclear Research, was established in 1954 to '... provide for collaboration among European States in nuclear research of a pure scientific and fundamental character, and in research essentially related thereto'. It acts as a European centre and co-ordinator of research, theoretical and experimental, in the field of sub-nuclear physics. This branch of science is concerned with the fundamental questions of the basic laws governing the structure of matter. CERN is one of the world's leading Laboratories in this field.

The experimental programme is based mainly on the use of two proton accelerators — a 600 MeV synchro-cyclotron (SC) and a 28 GeV synchrotron (PS). At the latter machine, large intersecting storage rings (ISR), which will allow experiments with colliding proton beams to be carried out, are under construction. Scientists from many European Universities and national Laboratories as well as from CERN itself take part in the experiments and it is estimated that some 700 physicists outside CERN are provided with their research material in this way.

The Laboratory is situated at Meyrin, Canton of Geneva, Switzerland. The site covers approximately 80 ha about equally divided on either side of the frontier between France and Switzerland. The staff totals about 2300 people and, in addition, there are over 400 Fellows and Visiting Scientists.

There are thirteen member States participating in the work of CERN. The contributions to the cost of the basic programme, 172.4 million Swiss francs in 1967, are in proportion to their net national income. Supplementary programmes cover the construction of the intersecting storage rings and preliminary studies on a proposed 300 GeV proton synchrotron for Europe.

Collaboration with Serpukhov

On 4 July, Professor A. Petrosiants, Chairman of the State Committee of the USSR for the Utilization of Atomic Energy, and Professor B. Gregory, Director General of CERN, in the presence of the President of the Council, Dr. G. Funke, signed an Agreement in Moscow concerning scientific and technical co-operation at the 70 GeV proton synchrotron, being built in the USSR. This machine, at the Institute of High-Energy Physics, Serpukhov, will be for several years the highest energy accelerator in the world.

Discussions on the possibility of this collaboration were initiated by Professor V. F. Weisskopf in his last year, 1965, as Director General of CERN. Throughout 1966, talks continued between the two parties and at its meeting in December 1966, the CERN Council authorized the Director General to proceed, in conjunction with the Soviet authorities, to the stage of drawing up a draft Agreement. This was presented to the Council in June 1967 when authorization to sign the Agreement, after some further negotiation on a few points, was given.

The main features of the Agreement are as follows :

1. CERN will provide a fast-ejection system for the Serpukhov accelerator which will become the property of Serpukhov. CERN will be responsible for the design, construction, testing and installation of the system (including its magnets, their vacuum tanks, and the associated supplies and controls) and for commissioning the fast-ejected proton beam at the accelerator.

2. CERN will provide radio-frequency particle separators which will be used at Serpukhov for at least ten years. CERN will be responsible for the design, construction, testing and installation of these items of beam-line equipment and for commissioning at the accelerator.

For the extraction system and the separators, the Soviet authorities will make available all the necessary technical information, will set up at the Institute the buildings and supplies of electricity, cooling water etc., and will provide general services such as workshops and stores. In addition, it will be the responsibility of the Institute to operate the accelerator and provide the beams which are necessary for the joint programme.

The principles of fast-ejection systems and radio-frequency separators are briefly described below.

3. CERN will have the right to propose a succession of electronics experiments to be incorporated in the experimental programme at the 70 GeV machine. One experiment of this type (involving the use of electronic counters and spark chambers) will be started in the first year of the physics programme by a mixed team of scientists from CERN and its Member States and scientists from the Soviet Union. This will be a tested experiment, previously run at CERN at lower energy. Further joint electronics experiments will follow, with one experiment at a time installed at the synchrotron.

Proposals for these experiments will be submitted to the Scientific and Technical Council of the Institute for High-Energy Physics. This Council is equivalent to the Nuclear Physics Research Committee which takes the decisions on all the proposals for experiments coming from European centres to be incorporated into the experimental programmes of the two accelerators at CERN. Scientists from CERN will be present, as consultants, at the meetings of the Scientific and Technical Council which discuss the joint programme.

4. CERN and the Institute for High-Energy Physics will collaborate in bubble chamber physics. Soviet scientists may join teams working in this field at CERN in the immediate future in preparation for the start of bubble chamber physics at Serpukhov. When bubble chambers come into operation at Serpukhov, CERN scientists will participate in joint teams analysing the pictures. Some of the pictures will be sent to CERN and then to Laboratories in the Member States for analysis. In the first years of operation of the 70 GeV machine, the main bubble chamber will be 'Mirabelle', a large hydrogen chamber being provided by France which is being developed at the Saclay Laboratory. Joint teams of French and Soviet scientists will take part in the bubble chamber programme and CERN scientists may also join these teams.

The results coming from the joint teams, for both electronics and bubble chamber experiments will be published jointly under the names of the Institute for High-Energy Physics and CERN and, where French scientists are also involved, of the Commissariat à l'Energie Atomique (CEA).

The Agreement will remain in force for a period of five years from the date at which the fast-ejection system and the r. f. separated beam come into operation. From then on, it will be extended automatically for periods of one year unless either side gives six months notice of its wish to end the collaboration.

The Director of the High-Energy Physics Institute and the Director General of CERN will be advised by a Scientific Committee of not more than twelve people in equal numbers from CERN and Serpukhov. This Committee will, for example, work out the scientific, technical and organizational programmes, and report the status of the joint experiments, in particular by producing an annual report.

The cost of meeting CERN's responsibilities under the agreement is estimated (in units of a million Swiss francs at 1967 prices) as 0.5 for 1967 ; 2.5 for 1968 ; 3 for 1969 and 3 for 1970. Beyond that date, a healthy level of collaboration is expected to cost about 5 million Swiss francs a year. The required sums for 1967, 8 and 9 have already been incorporated in the forward budgets for these years presented to the CERN Council at its December 1966 meeting.

Some footnotes :

The Serpukhov Institute for High-Energy Physics is situated some 100 kilometres south of Moscow.

The project for the 70 GeV machine started under the guidance of the Moscow Institute of Experimental and Theoretical Physics and work began on the site in 1960.

The accelerator design was done at the Research Institute for Electro-Physical Equipment in Leningrad. It is a strong-focusing machine, 470 metres in diameter, accelerating protons to energies of 58 to 70 GeV. The total weight of silicon steel in the main magnet ring is 20 000 tons, plus 700 tons of aluminium coils which receive a peak power of 100 MW to give a peak field of 12 kilogauss. Injection energy is 100 MeV. The vacuum chamber has a cross-section of 17 x 11.5 cm. The design intensity is 2 to 3 x 10^{12} protons per pulse (beams of around 10^{11} are expected in the early months of operation) with 5 to 10 pulses per minute.

One very large experimental hall (150 x 90 m^2), with no internal supports, has been built across the ring. The bubble chamber Mirabelle will be in a separate building several hundred metres away to which the beams will be guided through a long gallery containing the radio-frequency separators.

More detailled information can be found in CERN COURIER vol. 6, page 69.

Fast-ejection systems

A fast-ejection system was first brought into operation on the CERN 28 GeV proton synchrotron in May 1963, and there are now three such systems in use (one serving the 2 metre hydrogen bubble chamber, one serving the muon storage ring, and one serving the neutrino beam-line).

Fast-ejection implies the ejection of all or part of the orbiting proton beam in times of the order of a microsecond. When all the beam is ejected the process is also called 'single-turn ejection' since the circulating beam is deflected out in one turn of the beam in the ring. The system on the CERN machine involves the use of two special magnets, installed in straight sections inside the vacuum system of the ring, and of pulsed beam-transport magnets in the ejected proton beam-line.

The first magnet is a fast kicker magnet (FK in Figure 1) which is plunged mechanically into position around the circulating beam at the end of the acceleration cycle when the beam has focused to a small cross-section. The magnet is then powered so that it deflects the beam slightly, into the aperture of the second magnet which is called the fast ejection magnet, FEM. This further deflects the beam clear of the magnet ring into the beam-line. There, a series of pulsed quadrupole focusing magnets and pulsed bending magnets (the units FQ and FM in Figure 1) guide the beam to its target.

