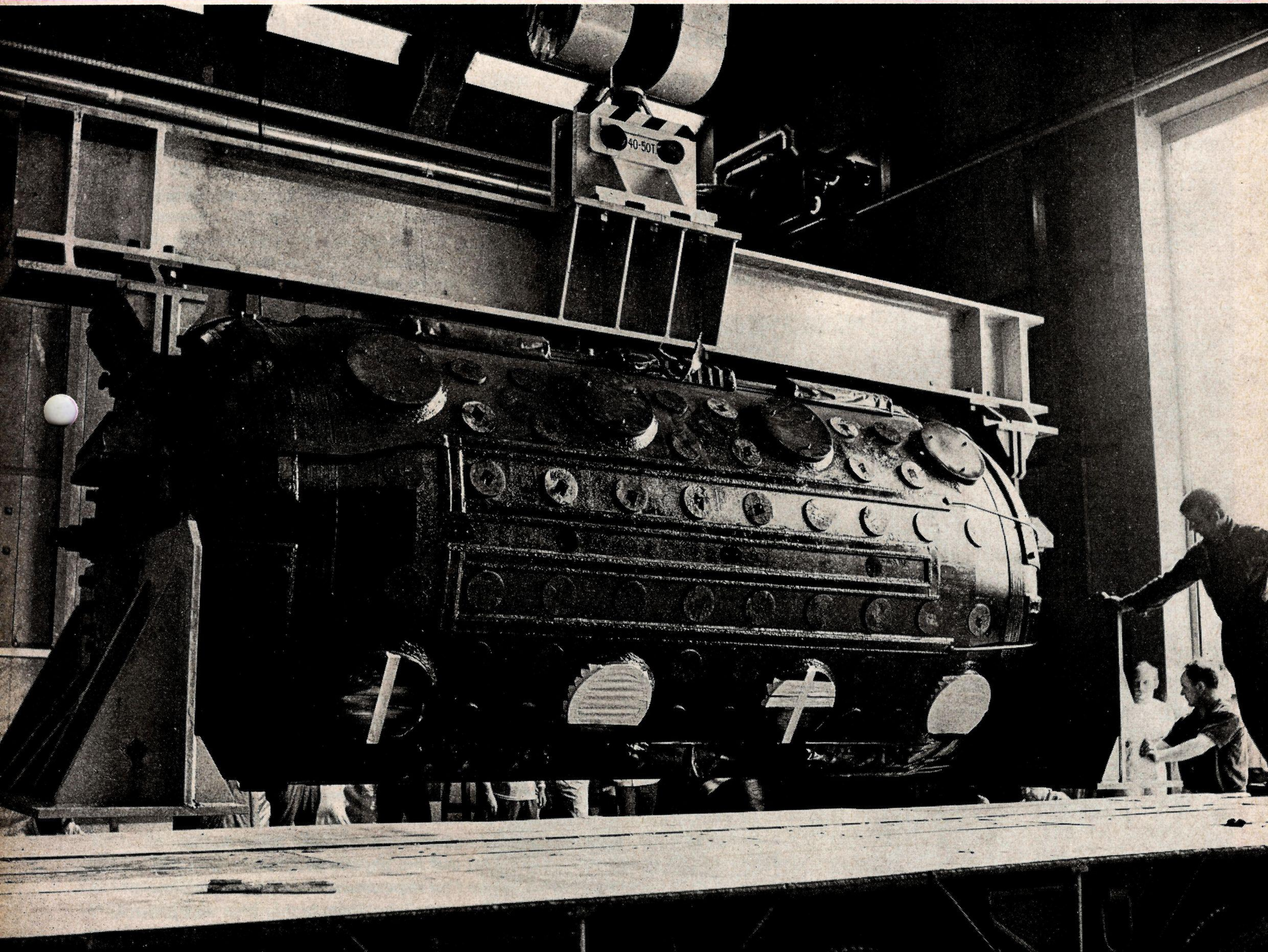
CERN COURIER

No. 8 Vol. 10 August 1970

European Organization for Nuclear Research



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 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), for experiments with colliding proton beams, are under construction. Scientists from many European Universities, as well as from CERN itself, take part in the experiments and it is estimated that some 1200 physicists draw their research material from CERN.

The Laboratory is situated at Meyrin near Geneva in Switzerland. The site covers approximately 80 hectares equally divided on either side of the frontier between France and Switzerland. The staff totals about 2850 people and, in addition, there are over 450 Fellows and Visiting Scientists.

Twelve European countries participate in the work of CERN, contributing to the cost of the basic programme, 244.1 million Swiss francs in 1970, in proportion to their net national income. Supplementary programmes cover the construction of the ISR and studies for a proposed 300 GeV proton synchrotron.

CERN COURIER is published monthly in English and French editions. It is distributed free to CERN employees and others interested in sub-nuclear physics.

Editor: Brian Southworth

Assistant Editor: Philippe d'Agraives

Advertisements: Micheline Falciola

Photographs: PIO-CERN photographic section

Public Information Office
CERN, 1211 Geneva 23, Switzerland
Tel. (022) 41 98 11 Telex 2 36 98

Printed by: Ed. Cherix et Filanosa S.A.
1260 Nyon, Switzerland

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Cover photograph: Arrival at CERN on 29 July of the chamber body of the heavy liquid bubble chamber, Gargamelle. Installation of the chamber body and final assembly and testing, together with the myriad associated components, will take place during the remaining months of this year. It is hoped that the physics programme with Gargamelle can then begin early in 1971. The first experiment will be a neutrino experiment detecting neutrino events at a rate almost a million times higher than was possible ten years ago. (CERN/PI 167.7.70)

Jean Willems

One of the men whose personality, energy and European spirit helped found CERN died in Brussels on 31 July. European science has lost a born organizer and one of its keenest supporters.

Jean Willems was born in Ghent in 1895. Appointed Secretary of the Free University of Brussels at the age of 25, he succeeded in coordinating a close-knit network of scientific bodies in his country. While holding the position of President of the Belgian Inter-University Institute of Nuclear Sciences, he also occupied the Presidencies of the University Foundation, the National Scientific Research Fund and the Francqui Foundation. His gifts were recognized by a great many countries, and among the honours bestowed upon him were the Order of the British Empire and the French Legion of Honour.

Jean Willems' name appeared as representative of Belgium on the list of delegates at the very first meeting of the provisional CERN on 5 May 1952. Even before then, however, he had been extremely active in his country as a protagonist for the establishment of a European laboratory. With Italy and France, Belgium had contributed in December 1950 to the first subsidies — the ten thousand dollars which were used to set up a study group to draw up the original plans for the laboratory. From then on, Jean Willems remained until his death in very close association with CERN. It was he who, on 1 July 1953, in the 'Salons de l'Horloge' on the Quai d'Orsay in Paris, signed the Convention for the Establishment of the Organization on behalf of Belgium. It was he also who in the early days of CERN, making use of his many contacts on the other side of the Atlantic for the benefit of the Organization, negotiated and obtained a donation of four hundred thousand dollars from the Ford Foundation to allow CERN to offer Fellowships to scientists from non-Member States.

In 1955 and for the following two years, Jean Willems was Chairman of the CERN Finance Committee. After serving as Vice-President of the Council from 1958 to 1961, he was elected President for the years 1961, 1962 and 1963. In this office, he spared nothing in his work for CERN. With his keen mind, he immediately went to the roots of the problems facing the Council, and brought then to their solution with remarkable speed, renowned logic and complete impartiality.

Although he was not himself a scientist, Jean Willems was fully capable of grasping the essentials of even the most technical matters. At the time when debate was raging over the question of the energy of the CERN alternating gradient synchrotron, he was one of those who supported the idea of building a 25 GeV machine. But he occupied himself with a wide range of problems, including the promotion of the need to establish information channels at CERN suited to the Laboratory's character. It is not out of place here to recall that he was one of the moving spirits behind the founding of CERN COURIER. From 1953 he took a great deal of interest in the press relations of the Organization, a subject with which he was well acquainted, since he was first a Director and later President of the Belga Press Agency.