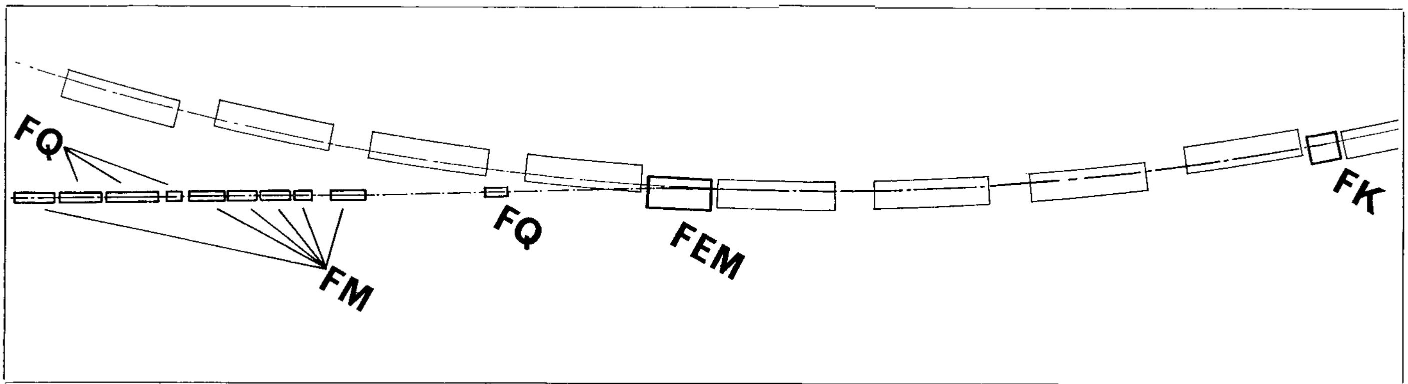
The radio-frequency acceleration system in the synchrotron causes the proton beam to orbit in twenty discrete bunches equally spaced around the ring with time intervals of about 0.1 microsecond between each bunch. When the technology of the fast kicker magnet and its associated electronics developed so that the magnet could be switched on in a time less than 0.1 microsecond, it became possible to achieve efficiencies approaching 100 % from the fast-ejection system. This is because it is possible to allow one bunch of protons to pass the magnet, then switch it on and, with the extremely fast rate of rise of the pulse, have it at the correct magnet field level to bend the next bunch into the fast ejection magnet. In principle, just one fast kicker magnet could do the job of bending the protons completely out of the ring, but this would involve switching on too powerful a magnetic field in such a short time for existing techniques to cope with.

The fast ejection magnet sits clear of the normal beam orbit and is constructed with a 'septum', which is a very thin plate (a few millimetres thick) across the mouth of the magnet gap which prevents stray field from the magnet disturbing the orbiting protons. It is therefore the job of the fast kicker magnet to deflect the protons from one side of the septum, where they do not feel the field of the fast ejection magnet, to the other, where a high magnetic field bends them out of the ring.

In 1964, the techniques to switch off the fast kicker magnet in the time between the

Figure 1 : Elements of a fast-ejection system.

Figure 2 : Schematic diagram of the mode of operation of a radio-frequency separator.



passage of successive bunches of protons were developed. This makes it possible to eject a selected number of bunches leaving the rest orbiting the ring to be used for other purposes. This use of the fast-ejection system is known as 'partial turn ejection'.

For fuller descriptions of fast-ejection systems see CERN COURIER, vol. 3, page 79 and vol. 5, page 148.

Radio-frequency separators

In January 1965, radio-frequency separators for high-energy particles were brought into operation at CERN for the first time in the world. Their purpose is to sift out a particular type of particle at a particular momentum, from the spray of many types of particle, which is produced when a high energy proton beam is incident on a target. Electrostatic separators had been used for this purpose for many years (and are still used) but the radio-frequency type has considerable advantages for beams of high momenta.

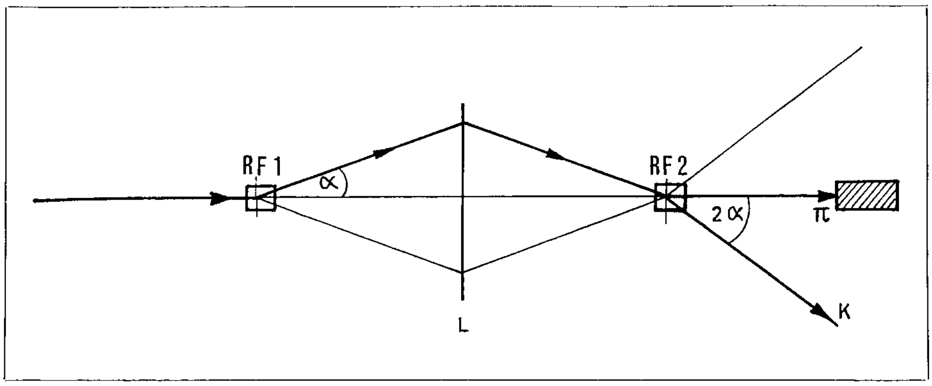
Their mode of operation can be briefly described as follows. Initial momentum selection is done by focusing and bending magnets but for some experiments, such as bubble chamber experiments which require a high momentum beam of kaons, the wanted particles can be swamped by a large number of unwanted ones having the same momentum (magnets sort out momentum, which is mass multiplied by velocity, but do not distinguish velocity or mass separately). Particle separators are then used to select the required particles of a particular mass by only allowing those with a particular velocity to remain in the beam.

The electrostatic type uses strong electric fields to achieve this second stage of separation but as velocities increase, because of relativity effects, many such separators are needed to give a reasonably pure beam. The new technique of r. f. separation involves basically a sensitive timing device, which ensures that only those particles covering a fixed distance at the correct velocity can stay in the beam.

Figure 2 shows the separation procedure for pions and kaons. In the first radio-frequency cavity, RF1, the incoming particles experience on an electromagnetic field deflecting them in the vertical plane through an angle α. Some tens of metres further along the beam-line, a second cavity, RF2, receives the particles focused by a magnetic lens system, L. Because of the slight velocity difference between the pions and the kaons, it can be arranged that the pions arrive when the electromagnetic field in RF2 is in the opposite sense to that which they experienced in RF1, and the pions are therefore deflected back through an angle α to be intercepted by a beam stop. The kaons arrive when the field is in the same sense and receive a further deflection, emerging at an angle 2α to the axis, to be collected into a pure kaon beam.

In the first CERN r. f. separator, each cavity was fed with 20 megawatts of power in pulses 8 microseconds long. The frequency was 2855 MHz corresponding to a wavelength of 10.5 cm. For the field to reverse between the arrival of a pion and a kaon, the pion must be 5.25 cm in front of the kaon at the second cavity. The precision of the device can be seen from the fact that the pion takes less than 0.000 000 2 seconds to cover the intervening distance between the two cavities.

A fuller story on radio-frequency separators appeared in CERN COURIER, vol. 5, page 35.



CERN News

Study on CERN Library use

With the coming spread of CERN's activities on to the new French site, various services available to the personnel will have to be extended and located so as to best serve the whole enlarged area. One of these services is the Library, with its related activities, and the Library Committee has recently set up a 'Working Party on future policies of CERN's Scientific Information Service' to enquire into its future. The Working Party, which brings together Library users and Library staff under the chairmanship of Prof. L. Kowarski, has as its first task the study of the future type and distribution of reading rooms on the site and the location of the main holdings of books and periodicals.

A necessary part of this study is a re-appraisal of the scope of the Library and the relative weights to be given to the central field of interest (high-energy physics) and the more peripheral fields (such as chemistry, astrophysics, computer science, questions of managements etc.). Other tasks of the Working Party will be concerned with more extensive use of computer techniques in the various operations of the Scientific Information Service, as well as the position of CERN in relation to developments elsewhere in information retrieval.

It is hoped that the full recommendation of the Working Party can be presented before the end of this year ; preliminary answers to the first part of the study will be available earlier. As part of this study, a questionnaire was circulated at the end of June to a widely defined spectrum of actual and potential users of CERN's library facilities with the aim of establishing more precisely the present user pattern, including the proportion of people in particular groups who in fact *do not* use the Library, and whether this proportion is in relation to the services available.

The Working Party intends to use the replies to this questionnaire as a basis for its recommendations on Library scope and siting. At the same time, it recognizes that the smaller the response, the less accurate the conclusions that can be drawn (does a missing reply denote a non-user of the Library or an extensive user who did not send back the questionnaire ?), so that a high proportion of replies is being eagerly awaited. First indications were favourable (in the first ten days after the Questionnaire was mailed, about 500 replies were received) ; more replies are expected to come in, thus bringing the response closer to a truly significant expression of the users' opinions.

CERN/PI 252.5.67

The r. f. power amplifier with its auxiliary equipment (transformer, rectifier and heat-exchanger) connected for tests to one of the new test cavities via a rectangular, symmetrical feeder 17.5 m long.

New r.f. cavities

In the May issue (page 87) we reported the arrival of the motor-alternator set which will increase the repetition rate of the proton synchrotron by a factor of two or three. The new power supply enables the rate of rise of the magnetic field in the synchrotron ring to be doubled and, to make full use of the consequent increase in repetition rate, the addition of extra radio-frequency cavities to the ring is being studied.

The new cavities are very different in design to the existing cavities. In order to fit into short straight sections, their axial length is limited to 1 m, and they have the maximum diameter, 2.4 m, which can be accommodated with the height of the beam path over the floor of the ring tunnel. The cavities would come into operation 80 ms after injection, at the second harmonic of the acceleration frequency, and would make it possible to accelerate the protons twice as fast during most of the rise-time of the magnet field.

To study the interaction between the proton beam and a 'high-Q' cavity of the new type, a test cavity, tuned to 19 MHz, has recently been installed in the synchrotron ring. Measurements which were carried out with the cavity connected to its damping network showed no effect on the beam. However, the importance of such studies for the future is evident from the measured value of about 30 kV which was induced in the unloaded cavity (i.e. without its damping network) by a beam of 10^{12} protons. This would correspond to about 300 kV induced by a beam of 10^{13} protons, and beams of this intensity are scheduled in the second stage of the improvement programme.

CERN in summer. A view of the main building taken from outside the restaurant.

CERN/PI 348.6.67

A prototype r.f. power amplifier, intended for laboratory tests with the 19 MHz cavity has been delivered by Brown Boveri and Co., and is installed in the Ejection Building. This amplifier works in the frequency range of 17.2 to 19.1 MHz. The peak power dissipation amounts to 680 kW, whereas the average power is about 100 kW. The amplifier is being run-in in preparation for its acceptance tests.

ISR Magnet Core Contract

The contract for the production of the steel cores of the main magnets of the intersecting storage rings has been authorized to go to the firm ASGEN, Italy, with ITALSIDER, Italy, as subcontractor for the steel. The value of this contract is just over 17 million Swiss Francs.

The two intersecting storage rings, which have an average diameter of 300 metres, will each consist of two kinds of magnet core, a focusing type and a defocusing type (96 of each per ring). Their purpose is to hold the proton beams to effectively constant orbits in the rings and to maintain a focusing effect to prevent the beams dispersing.

The stringent requirements of beam storage impose very tight tolerances on the magnetic field configuration across the magnet aperture and from one magnet unit to another. The fields at corresponding points of the apertures of the various magnet units in one ring must be the same to 0.05 %. These restrictions apply over the range of magnetic field levels that might be required (corresponding to various energies of the stored beams).

The field configuration is determined by the geometric shape of the magnet pole profiles and by the magnetic characteristics of the steel. To keep within the specified tolerances for the magnetic field, the pole profiles must be punched with an accuracy of 0.015 mm and the average magnetic permeability of the steel cores must be very uniform (e. g. to within 2 % at 15 kilogauss).

The magnets will be constructed of low carbon steel laminations, 1.5 mm thick, punched by a precision die and welded together. To achieve the specified degree of uniformity between the different magnets, each one will be made up of laminations from batches of steel coming from all parts of the delivery.

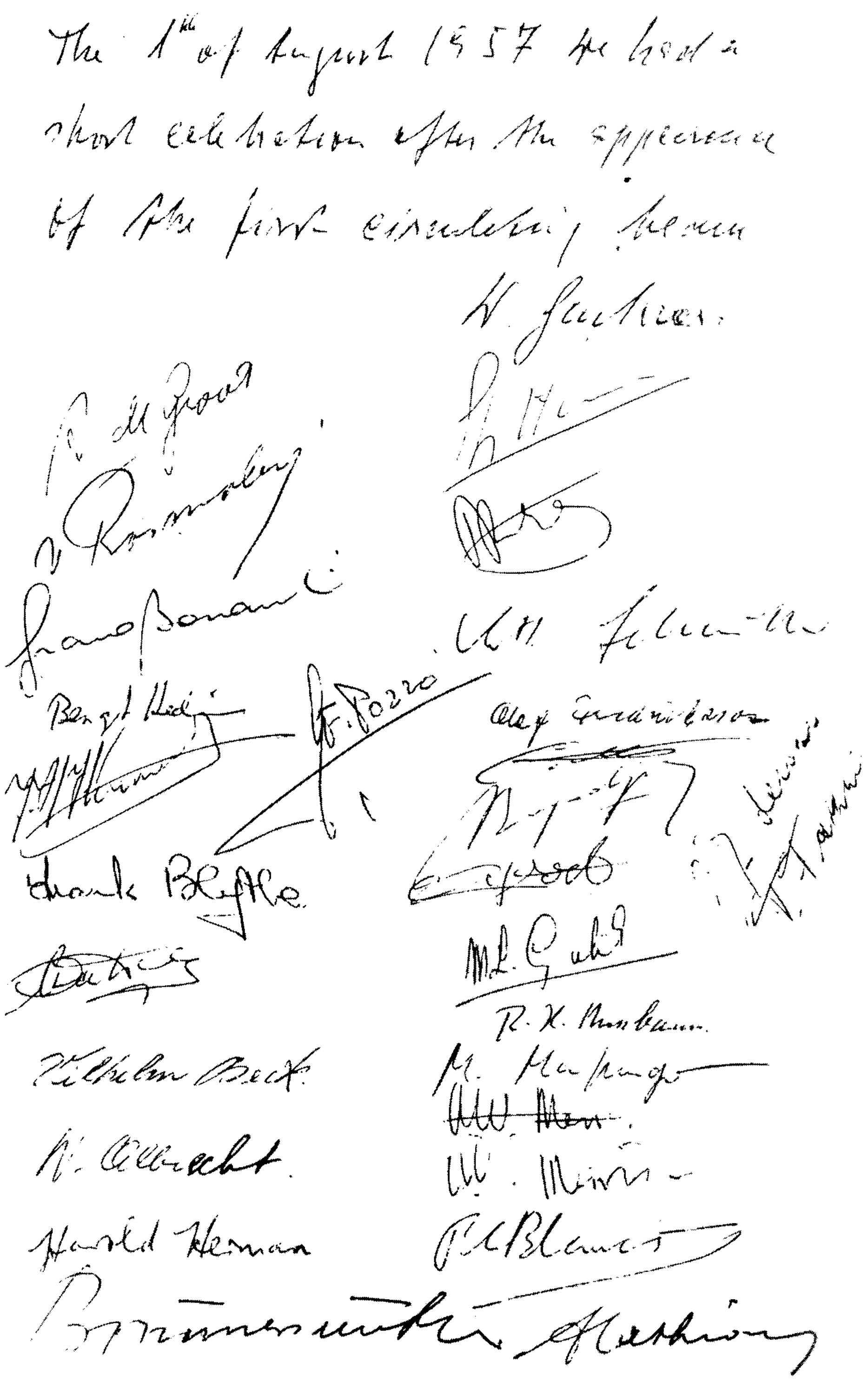
In the tendering process, many firms in the Member States were contacted and tenders were received from 8 manufacturers with 6 steelmakers as potential sub-contractors. The contract was finally authorized at the meeting of the Finance Committee on 13 June.

Visits to Russia

In the latter part of June and in early July, about a dozen CERN scientists visited the Soviet Union. First of all, Dr. Goldschmidt-Clermont and Dr. Winter went to the Institute of Professor Budker at Novosibirsk. They then went to Serpukhov where they were joined by Professor Cocconi and Drs. Kuiper, Lazeyras, Lengeler, Lock and Ramm for several days of discussions with Professor Logunov and his colleagues on all aspects of the collaboration now being established between CERN and the High-Energy Physics Institute.

Some of the group then returned to Geneva, while the remainder travelled on to Riga (Latvia) where they were joined by the Director General, Professors Bethelot (Saclay), Citron (Karlsruhe), Van Hove, and Dr. de Raad, for a meeting of senior scientists organized by the Joint Institute for Nuclear Research, Dubna. Three days were spent discussing the future perspectives in high-energy physics with particular reference to CERN, Dubna and Serpukhov. The Soviet participants included Professors Bogolubov (Director of Dubna), Blokhintsev, Dzhelepov and Pontecorvo.