Jean Willems' wide ranging thought and European spirit were displayed more than once in meetings at CERN. His words at the Council Meeting in June of this year were typical of him. In spite of the importance he had attached to the construction of a new CERN Laboratory on Belgian soil, he spoke in favour of the new proposals concerning the 300 GeV project and expressed his country's strong support for the future of European science, over-riding national interest.

That was on 19 June. Shortly afterwards Jean Willems left the Council Chamber for the last time and CERN lost one of its strongest and most articulate allies.

R.A.

Jean Willems (on the left) in conversation with Professor V. Weisskopf (standing), then Director General of CERN, and S.A. ff. Dakin, then Directorate Member for Administration, during the Council Meeting over which he presided in June 1963.

CERN/PI 216.6.63

The European Southern Observatory
and its collaboration with CERN

This article is an amplified version of an article by Professor Blaauw prepared for the September issue of Europhysics News, the Bulletin of the European Physical Society.

A. Blaauw
Director General of ESO

The Councils of ESO and CERN, through the resolutions adopted at their meetings of 11 and 18 June respectively, have opened the possibility for collaboration between the two Organizations in connection with ESO's Large Telescope Project. This collaboration is expected to start in the coming months, when a group of astronomers and technicians with their administrative assistants will gradually settle on the CERN site, thanks to the hospitality offered by CERN's Council and Directorate.

What is ESO ? The initials stand for European Southern Observatory, an Organization for astronomical research. Like CERN, it is a joint enterprise of European scientists — in this case astronomers — aimed at conducting research at a level beyond that which can be reached by the scientific institutes and manpower of the individual Member States. These States are Belgium, Denmark, France, the Federal Republic of Germany, the Netherlands, and Sweden, all of which also participate in CERN.

The large telescope, on the development of which ESO and CERN will collaborate, is destined to be erected at ESO's observatory in Chile. In the southern part of the Atacama desert in that country, ESO already operates its observatory with modern astronomical instrumentation of medium size. This distant site was chosen for several reasons: first, in view of the outstanding weather conditions, but also because the ESO astronomers are particularly interested in the study of a number of celestial objects visible from the southern hemisphere which have no counterpart in the northern sky.

A battery of telescopes is in use. One of them serves mainly for astronomical spectroscopy; it is equipped with a light gathering mirror of 1.5 m diameter and various spectrographs. Another serves for photometric measures (for observing the intensity of star light by photoelectric methods in the integrated wavelength areas the astronomer wishes to study); it has a mirror of 1 m diameter and is equipped with various kinds of photometers. Also in operation is a double astrograph, i.e. twin telescopes using objective lenses of 40 cm diameter, one of which is equipped with an objective prism of special design constructed for the wholesale measurement of stellar velocities through the Doppler shift. A large Schmidt telescope, equal in size to that of the Palomar observatory in California, is now under construction and should be tested by the end of this year. It is expected to be in operation at the observatory by the middle of 1971.

Research has been in progress at the observatory since 1967. It is carried out by astronomers who are on the permanent staff of ESO (about ten in number) and by visiting astronomers from the Member States, in a similar way, though on a much smaller scale, to the way in which research is conducted predominantly by visiting scientists at CERN. There have also been some guest astronomers from countries such as Argentine, Chile, Czechoslovakia and USA.

The Large Telescope

ESO's main instrument, however, will be a telescope of exceedingly large light gathering power with a mirror of 3.6 m diameter. It was meant to be the largest telescope in the southern hemisphere, far surpassing in size the largest one now in operation (in South Africa). After the ESO project was initiated by European astronomers, plans for large southern telescopes of about equal size were also proposed, and are being realized, by groups in the USA and in the United Kingdom. This development underlines the need for such equipment in current astronomical research.

A telescope of this size presents problems of design and construction of a new order of magnitude. Moreover, it must be equipped with auxiliary instrumentation of a complexity comparable to that of the telescope proper. Hence, this telescope requires a considerable amount of new developments in the fields of optics, mechanical design, electronics, and automation. There are, moreover, interesting interface problem between the telescope and the building that houses it.

Thus, the ESO 3.6 m telescope project is comparable in scope to the large instrumental developments which have been completed or are still under way at CERN. The engineering experience, the extensive technical know-how, and the administrative apparatus built up by CERN for handling projects of this size, has led the Council of ESO to seek CERN's collaboration at this moment, at which ESO wishes to pursue with the utmost strength the realization of its principal instrument. Details of the agreement for this purpose have been worked out by the Directorates and Councils of the two Organizations.

Basic principles are, that the 'ESO Telescope Division' will have a status of, on the one hand, financial independence of CERN with responsibility exclusively to the ESO Directorate for the development of the properties of the telescope, but, on the other hand, in respect to administrative set-up and staff regulations, it is largely to be adapted to the CERN situation so as to ensure smooth working conditions. In brief: what we expect to build up at CERN is an ESO Telescope Division performing its task with the best possible efficiency by being placed in the collaborative and expert medium of CERN.

Accommodation is now being prepared on the CERN site (close to the large building where Technical Services and Buildings Division is centred) to receive the ESO staff. The first will probably arrive in October and over the next two years, as the telescope project gathers momentum, the total ESO staff at CERN could rise to nearly 60 people. Of these between 30 and 40 are likely to be 'professional' staff.

The following features of the telescope design may be of interest. The telescope is to be used in three modes: the prime focus, the secondary, and the Coudé focus. The prime focus — also called Newton focus — with aperture ratio 1:3 serves primarily for the observation of objects of low surface brightness. It is located in the top section of the telescope's tube at a distance of about 11 meters from the main mirror. The observer sits in a small cage within the tube (blocking as little as possible the star light entering the telescope), moving with the telescope while it follows the star's apparent motion due to the earth's rotation.

The secondary, or Cassegrain focus with aperture ratio 1:8 is located immediately below the large mirror cell, and

1. *Aerial photograph of the ESO observatory on the mountain La Silla in the Atacama desert in Chile. Near the top right hand corner can be seen the already flattened summit on which is to be erected the 3.6 m telescope to be constructed with the collaboration of CERN. In the foreground are the domes housing the already operating telescopes.*

2. *Inside the dome housing the 1 m photometric telescope, of which the lower part is shown. Attached to it is equipment for photoelectric measurement of stellar light intensities. In the background are the digital output and steering panel for the telescope.*

reached by the star light through a hole in the mirror. Whereas for smaller telescopes this focus is usually reached by the observer from a platform below the telescopes, the ESO telescope will have a cage around this focus also, fixed to, and moving with, the telescope. This cage can be much roomier and may contain fairly large size equipment, like spectrographs and electronic racks.

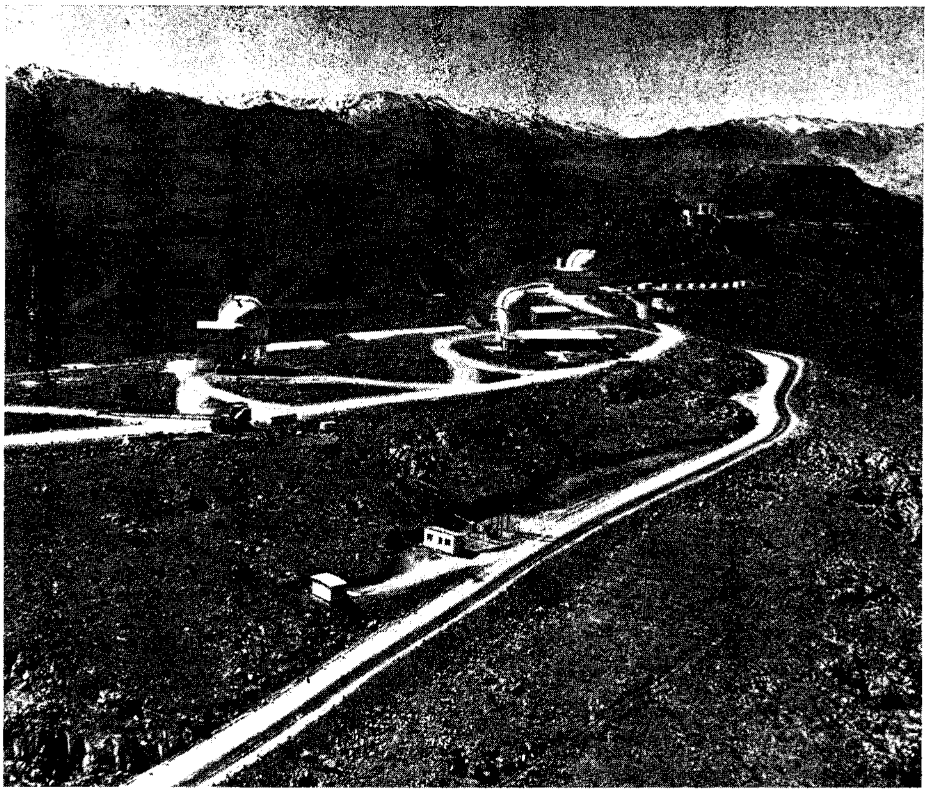
The third, or Coudé focus, will have an aperture ratio of 1:30 and be located below the telescope in a room at constant temperature. It is reached by the star light via a complicated system of four mirrors. In this Coudé room the light of the star can be analyzed in a variety of ways, mainly by means of permanently mounted powerful high dispersion spectrographs.