After this meeting, the Director General with four other colleagues from CERN went to Leningrad where they visited the Electro-physics Institute (Komar) of the State Committee for the Utilization of Atomic Energy, which is responsible for the design and construction of most of the accelerators in the Soviet Union. The Director General then flew to Moscow where he was joined by Mr. Hampton for the signing of the Agreement on collaboration at Serpukhov. (See the article on page 123.)


The 1st of August 1957 we had a short celebration after the appearance of the first circulating beam

W. Gentner

Ten years ago

A reproduction of a page from the logbook of the 600 MeV synchro-cyclotron recording the first circulating beam on 1 August 1957. The entry is by Professor W. Gentner, who was then Head of the Synchro-cyclotron Division, followed by the signatures of many of those who contributed to the construction and commissioning of the first CERN accelerator.

Vacation students

Once again this year some 100 students have chosen to spend their summer vacation working at CERN. For times varying from two to four months they will mingle with the CERN personnel, studying physics problems, taking part in an experiment and following a series of lectures, instead of sun-bathing on a beach at the seaside.

The students come from the 13 Member States of CERN and were carefully chosen from over 350 who applied. They have all spent at least three years at University specializing in physics, electrical engineering, electronics or mathematics. During their stay they join one or other of the Divisions : proton synchrotron, synchro-cyclotron track chambers, nuclear physics apparatus, storage rings, data handling and health physics where they will be involved in the everyday work. They can, in particular, take part in the development and use of the experimental equipment, become familiar with the use of electronic computers and work on the new accelerator projects.

This annual invasion is not designed to step up the output of work from CERN but rather to give the young university students the opportunity to gain experience in the field of their studies, to learn to work in a team, to have some foretaste of their future careers in research laboratories and in industry.

In addition, the students have the chance to attend a series of lectures and special courses given by CERN specialists including some of the Directors of Departments and Division Heads, on subjects such as computer programming, accelerator technology, theoretical physics, experiments in sub-nuclear physics, etc...

In this way, the 100 vacation students will take part in the life of a big laboratory such as CERN, and will be able to improve their theoretical grounding through the lectures and their practical experience though their work in the different Divisions which receive them.

Safety at CERN

A brief description of the work of the Safety Group.

The use of dangerous reactive products, such as liquid hydrogen and propane, and the use of a great deal of high voltage equipment is so much a part of the daily work of CERN that it is surprising, though very reassuring, that there are practically no serious accidents.

The main reason is that great importance is attached to safety at CERN and every attempt is made to reduce the risk of accident to a minimum.

By its statutes, CERN is not subject to control by outside authorities with respect to safety, and must, therefore, take every precaution to guarantee the safety of its employees.

That is why there has been, since the beginning of 1962, a specialized service — the Safety Group — whose task it is to ensure that safety never takes a back seat.

The Safety Group is directly responsible to the Directorate so that it has greater freedom of action. The Director of the Administration Department has two main representatives to help him in matters of personnel safety : the Safety Group and the Health Physics Group. The latter is concerned exclusively with safety questions connected with radiation. Its task is to assess the risks, to make sure that the permissible doses of radiation are not exceeded, to develop control methods, to control entry into dangerous areas and to keep a check on the radiation doses received by personnel, by means of film badges and medical examinations.

The Safety Group on the other hand takes care of all the other questions concerned with safety at CERN. It acts in a sense as 'Advisor' to the Organization in matters concerning :

- general safety in workshops and laboratories,
- the use of pressure vessels,
- risks of fire, explosion and poisoning,
- the use of hydrogen and propane,
- electrical installations.

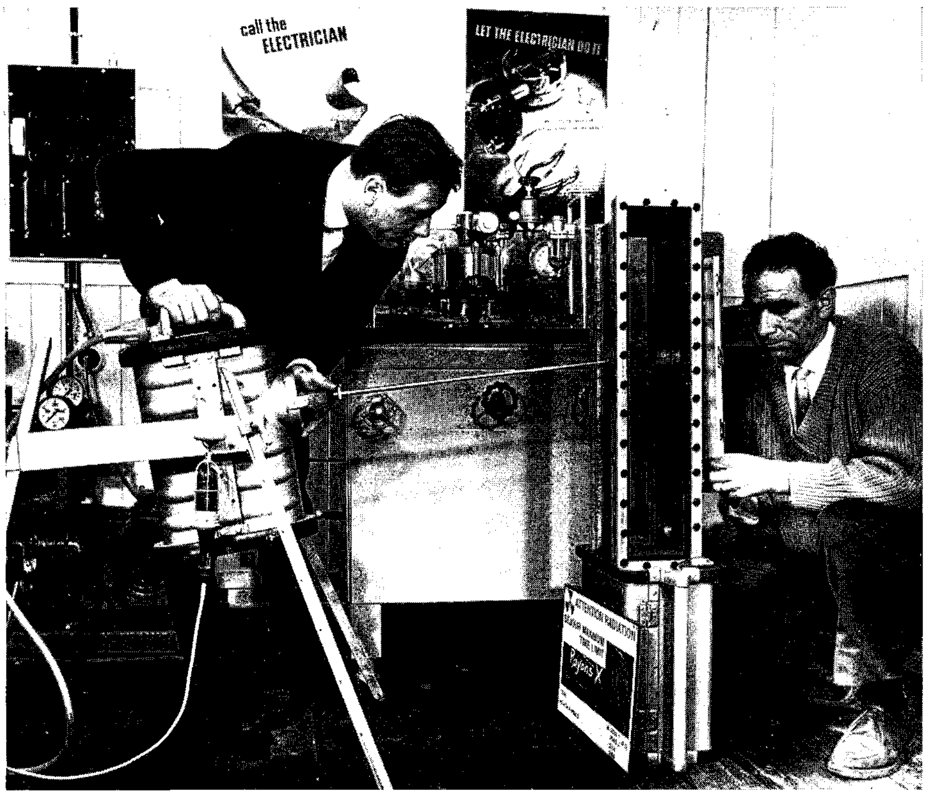
The Group is divided into three main sections. The industrial section has five engineers carrying out daily tours of inspection in order to prevent accidents (particularly by electrocution). The section works in close co-operation with the Technical Services and Buildings Division and also with the safety officers in the various sections.

The inflammable liquids section has two engineers who, with the help of specialists in the Divisions which use these liquids, check the installations and their surroundings before each experiment. Work involving the use of liquid hydrogen or propane requires constant supervision to remove, as far as possible, any risk of accident. In co-operation with the hydrogen safety officers and monitors, the section tries to eliminate any danger from leaks or sparks which could cause an explosion. Regular inspections are carried out. In the event of leakage, hydrogen detectors automatically cut off the electricity supply and start a powerful ventilation system in the area which has been contaminated. Moreover, the electrical apparatus in these areas is designed so that it cannot produce a spark.

The third section is responsible for the inspection of installations and equipment. Three engineers and two technicians carry out checks on new apparatus (both at the design stage and on receipt of the actual equipment), on all apparatus in use and on all the work done at CERN or outside firms for CERN. This section also carries out investigations on equipment for special uses.

It is easy to see that the greatest risks arise in the use of inflammable liquids and of high voltage equipment. For this reason, without neglecting the other risks, a particular effort is made in these two sectors.

In conclusion, two figures are rather significant :
in 1961 there were 2 accidents for 100 000 hours of work
in 1967 so far there have been 0.35 accidents also for 100 000 hours of work.



A 200 kV x-ray machine, on the left, being used by members of the Safety Group for non-destructive testing of a Mylar beam window. On the right of the 'window' the x-ray film holder is being adjusted.

CERN/PI 35.1.64

Status report on high-energy physics research

A summary of the talk given by Professor L. Van Hove to journalists from many European countries at a Press Seminar on 2 June.

The main objectives of high-energy physics research are the study of matter and interactions on the sub-nuclear scale, corresponding to dimensions shorter than 10^{-13} cm. This field of physics is dominated by the fact that, at this scale, matter exists in the form of a great variety of particles (often called 'elementary particles'), most of which are highly unstable with life-times between 10^{3} and 10^{-22} seconds, decaying into more stable daughter particles. High-energy physics is at present concentrating its efforts on the study of these particles, their decay modes, and the interactions which they undergo when they collide with each other.

The number of known particles has increased rapidly in recent years and is approaching 200. Despite this proliferation of particles, our understanding of their properties has made very considerable progress through the fact that basic rules of classification have been found.

In contrast with the number of particles, the number of basic interactions has not increased in the last 30 years. Now as then, sub-nuclear physics is dominated by three interactions: the strong, the electromagnetic, and the weak. The symmetry or invariance properties of these interactions (i.e. the quantities which do not change when particles are subject to these interactions in collisions or in decays) have gained an ever increasing importance in our understanding of sub-nuclear physics.

Strong interactions

It is in the field of strong interactions that the proliferation of new particles has occurred. Most of the new particles are so-called 'hadrons', i.e. particles participating in the strong interactions. Hadrons are either mesons (which have spin 0, or 1, or 2,... ; examples are the pion, the kaon, the rho meson, ...), or baryons (which have spin 1/2, or 3/2, or 5/2 ... ; examples are the proton, the neutron, the lambda hyperon, the N* resonance, ...), or antibaryons which are the antiparticles of the baryons, (the antiparticles of mesons are again mesons).

In recent years, powerful schemes of classification have been developed, and all the indications are that they have a fundamental significance. The following classification principles have been discovered :

a) isospin and strangeness
b) SU(3) symmetry, which combines isospin and strangeness ; it groups particles in octets, nonets, decuplets and possibly also in higher multiplets
c) combination of SU(3) symmetry and spin, which groups together several SU(3) multiplets with different spin values (for example, the baryon octet of spin 1/2 is grouped with the baryon decuplet of spin 3/2 ; the odd parity meson nonet of spin 0 is grouped with that of spin 1). This combination of SU(3) and spin is often described as SU(6) symmetry : it is unlikely to be a genuine symmetry, however, because it conflicts with relativity ; it is much more likely to be a dynamical structure property of hadrons
d) another classification according to spin alone which seems to emerge in recent findings. It states that particles can be grouped in so-called 'rotational series' or 'Regge series' The particles in a series differ only by their spin, which has values J, J + 2, J + 4, ... ; all their other properties are the same
e) remarkable indications of structural properties common to mesons and baryons. They make it possible to calculate meson properties starting from baryon properties (for example, the decay rate of the omega meson into a neutral pion and a gamma can be calculated from the magnetic moment of the proton).

There is a simple and surprisingly successful 'mechanistic model' which gives a compact description of all the above classification properties. It is the quark model, quarks being so far purely theoretical objects which are supposed to carry the most important properties of meson and baryons. In this model, a meson would be composed of a quark and an antiquark, a baryon of three quarks, and an antibaryon of three antiquarks. The main properties of mesons and baryons are well approximated by saying that they are the sums of the corresponding properties of their constituant quarks. It is not yet known whether quarks can exist free, i. e. not bound with other quarks in mesons or baryons. Free quarks would be characterized by the remarkable property of having fractional electric charges ($\pm$ 1/3 or $\pm$ 2/3). The search for quarks will continue on present accelerators and, more hopefully, on future machines of higher energy.

A large number of high-energy experiments aim at discovering new hadrons and at establishing their properties, especially the decay modes of the known hadrons. Most bubble chamber experiments contribute to this research. Among electronic experiments, a new and powerful method, known as the missing mass method, has been found to search for new hadrons. (See CERN COURIER vol. 7, page 31.)

The strong interactions which occur between hadrons when they collide with each other, form the second very important field of strong interaction research. It is now known that a remarkable simplicity of principle regulates the high energy collisions of hadrons which are of two-body type, i. e. in which only two particles come out of the collisions. All the principles above, which are the basis of hadron classificaton, form also the basis for the analysis of two-body collisions. This study requires :

(i) a systematic comparison between collisions of various hadrons,
(ii) a systematic study of the energy variation of a given collision over wide energy intervals.

The work of type (i) is done extensively around high energy proton synchrotrons and uses the many secondary beams (such as pion, kaon, and antiproton beams). These experiments also make it possible to study point (ii), but the energy interval available (up to about 30 GeV) turns out to be narrow for the effects to be measured. The study of point (ii) for proton-proton collisions will be one of the important experimental programmes on the intersecting storage rings being built at CERN. A similar study for other collisions will require much larger synchrotrons than are now available. Experiments of type (i) are carried out both with bubble chambers (for common collisions) and with counter and spark chamber arrangements (for rare collisions or for high precision work).

Electromagnetic interactions

A distinction needs to be made between the electromagnetic interactions of the electron, the muon and their antiparticles on the one hand, and the electromagnetic interactions of hadrons on the other. For the first category, an extremely accurate theory exists called 'quantum electrodynamics'. Up to now, it has been found to agree with experiment to extremely high precision, often better than one part in ten thousand. Further tests of quantum electrodynamics are under way in many high-energy physics Laboratories, using either electrons or photons coming from electron accelerators, or muons coming from proton accelerators via the decay of pions. A high precision experiment of this sort is now going on at CERN involving the measurement of the magnetic moment of the muon. The present precision is of the order of one part in a million. If it can be pushed further by about a factor 10, one may be able to reach the true limit of pure quantum electrodynamics, namely the very small effects through which the existence of hadrons are theoretically expected to affect the properties of the muon, the electron, and the photon.

The electromagnetic properties of hadrons pose completely different problems because of the virtual effect of the strong interactions. Whereas electrons and muons, which are not subject to strong interactions, behave as point electric charges, the hadrons have their electric charge smeared out in space and carry electric currents smeared out in a similar way. The systematic study of the electromagnetic properties of hadrons proceeds through various measurements, such as electron scattering on protons or neutrons, measurement of the magnetic moment of baryons, detection of electromagnetic decay modes of hadrons, etc...

We know now that the hadron classification principles described above also allow us to correlate and predict many electromagnetic properties. For example :

i) from SU(3) symmetry, we can predict that the magnetic moment of the lambda hyperon is equal to —0.5 times that of the neutron. Existing measurements at CERN and Brookhaven agree with this prediction, but the error is still large. A new measurement has been undertaken at CERN

ii) as already mentioned the electromagnetic decay of the omega meson into a pion and a gamma is calculable from the proton magnetic moment. The experimental value agrees with the calculation.

Weak interactions

In weak interactions also there is a special class of phenomena where strong interaction effects can be neglected to very high precision. It concerns the weak interactions of electrons, muons and neutrinos. Since the discovery that neutrinos exist in two types, one associated with electrons and the other with muons, the main features of this type of interaction seem to be cleared up to a considerable degree. Only work of extremely high precision or at extremely high energies is likely to give further progress.

Weak interaction properties of hadrons, again due to the virtual effect of the strong interactions, are very complex. Nevertheless, recent progress, closely connected with SU (3) and SU (6) symmetries, has allowed us to classify and correlate many properties. Important relations have also been found between weak and electromagnetic properties of the hadrons.

Up till recently, weak interaction properties of hadrons could only be studied by investigating appropriate decay modes. But development of intense neutrino beams produced by proton accelerators has opened up a completely new field of experimentation. It is now possible to study directly the interaction of high energy neutrinos on protons and neutrons. The neutrino beam available at CERN even makes it possible to do this work in a bubble chamber, so that all the details of neutrino-induced collisions can be observed and measured. Radical increases in neutrino intensity and energy will be reached with the next generation of proton accelerators. One important theoretical speculation, concerning the possible existence of a so-called 'intermediate boson' which would mediate the weak interaction, has not been confirmed with present accelerators. It will have to be tested again with higher energy machines.

Finally, a class of problems of the greatest importance for weak interactions concerns their symmetry and invariance properties, especially under the transformation C of particle-antiparticle conjugation, the transformation P of space reflection, and the transformation T of time reversal. As is well known, C and P invariance are violated to a large degree by weak interactions, whereas the combined CP invariance is preserved to good precision. A fundamental experiment, carried out at Brookhaven in 1964, revealed a small amount of CP violation in the decay of the long-lived kaon into a positive and a negative pion. In 1966, CP violation was also shown to exist, first at CERN and soon afterwards at the Princeton accelerator, in another decay mode.

The discovery of CP violation in the kaon decay has led to many speculations concerning the possibility of similar violations in strong or electromagnetic interactions. The possibility of such violations gave rise to an extended experimental effort, especially at CERN. A major experiment, which was devoted to the eta meson decay, established CP conservation to a precision of 1 %, by far the greatest accuracy reached to date. While the eta meson experiment tests simultaneously the possibility of violations in the strong and electromagnetic interactions, an anti-proton-proton annihilation experiment has been carried out at CERN to test purely the strong interaction. The result is again that CP conservation holds to about 1 % precision.