One of the special features of the ESO equipment will be that, during periods when the telescope operates at the prime or the secondary focus, the Coudé spectrograph need not stand idle but can be fed by a separate coelostate mounted outside the telescope building.

The objects of research

Objects for study of particular interest are the Magellanic Clouds and the central regions of the Galaxy (the Milky Way stellar system). The Magellanic Clouds are stellar systems outside the Galaxy — probably satellites of it — and can be seen only from the southern hemisphere. They are ten times nearer to us than the Andromeda nebula, the stellar system which is the principal object for extragalactic studies for northern hemisphere astronomers. Thus, the Magellanic Clouds are in a much more favourable position. They contain both very old and quite young stars and are still the scene of active star formation. They are therefore, for studies of the process of star birth and of stellar evolution, a magnificent natural laboratory.

The central region of the Galaxy — also a typical southern object — is of great importance for the study of galactic structure. We know, from scarce observations so far in our Galaxy, but from more extensive information derived from other stellar systems, that in the central parts of the large spiral nebulae violent



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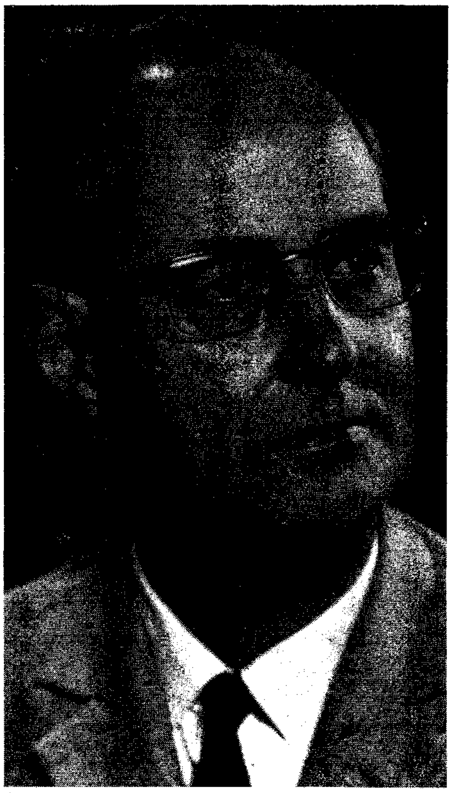
3. Professor Adrian Blaauw, Director General of ESO.

(Photos ESO)



3.

physical processes occur which are of fundamental importance for the outer parts of the system and which must give valuable clues to their evolutionary history.

Whereas these two fields of research were the principal inducement for putting the observatory on the southern hemisphere, a new direction of research will probably draw much attention in the coming years; it is connected with high energy astrophysics. Recent discoveries in both radioastronomy and optical astronomy have pointed to the existence of phenomena dominated by high energy physical processes. We observe these in the form of quasars and sources of high frequency radiation. We are entering here a field of great common interest to astronomers and high energy physicists, which may open fascinating prospects for scientific collaboration between ESO and CERN.

The nature and structure of ESO

ESO's nature and structure are in many respects similar to those of CERN, although the Organization is much smaller. It is governed by a Council, now under the presidency of Mr. J.H. Bannier of The Netherlands, in which each of the Member States is represented by two delegates, usually one astronomer and one government official. The Organization's affairs are conducted by the Director General. He delegates responsibility for the daily affairs in the operation of the observatory to the Director in Chile, Professor B.E. Westerlund, and in technical matters is assisted by Professor J. Ramberg. The ESO Telescope Division at CERN will be, at least provisionally, under the daily supervision of Dr. S. Laustsen.

Several advisory committees assist the ESO Council and its Directorate, the Instrumentation Committee (Chairman Professor Ch. Fehrenbach of France); the Finance Committee (Chairman Dr. C. Zelle of the Federal Republic of Germany); and the Scientific Programs Committee (Chairman Professor B. Strömgren of Denmark). The current annual budgets of ESO are in the region of 15 million Swiss Francs.

Although already more than a decade has elapsed since the initiative to create ESO was taken, activities in Chile started only fairly recently. In the early years, extensive site tests were conducted in the South African desert region, but their results turned out not to be quite as promising as those discovered in the meantime in Chile. On the basis of a multilateral agreement between ESO and that country, constructions began in Chile in 1964, under the former Director General, Professor O. Heckman and the superintendent in Chile, Dr. A.B. Muller.

ESO built its Chilean Headquarters in Santiago, the capital of Chile, and the observatory proper on the mountain La Silla. These Headquarters contain the administrative offices and the permanent facilities for the scientific staff — offices, main library, measuring apparatus, computing facilities — and also the main workshop and laboratories (electronics, optical). Most of the scientific staff live with their families in Santiago and divide their time for research between the observatory on La Silla and the Santiago Headquarters. About 120 staff are currently employed in Chile and this may grow to over 250 when the big telescope is in operation.

The observatory is located about 600 km north of Santiago — a day's travel by plane, car or bus. Through the collaboration of the Chilean Government, ESO acquired a property of about 630 km^2 of desert area, large enough to saveguard it from building or mining activities which might disturb the astronomical observations by the production of dust or light. After the completion of the construction of almost 40 km of road, leading to the summit of La Silla at an altitude of 2400 m, the present telescope buildings as well as a hostel for the lodging of astronomers, technical staff and administrative personnel were erected, including the many auxiliary facilities like power supply, water supply, heating plant, etc., which are needed for such an isolated establishment in the desert. This first phase of the ESO construction in Chile was completed early in 1969, and on 25 March, 1969, its official dedication by the President of the Republic, Eduardo Frei Montalva, took place on La Silla. Among the guests of honour it was a pleasure to welcome the Director General of CERN, Professor B. Gregory.

The European Central office of ESO is at Hamburg, in the Federal Republic of Germany, where the principal offices of the Director General, the Technical Director and the Head of Administration are located, involving about 20 staff. This office maintains relations with, on the one hand the astronomers and the governments of the Member States, and on the other hand the observatory in Chile and, from now on, the Telescope Division at CERN.

The aerial view of La Silla of the previous page shows, in the foreground, the array of telescope buildings, workshops, etc., and in the background the summit of La Silla, already flattened for the erection of the 3.6 m telescope. For its successful realization, hopefully within the next five years, ESO looks forward to the fruitful collaboration of all those whose contributions will be involved: the ESO Telescope Group at CERN, the CERN expertise and experience, the ESO astronomical staff in Chile, and the ESO Instrumentation Committee.

CERN News

Sigmas and antiprotons in orbit

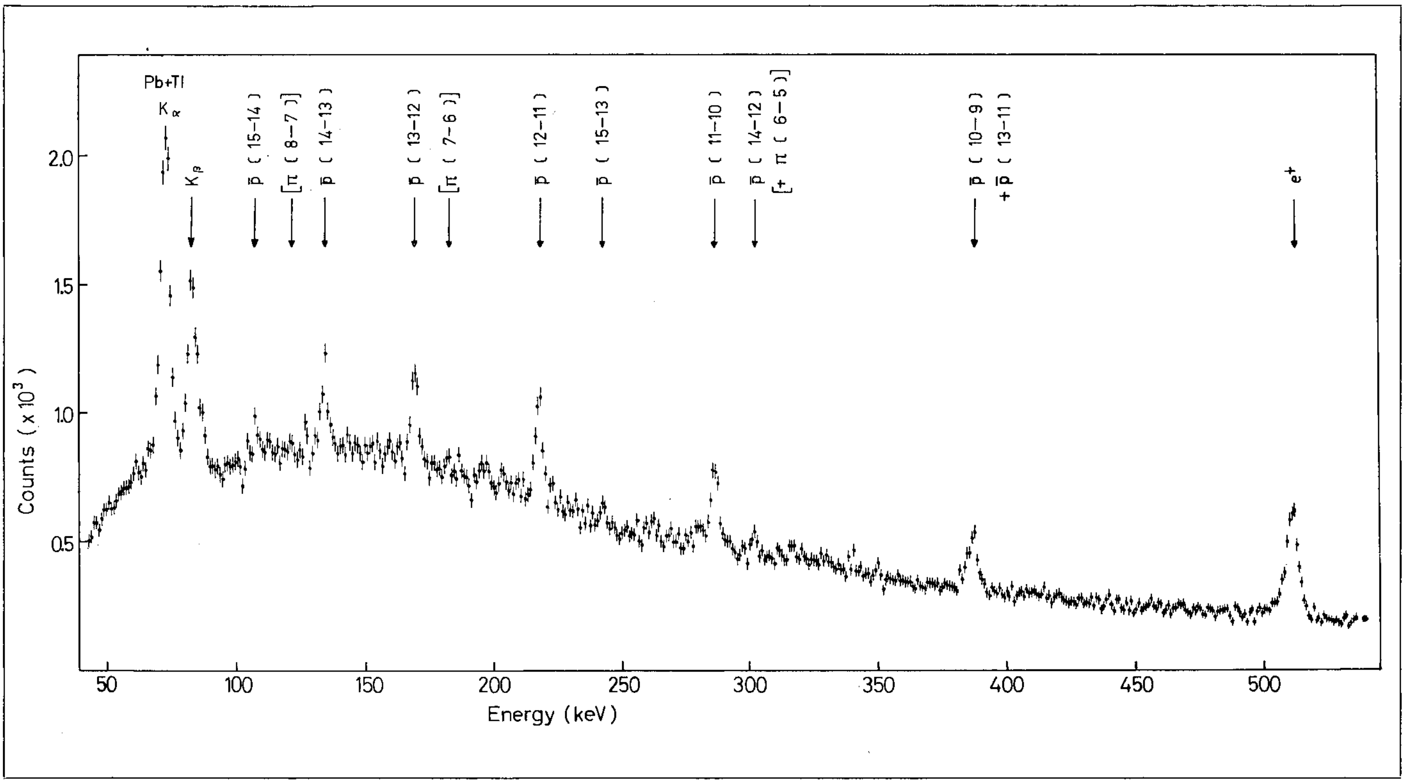
In what is probably one of the most important discoveries made at CERN in recent years, the existence of two new types of 'exotic' atom has been demonstrated. In one type a negative sigma particle has been detected 'in orbit' taking the place of one of the electrons in the atom. In the second type an antiproton has been detected 'in orbit'.

. When a negative particle of low energy travels close to a nucleus it can fall under the influence of the field of the positive nucleus and be captured into the atom. The process is known as 'Coulomb capture' since it is the Coulomb field between opposite charges which brings it about. The negative particle can then be thought of as orbiting the nucleus of the atom taking the place of one of the usual orbiting electrons. Initially, it is likely to be in a high energy state and it will tumble down closer to the nucleus to sucessively lower energy levels. As it does so it will emit characteristic quanta of energy (each quantum corresponding to the difference between two energy levels) which emerge as gamma rays usually known as X-rays. It is by observation of the emerging X-rays that knowledge of the phenomenon can be deduced. The negative particle generally finishes up interacting with a particle in the nucleus itself (being absorbed by the nucleus).

The existence of such exotic atoms was predicted in 1947 and they were observed in 1952 in Rochester and Pittsburgh. The first ones to be identified were pionic atoms in which a negative pion had taken the place of an electron. In 1953 muonic atoms were discovered at Columbia and in 1967 kaonic atoms were discovered at Berkeley. CERN has now added sigmic and antiprotonic atoms to the list.

The usefulness of studying these exotic atoms rests in the differences between the heavier negative particles and the electron. Taking first the muon (which is a twin particle to the electroh in terms of practically all its properties), the fact that it is about 200 times heavier than the electron means that it lives in the muonic atom in orbits 200 times smaller in radius. (In fact the words 'in orbit' is not so clear for heavier negative particles since they spend part of their live passing through the nucleus itself). Being so much closer to the nucleus, it is much more sensitive to the way in which the positive charge is distributed in the nucleus. Measurements on X-rays emerging from muonic atoms have served to specify charge distributions in nuclei and have been used to confirm the validity of the theory of quantum electrodynamics operating at very small distances.

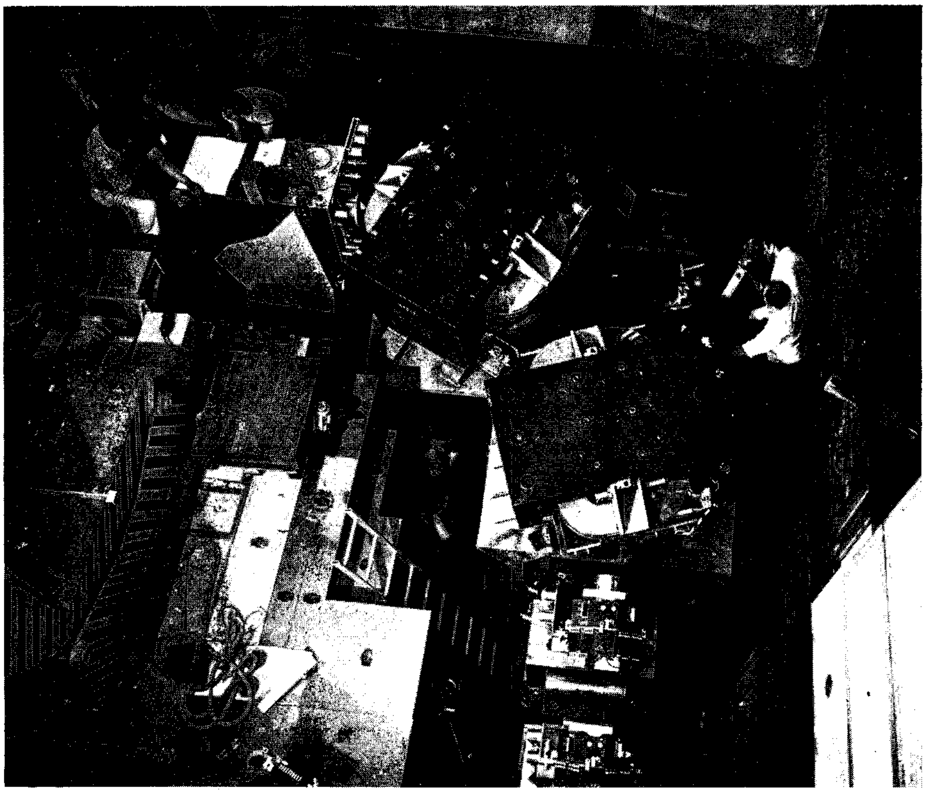
Turning to the pionic atom, a new factor is introduced because the pion is affected not only by the electromagnetic force between charged particles, as are the electron and muon, but also by the strong nuclear force exerted by the nucleons. By studying for example the X-rays from pionic atoms of oxygen 16 and oxygen 18 the effect of two additional neutrons can be found and further knowledge gained on the pion-nucleon interaction. There has been fruitful research on muonic and pionic atoms carried out at the CERN 600 MeV synchro-cyclotron for several years.