The main tools required for weak interaction studies are very intense beams of appropriate particles, especially mesons, and detection and analysis methods capable of handling very high statistics and of measuring decay modes with high precision. Similar requirements are needed also for the study of many strong and electromagnetic properties. Hence the desirability of extensive improvement programmes for existing accelerators, such as have been started at Brookhaven and at CERN, and the necessity of powerful equipment for detection and data analysis.

News from Abroad

Professor Merrison (left) escorting the Prime Minister (centre) and Sir Harry Melville (right) around the magnet ring of NINA when the Daresbury Laboratory was formally opened.

An aerial view of the Daresbury Laboratory bounded on the north side by the Bridgewater canal. NINA is in the circular building and its adjoining experimental hall is the tallest building on the site.
(Photos Daresbury.)

Daresbury

The Daresbury Nuclear Physics Laboratory was formally opened on 16 June by the Prime Minister of the UK, the Rt. Hon. Harold Wilson.

The Laboratory houses a 4 GeV electron synchrotron, NINA, capable of very high beam intensity which produced its first full energy beam in December 1966, after a construction period of only three years (see CERN COURIER, vol. 7, page 12). The machine was put to use for physics almost immediately and by now teams from the Universities of Glasgow, Liverpool, Manchester, Lancaster and Sheffield are involved in the experimental programme.

Experiments include investigations on the photoproduction of neutral pions and eta mesons, and of neutral kaons ; elastic electron-proton scattering ; wide-angle electron and muon pair production ; inelastic electron-proton scattering, in particular, the electro-production of nucleon isobars.

In his speech at the Opening Ceremony, the Prime Minister paid tribute to the Director Professor Alec Merrison, and his staff for the speed at which the Laboratory became operational, and wished the Laboratory well in its future research programme. Professor Merrison has been seconded from the staff of Liverpool University to become Director of Daresbury, and he continues to lecture at the University. He spent several years at CERN in its early days (his signature can be found on page 128 among those celebrating the first beam in the synchro-cyclotron).

Referring to future support for sub-nuclear physics, the Prime Minister said that CERN had already proved successful, not only in its prime scientific purpose but as a manifestation of European collaboration in an advanced scientific field, and that the Government of the UK was giving most sympathetic consideration to the proposed project for a 300 GeV machine.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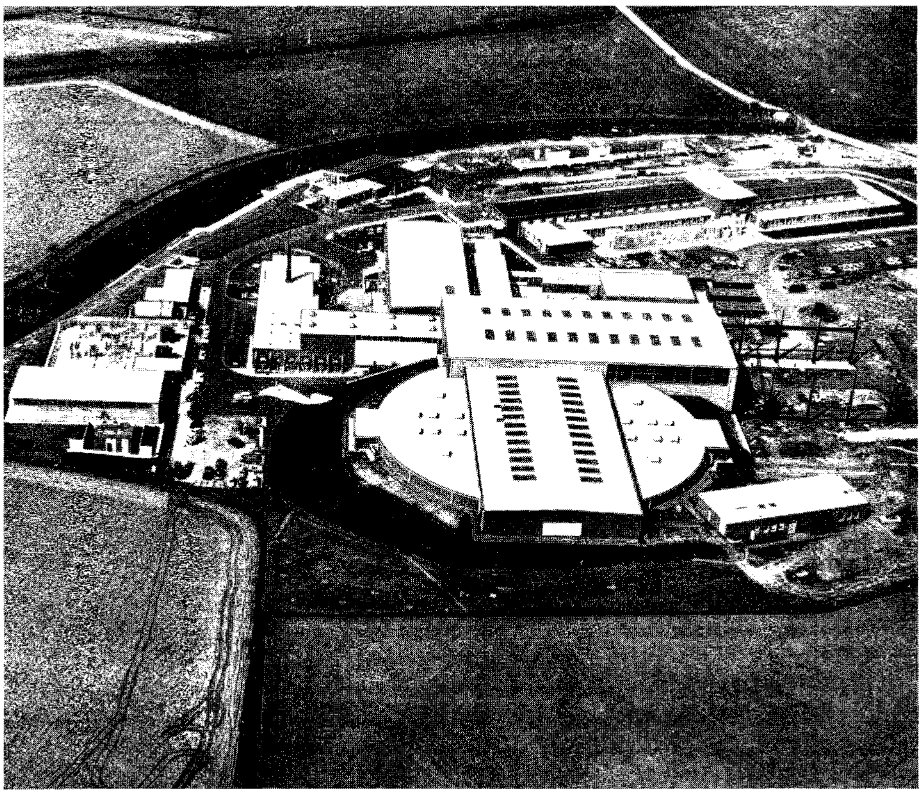
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DESY

It has been found necessary to change the vacuum chamber of the 6 GeV electron synchrotron at DESY, Hamburg, Federal Republic of Germany. The accelerator ring is 100 m in diameter with a vacuum vessel cross-section of 48 x 144 mm. The initial chamber material of organic resin has suffered radiation damage, causing high out-gassing rates in the vacuum chamber. A new chamber is being constructed of alumina ceramic.

Erevan

The 6 GeV electron synchrotron under construction of Erevan, USSR, is scheduled for completion in August.

Excavation work for the machine started in 1960. The ring vacuum chamber is 70 metres in diameter with a cross-section of 42 x 120 mm. There are 48 magnets (in FOFDOD sequence) and 24 accelerating cavities. Injection is at 50 MeV from a linear accelerator. The pulse repetition rate is 100 pulses/second. Hydrogen and heavy liquid bubble chambers and spark chambers, including a wide gap (30 cm) chamber, will be used in the experimental programme.

Weston

The Director, Professor R. Wilson, of the National Accelerator Laboratory at Weston, Illinois, USA, where it is intended to construct the 200 GeV proton synchrotron, has made several statements in recent months concerning the new accelerator and the Laboratory.

At a two day conference of accelerator builders and users organized at Argonne by the Universities Research Association (an association of 46 Universities in the USA who will manage the National Accelerator Laboratory), Professor Wilson stated that his approach to the accelerator construction will be as far as possible similar to that he has used in the construction of electron accelerators at Cornell University. He hopes to rely on a comparatively small staff at Weston itself with the minimum administrative structure. He also hopes to use the machine himself as an experimentalist. Professor Wilson has set up a Physics Advisory Committee, chaired by R. Cool from Brookhaven, to have the advice of the rest of the Physics community.

Design effort on the machine has started, working on a cost estimate of $ 240 million, with a reasonable amount in addition if it is decided to make provision for eventually going to higher energies (for example, an extra $20 million is estimated for the magnet ring, if provision for an increase in energy to 300 GeV is to be incorporated ; the design team will consider rings capable of up to 500 GeV).

Professor Wilson hopes for full authorization of the project for fiscal year 1969 ; authorization will be requested in Spring 1968. A construction period of 5 to 6 years, after full authorization, is anticipated. For fiscal year 1968, the US Atomic Energy Commission requested $10 million, but this request was regarded as being in some jeopardy because of the failure so far to achieve a guarantee of non-discrimination in housing at the Weston site. In fact, the Joint Congressional Committee on Atomic Energy, JCCAE, allocated $7.3 million which it believed to be sufficient to meet the first year capital requirements.

A sub-committee of the JCCAE has recommended that the design intensity be set at 3 x 10^{13} protons per pulse rather than 3 x 10^{12} proposed for budgetary reasons, and that the accelerator should have experimental areas which are consistent with the national scope and purpose of the machine. They also support careful study of the possibility of increasing the energy eventually to 300 GeV or higher.

Argonne

Construction of what will be the world's largest bubble chamber has started at the Argonne National Laboratory, USA.

The chamber will contain about 32 000 litres of liquid hydrogen in a tank of cylindrical construction with diameter about 4 metres. A superconducting magnet will give a field of 20 kilogauss over the useful volume and the optics will involve the use of a bright-field illumination system with Scotchlite on the interior walls.

The total cost of the project is estimated at $17 million. It is hoped to have the chamber ready for commissioning in 1969. It will be used at the 12.5 GeV ZGS (Zero Gradient Synchrotron) at Argonne.

Book Reviews

Unitary symmetries and their application to high-energy physics

by M. Gourdin (Amsterdam, North Holland Publishing Company, 1967, 110 sh.)