The antiprotonic X-ray spectrum from thallium 81 observed during an experiment at CERN in July. The peaks correspond to X-rays emitted as antiprotons fall from one energy level to a lower energy level in the atom and it is from measurements on such peaks that the existence of antiprotonic and sigmic atoms has been verified for the first time.

A view from above the k12 beam-line to the experiment where sigmic and antiprotonic atoms have been identified for the first time. The equipment receives an intense beam of negative particles from the beam-line, entering from below climbing vertically at 17°, which is fed by the slow ejected beam in the East experimental hall. Two large magnets curve the beam to the left and into the target. Measurement of the X-rays emerging from the target identify the exotic types of atom which are produced. When the experimental set up was complete it was covered above also by shielding because of the high radiation levels.

The first large units of the magnetic shield for the 3.7 m European hydrogen bubble chamber arrived at CERN from CAFL (France) at the beginning of August. The unit shown in the photograph is the lower disc weighing 48 tons which will support the expansion system operating from below chamber. A second unit is the lower ring weighing 80 tons on which the chamber body and the superconducting magnet will be supported. The installation of these units is scheduled to take place in September.



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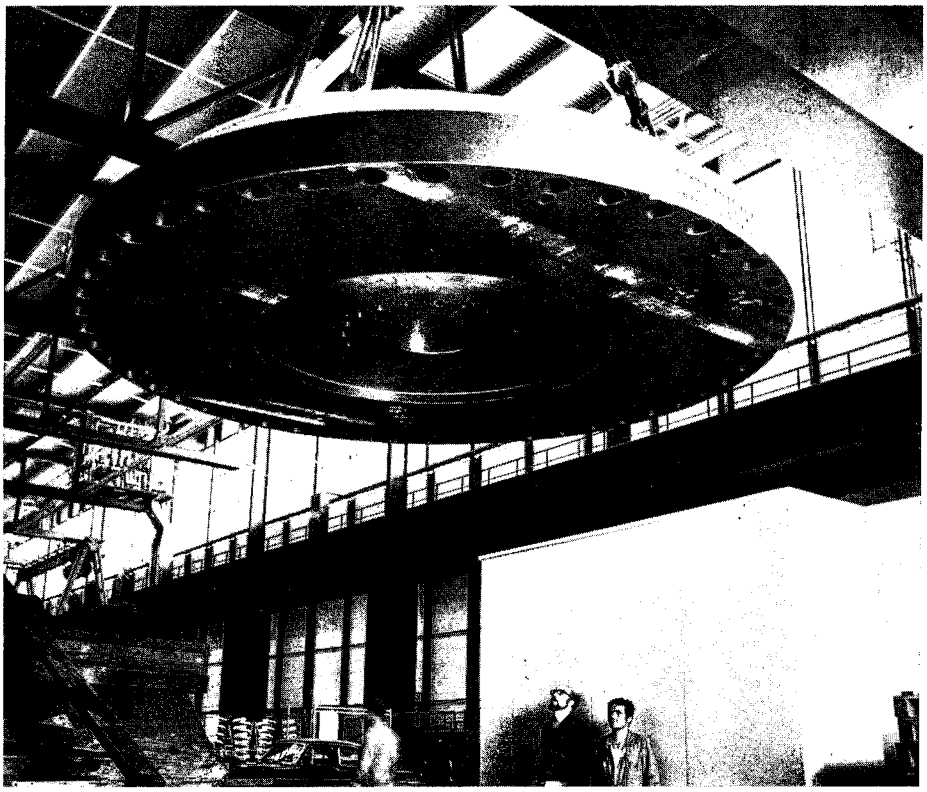


CERN/PI 6.8.70

Research on kaonic atoms is only just getting off the ground. The initial identification at Berkeley could not be carried much further in terms of detailed studies for lack of negative kaon beams of sufficiently high intensity. Such a beam has been set up at the CERN 28 GeV proton synchrotron and a CERN-Karlsruhe-Heidelberg collaboration recently began an experiment to study kaonic atoms and to look for other types of exotic atom.

The experimental set-up

For the study of kaonic atoms, an intense beam of negative kaons, is obtained by bombarding a target with the slow ejected proton beam from the PS in the East experimental hall. Since more pions are produced than kaons, the kaon beam-line (k 12) is designed to filter out as many of the pions as possible using a collimator, followed by a glycerine-bath moderator (which slows the kaons more than the pions) and finally a spectrometer which focuses the pions and kaons at two different points. In spite of this, the number of pions reaching the experiment target is fifty times greater than that of the kaons, so that discrimination has to be carried out by means of four scintillation counters and two anticoincidence Cherenkov counters. Eight hundred kaons stopped in the experiment target per PS pulse are finally obtained.

This arrangement also makes it possible to study sigmic atoms since negative sigma particles are produced in the reactions between the kaons and the nucleons of the target:

$$K^- + p \rightarrow \Sigma^- + \pi^+$$

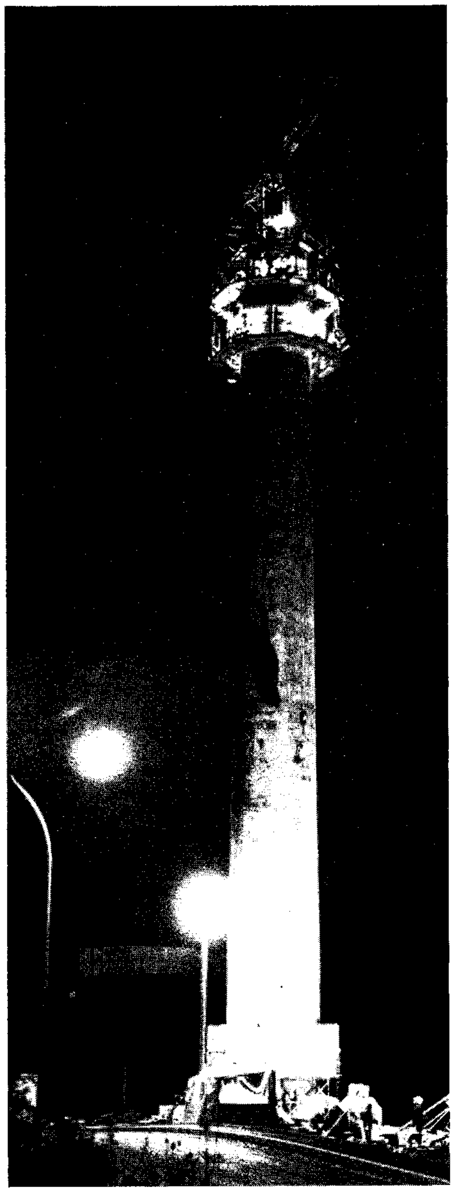
$$K^- + n \rightarrow \Sigma^- + \pi^0$$

Some of the sigmas thus produced can be captured by nuclei, resulting in X-ray emission as they fall through energy levels.

For the study of antiprotonic atoms, the beam-line from the target bombarded by the slow ejected beam is adjusted differently so as to select antiprotons. An intensity of about 300 antiprotons stopped in the experiment target per PS pulse is obtained.

Four lithium-doped germanium counters with a high resolving power (1 %), connected in coincidence with the signals indicating the stopping of particles in the

The ISR water tower which has been climbing into the sky day and night since April. The stage has now been reached when the cylindrical reservoir, 20 m high and 9 m in diameter, is beginning to take shape. The height of the finished tower will be 56 m and it is intented to install a viewing gallery at the top, reached by a lift, from where there will be an excellent panoramic view of the CERN site and the surrounding countryside. The temptation to install a revolving restaurant has been successfully resisted.



CERN/PI 304.7.70

target are used to detect the emitted X-rays. The experiment target is specially shaped to prevent, as far as possible, the X-rays from being reabsorbed.

The results and their interpretation

The results appear in the form of a graph, like the one shown in the figure, where the number of X-rays observed is plotted against the energy of the X-rays. Each peak corresponds to a transition from one level to another in the atom.

The energy levels, and thus the X-ray energy emerging from transitions between levels, can be predicted as a function of the mass of the negative particle (according to the Bohr atomic model) and following sophisticated calculations from the theory of electromagnetism. The various peaks can thus be identified by comparison with theory. The experimentally observed peaks however differ in several ways from the theoretical predictions when the strong interaction comes into play.

The most important differences are:

1) The peak width (more usually known as the line width) which is broadened because of the short life of the level due to the rapid absorption of the negative particle by the nucleus under the strong interaction. From the Heisenberg uncertainty principle, short lifetimes (about 10^{-19} s in this case) mean that the energies cannot be known to great accuracy (not better than about 1 keV);

2) The extent of the difference between the calculated X-ray energies, using electromagnetic theory, and the experimentally observed ones (usually known as the line shift) is another result of the strong interaction.

It was at CERN that these two differences were studied for the first time for kaonic atoms.

Another important feature is the intensity of X-rays corresponding to transitions between energy levels. The extent to which a level is populated can be measured by effectively counting the transitions to that level. The number of transitions from that level to lower ones can also be measured and the remainder must have gone by direct absorption into the nucleus. It is interesting to note that the heavier the nucleus and the particle captured, the higher the energy level from which absorption can take place and the more sensitive is the phenomenon to the surface or 'atmosphere' of the nucleus.

Another possibility is the measurement of the magnetic moment of the orbiting particle. As is well known from studies of electrons in orbit, energy levels are split due to the spin of the particle. In the exotic atoms, line doubling, or splitting into two energy levels, occurs with particles which have a value of $^1/_2$ for their spin (such as the sigma, antiproton and muon) and, if this splitting can be measured, the magnetic moment of the particle can be calculated.

Apart from demonstrating the existence of sigmic and antiprotonic atoms, the recent experiments at CERN have produced, or will produce, information on:

(i) the mass of the antiproton (it has already been possible to check that it differs from that of the proton by an amount less than 500 keV, i.e. less than about five parts in ten thousand);

(ii) the structure of the surface of the nucleus (this will come from comparative studies of pionic, kaonic, antiprotonic and sigmic atoms);

(iii) the distribution of particles within the nucleus (better than previously determined).

Also, a line broadening effect coming from the line doubling mentioned above has already been seen in the measurements on antiprotonic atoms. Whether these measurements can be refined to such an extent that it will be possible to derive a value for the magnetic moment of the antiproton (and similarly for the negative sigma) from them remains to be seen.

The results of the CERN experiments have been presented at the high energy physics conference which began at Kiev on 26 August and will appear in 'Physics Letters'.

Gargamelle chamber body arrives

On 29 July the chamber body of the heavy liquid bubble chamber Gargamelle, which had been eagerly awaited for a long time, arrived at CERN from the CAFL workshops in France. The exterior view of the chamber seen in the photograph on the cover of this issue gives little idea of its complexity.

On the outside, heat exchangers are welded to the body forming a sort of second casing, together with a large number of connections and apertures. The inside, in contrast with the smooth appearance of hydrogen bubble chamber bodies, is riddled with holes — 21 for the flashes, 8 for the lenses and 44 for the expansion system, in addition to four drain holes and the beam windows. The body thus has almost the structure of a colander, with welded ribs to which the expansion system diaphragms will be connected. Another striking feature is the black vitreous layer covering most of the inside walls. This is a coating of epoxy resin 0.3 mm thick, which was adopted after a large number of tests as the only finish which would ensure that the liquid would remain clear and the lenses of the optical system clean.

The chamber magnet arrived at CERN in June 1968 and delivery of the rest of the equipment, i.e. the large expansion system, cameras, flashes, liquid filtering

Example of a display of the results provided by the beam monitoring equipment. It shows the beam profiles in the horizontal (x) and vertical (y) planes coming from three proportional multiwire chambers during the adjustment of the p5 beam in the East Hall in June.

system, propane storage tanks and controls, began towards the middle of 1969. It has thus been possible over the past year progressively to assemble, test and check equipment, so that everything is ready for the installation of the chamber body.

The installation procedure is as follows:

1) the chamber body is fitted into the magnet and a check is made on the fit of the various components, especially those which are connected to both the body and the magnet;

2) it is removed again and any necessary adjustments are made;

3) all monitoring and control equipment is fitted;

4) the body is finally installed inside the magnet, the expansion system is connected up, the yoke is replaced, the cameras, flashes, monitors and controls are fitted.

This work is scheduled to be finished ready for the first photographs to be taken at the beginning of 1971.

Design features

Gargamelle has been built as a result of a collaboration between the Ecole Polytechnique, Orsay, CERN and the CEA (French Atomic Energy Authority) at Saclay (which is responsible for commissioning and has provided the major part of the construction costs, which will finally amount to almost 25 million Swiss francs).

We recall here a few features of its design (see also CERN COURIER vol. 8, page 95):

The useful volume is 10 m^3, which puts it immediately below the new large hydrogen chambers (20 m^3 for the European chamber, for example) in the bubble chamber 'pecking order'. What sets it apart from other chambers, however, is the unusually high ratio between the useful volume and the total volume of the body (12 m^3). This is mainly due to the design of the optical system, comprising eight wide-angle lenses in two rows of four, each of which 'sees' a part of the total volume. With this arrangement almost the whole of the volume subject to the magnetic field is available for particle detection.

The use of propane or freon implies operation at moderate temperatures (between 30 and 60° C depending on the mixture) and pressures (between about 15 and 25 atmospheres). Because of these operating conditions, it is possible to have an expansion system which is simple in principle, though not in actual construction. It involves the use of an internal polyurethane and elastomer double diaphragm, one side of which is in contact with the liquid filling the chamber and the other with a nitrogen circuit via which pressure variations are transmitted to the chamber liquid.

For an installation of the size of Gargamelle this 'simple' design results in a spectacular assembly for the expansion system, the heart of which is a 2.5 MW rotary compressor, providing a nitrogen flow rate of 36 000 Nm^3/h. The compressor pumps nitrogen into several tanks at staggered pressure levels, and thus, by triggering pilot electric valves, controls the opening and closing of a set of three-inch fast-acting valves, providing for decompression and recompression.

Construction and testing

Since 1967, tests have been carried out at Saclay on a chamber body model of full-scale diameter and tenth-scale length (called the Gargamelle 'slice') with only one lens and no magnetic field. These tests have been used to perfect the optical and expansion systems; in addition, they have served in the choice of material for the diaphragms and the specification of the liquid filtering system. The 'slice' has since been set up for further tests at CERN behind the 2 m hydrogen chamber.

Beams for Gargamelle

Final work on the beams to supply Gargamelle began on 6 August, just after completion of the last experiment on the CERN 1.2 metre heavy liquid chamber.

Two beams are scheduled initially:

1) a neutrino beam comprising a three-stage magnetic horn focusing system and 4000 tons of rebuilt steel shielding. A large number of the components are taken from the previous neutrino beam-line (see CERN COURIER vol. 6, page 214). Tests are now on hand and the first beam trials are to be before the annual PS shutdown, scheduled for 15 November, so that any adjustments can be made during the shutdown and the neutrino spectrum can then be calibrated when the PS starts up again;

2) a beam-line, known as G4 to give beams of several kinds of particle (pions, muons and protons) with little modification. About 30 pulsed magnets are being manufactured. It is hoped to begin operating this line after the shutdown and to use it for the acceptance tests on the chamber (taking about 100 000 photographs).