Of all the great theoretical ideas of recent years in elementary particle physics, the one which has met with the greatest success and which seems assured of a long life is certainly that connected with unitary symmetries. It may even be said that SU(3) has now become a habit with physicists and that whatever its future may be, some of it will surely remain at least in their manner of thinking. For the moment at any rate, no high-energy physicist can afford to ignore it ; the mathematician, the experimentalist, and the theoretical phenomenologist, each find a use for it.

So it was both natural and useful that a publication should appear to give a synthesis of the enormous amount of work on this subject in recent years. We are indebted to Professor M. Gourdin for having undertaken this task.

'Unitary Symmetries' is intended to collect together for the largest possible public, both the physical and mathematical aspects of unitary symmetries. The author has accentuated the physics side of the problem as can clearly be seen from the way the book is arranged. The first part, devoted purely to physics, takes up two-thirds of the book. The SU(3) group and its experimental consequences are dealt with in detail : classification of elementary particles, charge operators, formulae of mass, etc... Each of the three types of interactions, strong, electromagnetic and weak, is reviewed in turn : 3 and 4-body coupling (with an impressive number of formulae), decay of resonances, for strong interactions ; differences of electromagnetic mass, form factors, photoproduction, for electromagnetic interactions ; currents, leptonic and non-leptonic decays for weak interactions.

This first part, which in our opinion is the most useful, is followed by four rather concise chapters on the SU(6) group. This is dealt with in the same way as the SU(3) group : general remarks on the irreducible representations of the group and applications in physics. The relativistic extensions of the SU(6) group are not discussed.

The last third of the book is purely mathematical using modern formulations, and deals with Lie groups and Lie algebra. Logically, this should have been at the beginning, but the author's intention was above all to write a book on physics. Therefore, this part should be considered as a long appendix, which will probably disappoint the mathematician since it was not written for him, but which should help physicists to bridge the gap between difficult mathematical theories and their applications in physics.

This is therefore a reference book which will be useful to high-energy physicists, and to advanced students who have already a good grasp of group theory, especially the SU(3) group with which the reader is assumed to be familiar.

Ph. Salin

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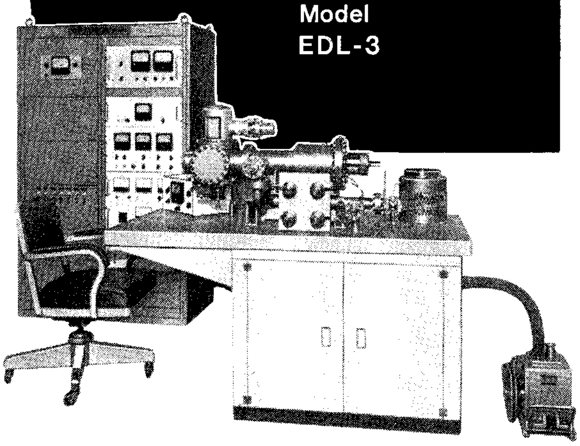

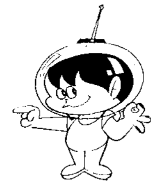

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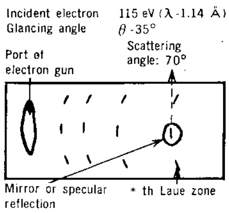
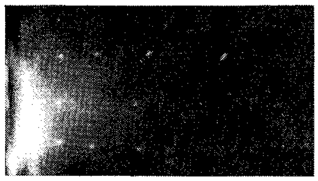


ZnS (01̄1) CLEAVAGED SURFACE


Typical example of diffraction pattern: ZnS (011̄)

Main Features:
* Observation over scattering angle, as wide as from 0° to 160° is feasible.
* Metal mesh grid and specimen holder do not obstract the diffraction pattern.
* Glancing angle is variable in wide range from 0° to 90°, azimuthal angle is also changeable.
* By using ULVAC excellent vacuum system, newly developed ULVION R PUMP PST-SERIES applied, 10^{-10} Torr is easily obtained in short pump-down time.

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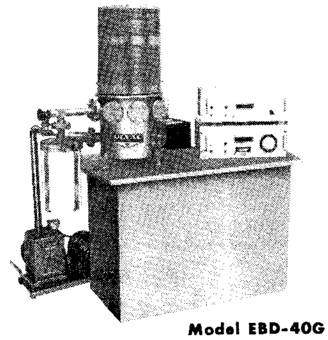
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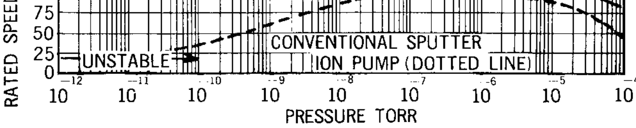

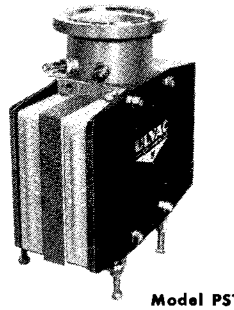
Model PST-4

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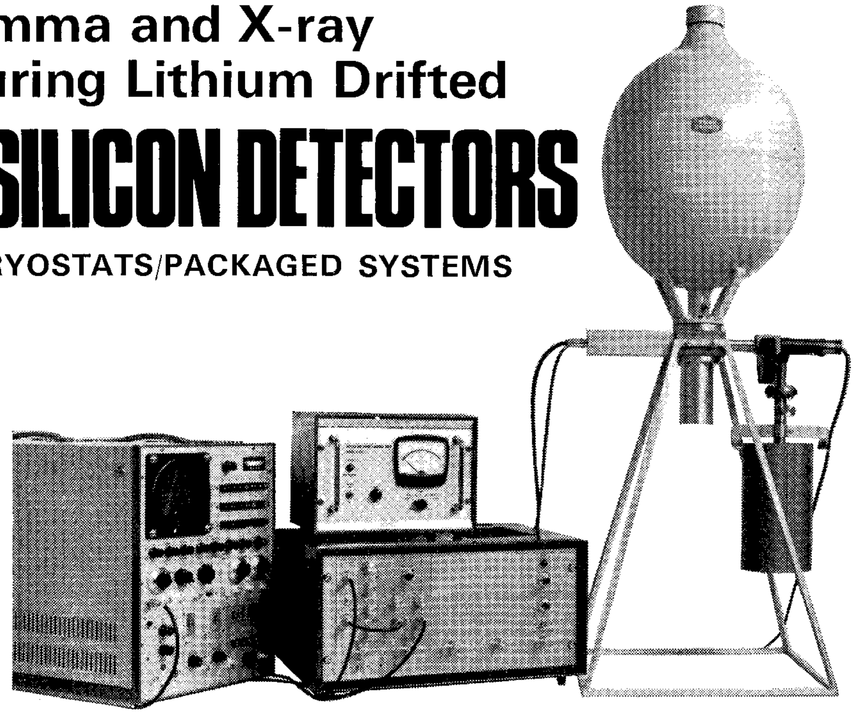

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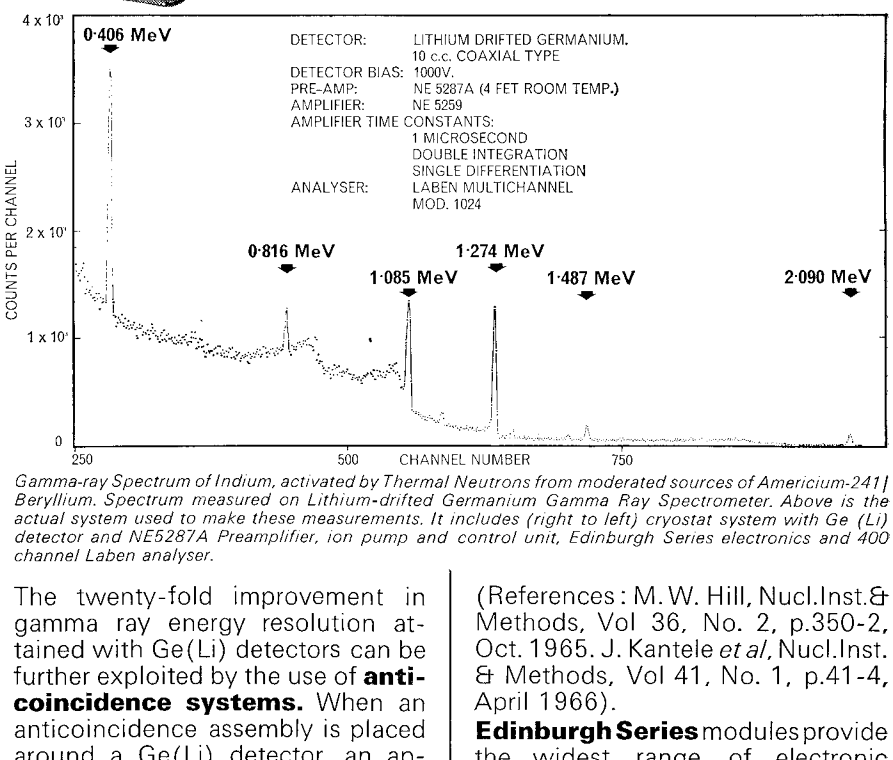
(Please note that the resolutions quoted are total system resolutions.)



Gamma-ray Spectrum of Indium, activated by Thermal Neutrons from moderated sources of Americium-241/Beryllium. Spectrum measured on Lithium-drifted Germanium Gamma Ray Spectrometer. Above is the actual system used to make these measurements. It includes (right to left) cryostat system with Ge (Li) detector and NE5287A Preamplifier, ion pump and control unit, Edinburgh Series electronics and 400 channel Laben analyser.

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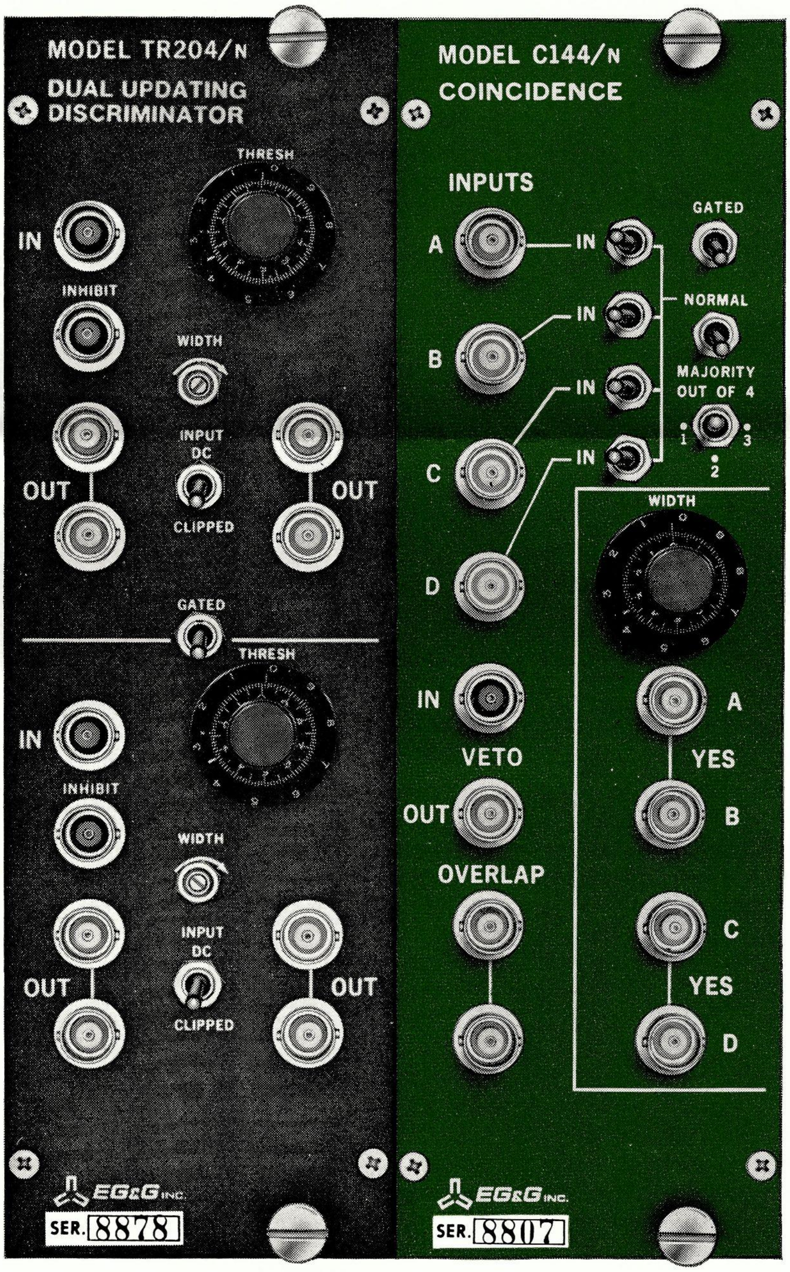

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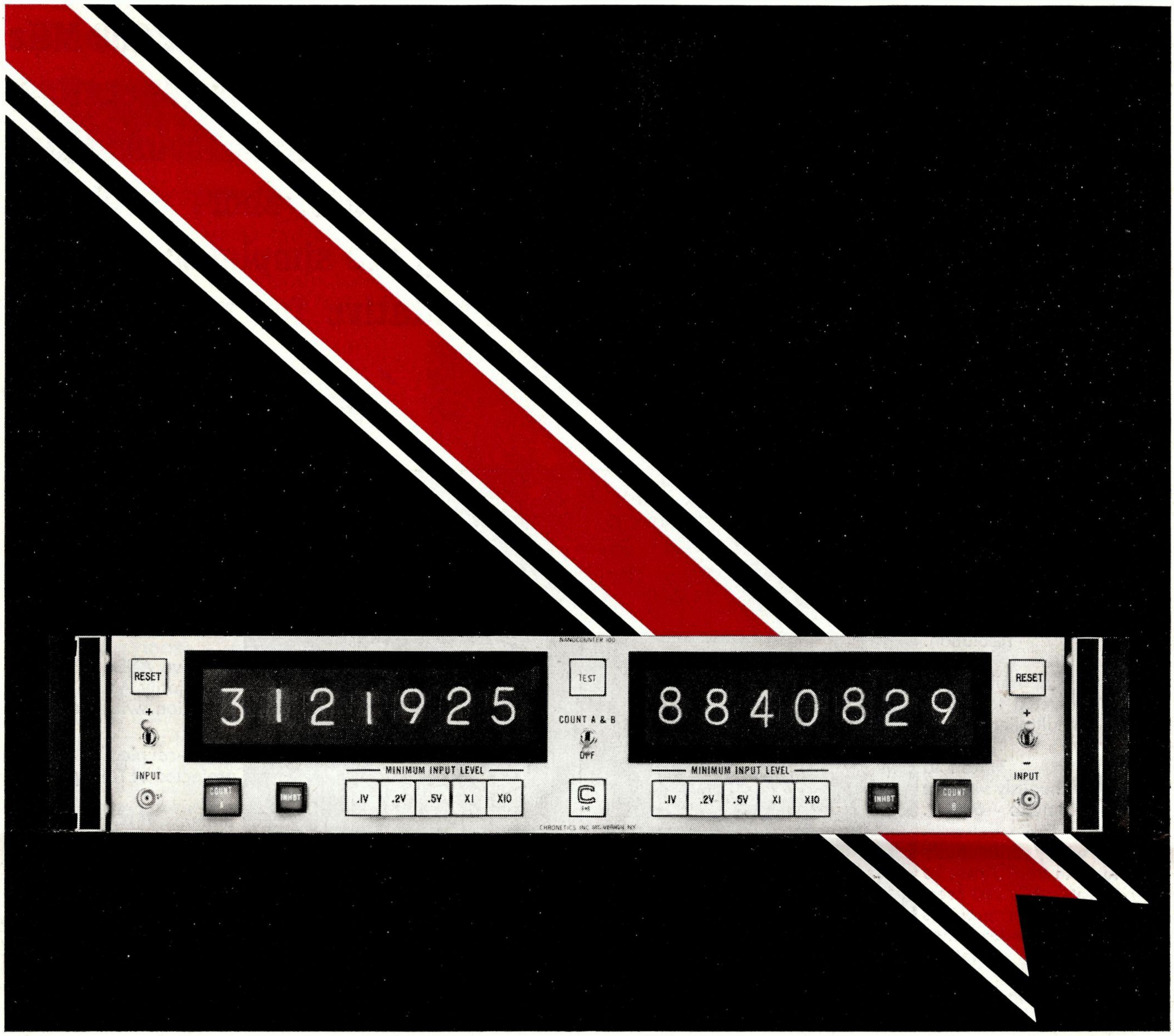
RESET
TEST
COUNT A & B
OFF
3121925
8840829
MINIMUM INPUT LEVEL
.1V .2V .5V X1 X10
INPUT
INHBT
RESET
INPUT