The first experiments

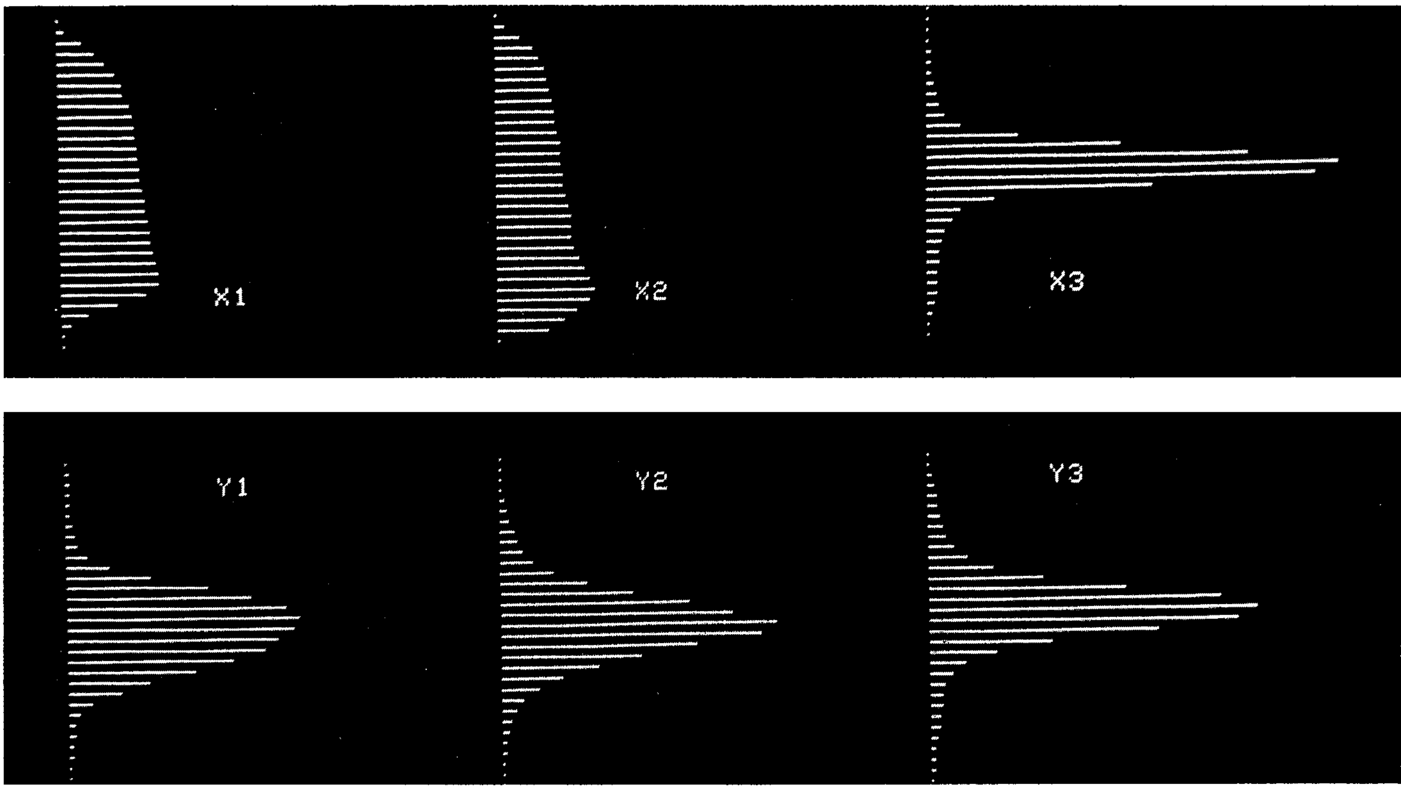
The first experiments to be carried out using Gargamelle were approved by the Nuclear Physics Research Committee in June.

1) A collaboration between Aachen, Brussels, CERN, Ecole Polytechnique, Milan, Orsay and University College London, will take probably a million photographs in a neutrino experiment (400 000 in an initial phase and 600 000 in a second) at a PS energy of 26 GeV with the chamber filled with freon. In view of the size of the chamber, it is expected that about 100 000 neutrino events will be recorded.

The experiment has four main aims: a) measurement of the ratio between the total cross-sections of the neutrino and the antineutrino, and a check on the various theories ascribing values of between 1 and 3 to this ratio; b) measurement of the total cross-section as a function of the energy (over the neutrino energy spectrum from 1 to 15 GeV). It might be possible, from these measurements to detect, by an indirect method, the existence of the intermediate boson; c) study of the inelastic continuum in high momentum transfer regions, and a check of the parton model; d) search for the intermediate boson by the possible observation of its decay products.

2) As an adjuct to this neutrino experiment the photographs will be scanned to look for cosmic ray interactions taking place in the chamber during the time that it is sensitive for the detection of neutrino interactions.

3) A collaboration between Bergen, CERN and Strasbourg will use 2 GeV/c positive pions, from a version of the G4



beam-line called m12, to take probably 400 000 photographs in the time between the two neutrino exposures. It will be aimed at the observation of neutral mesons and especially at the study of the decay into two gammas (about which little is known because, up to now, it has been difficult to observe) and the decay into positive and negative pions and a gamma (which will help clear up the question of the quantum numbers of the neutral meson).

ISR magnets powered

Commissioning of the main magnet power supply for the Intersecting Storage Rings began on schedule on 3 August. Current was passed through both complete magnet rings (268 magnet units) for the first time. The design peak current is 3750 A to produce a peak field of 12 kG which will hold 28 GeV protons in the magnet rings. The power is then 7 MW per ring.

Unlike conventional accelerator magnet power supplies, the ISR system does not need to provide pulsed current. It does, however, have quite exceptional stability criteria to satisfy in order that the beams can be retained circulating in the magnet field for many hours. The magnet current has to be held stable to $\pm 3 \times 10^{-5}$ of its nominal value over ten minutes and to within $\pm 10^{-4}$ over two months. This applies over the full current range needed to store beams with energies from around 8 GeV to 28 GeV. Two big power supply units, of 7 MW each, having refined regulation systems have been manufactured by Smit-Brentford (Netherlands-UK).

The initial tests went very smoothly which is no small achievement when the Intersecting Storage Rings are the biggest accelerator magnet system ever built up to now. Tests are continuing every weekday from 16.00 h to 06.00 h when the ISR tunnel is closed.

During the rest of the time, work in the tunnel continues. Long sections of the ultra-high vacuum system have been installed, baked out and pumped down. The vacuum system for the ISR is another 'biggest ever' and we must return to it in a later issue since it is one of the great achievements in connection with the project. The two beam transfer lines to feed the rings are under vacuum and tests on the beam transport magnets have been under way for some time. The crucial r.f. system for both rings has also successfully passed its first tests.

Beam monitoring

Since June the Beams Group of the Nuclear Physics Division has had a new tool to help in the setting up of the beams feeding experiments. It consists of a beam monitor based on proportional multiwire chambers (PMC) coupled to a computer, which provides almost instantaneous information on the main features of the beam, i.e. energy spectrum, divergence spectrum, beam profile, emittance, etc.

The main advantages of this equipment, developed by H. Verweij and G.B. Lindsay (electronics) and J. Baele (programs), result from the properties of the PMC and include:

a) operation with relatively intense beams (a few million particles per second) without becoming saturated — thanks to the very short resolution time of the PMC (60 ns);

b) being unaffected by magnetic fields;

c) providing a high degree of spatial resolution allowing small sections of the beam to be analysed.

The proportional multiwire chamber which is used has wires in two planes (horizontal and vertical), each plane containing thirty-two wires three millimetres apart (the distance between the wires can be changed as needed). A pulse amplification, shaping and storing system is connected to each wire (the system being of the type described in CERN COURIER vol. 10, page 151). The information thus provided is read off sequentially in groups of four wires and passed to the computer. A measuring system usually comprises three or four chambers of this type installed at points along a beam-line, usually in association with focusing lenses and bending magnets.

The assembly operates on a sample basis (taking about 100 to 1000 readings per burst of particles down the beam-line). The data are handled by an HP 216/B computer equipped with a keyboard, a write-in unit, a tape-punch reader and a screen. The operator can thus interact with the computer as the beam is being adjusted. Data handling is virtually simultaneous, and the results can be either displayed on a cathode ray screen or printed out on tape in a number of different ways.

It is possible, by means of such a system:

1) to obtain a very complete description of the beam after only a few bursts, which would previously have been possible only after several hours;

2) to understand the behaviour of the beam better and to set it up more easily

— in the more complicated cases, this will greatly reduce the time formerly wasted in trial-and-error settings;

3) to calibrate the beam easily, thus helping the experimenters considerably.

The equipment was first used in June to calibrate the p5 beam in the East Hall, and gave an accuracy of 0.5 % on the momentum measurements. Some improvements have since been made in order to increase the flexibility and to provide even better accuracy.

Linac troubles

From the beginning of July the performance of the 50 MeV linac feeding the proton synchrotron became erratic and in the middle of the month the PS was stopped (from 17 to 19 July) in an attempt to find and cure the source of the trouble. It was brought back on the air at reduced power. The output current at 50 MeV was limited to about 55 mA rather than the usual hefty beam of 110 mA. This was because the beam loading in tank 3 could not be compensated for an intense accelerated beam. Fortunately the effect on the PS accelerated intensity was comparatively small causing a reduction in the average beam from 1.5 to 1.4×10^{12} protons per pulse.

The difficulties seem to have been caused initially by a detecting loop which was protruding too far into an r.f. power line by about 1 mm. The extent of the sparking damage at this point suggested that breakdown had occurred steadily for some time, and had progressively broken down cables and components by reflection over-voltages. It had also indirectly led to further breakdown elsewhere by requiring other parts of the r.f. system to run at voltages higher than normal in order to compensate for the loss of power.

Contributing to the problems also was the slightly lower power capacity of a new set of cables from a different manufacturer, and low gain in one of the beam loading compensation power amplifiers. The system was tuned up again satisfactorily at the beginning of August, but it has been decided to replace the amplifier during the next maintenance period.

SERPUKHOV
Experimental programme

At the beginning of August several scientists from the Institute of High Energy Physics at Serpukhov visited CERN. They saw the progress on the items of equipment (fast ejection system, r.f. separators) being prepared for use on the 76 GeV synchrotron at Serpukhov and studied other aspects of CERN's work, particularly the data handling facilities for bubble chamber film. While they were at CERN, Professor A.A. Logunov, Director of the Institute, gave a special seminar to theoreticians and a general seminar, together with Dr. V.A. Yarba, on the experimental programme at Serpukhov. The following information was drawn from the general seminar.

Professor Logunov began by expressing his great satisfaction with the progress of the CERN-Serpukhov collaboration both in terms of the joint experiments and of the development of machine equipment. He expressed his confidence that the collaboration which has begun so very well will prove still more fruitful for both Laboratories in the future.

Performance of the accelerator

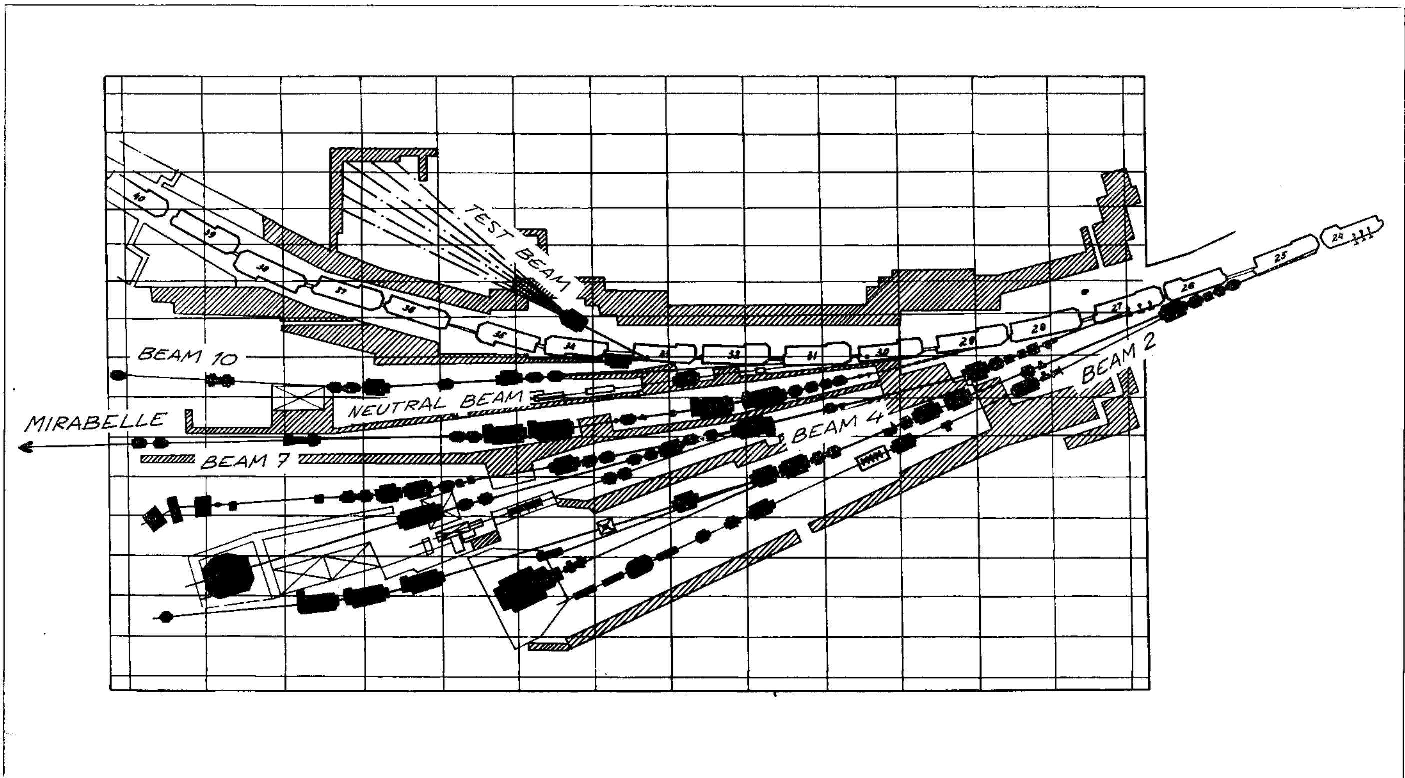
In 1969 the 76 GeV proton synchrotron operated for 3700 hours of which 3000 hours were used for the physics research programme. The peak beam intensity was 1.5×10^{12} and the average per cycle was 0.6×10^{12}. The magnet cycle flat-top at all energies up to 70 GeV was up to 1.5 s long and usually two or three experiments were taking data simultaneously with a spill time of 0.3 to 0.5 s. A fast spill suitable for bubble chamber physics has also been achieved. The machine schedule was 20 days of continuous operation followed by a 10 day shutdown.

In the first half of 1970 the accelerator operated for 2000 hours and the reliability of all components is being steadily improved. A long shutdown began on 20 July (it will extend to 15 October) and will be occupied mainly in preparations for the fast ejection system.

EXPERIMENTS AT SERPUKHOV

Beam channel	*Experiment*
Beam 2 (30-65 GeV/c)	1. Total cross-section measurements 2. Elastic scattering 3. 6 m spectrometer
Beam 4 (20-45 GeV/c)	4. Pion-proton charge exchange 5. Pion-neutron backward scattering 6. Search for heavy particles and antinuclei 7. CERN-Serpukhov missing mass spectrometer 8. 2 m heavy liquid bubble chamber from Dubna
Neutral Beam	9. Neutral kaon, regeneration on hydrogen
Internal Beam	10. Elastic proton-proton and proton-deuterium scattering

Diagram of the layout of beams in the large experimental hall of the 76 GeV proton synchrotron at the Institute of High Energy Physics, Serpukhov.
Some information of the beam parameters and the experiments is given in the accompanying article.



Beam-lines

In 1969 four beam-lines were mainly in use. Beam 2 provides negative particles in the momentum range 30 to 65 GeV/c with beam intensities from 10^4 to 7×10^5. Beam 4 covers the momentum range 20 to 45 GeV/c with beam intensity of 10^6 at 32 GeV/c. Beam IK°/I° supplies neutral particles, the intensity of the neutron beam being 10^7. Beam 10 came into operation at the end of 1969 to give low energy negative particles in the range 10 to 13 GeV/c. The beam intensities are 3.5×10^6 for pions, 3×10^5 for kaons; 10^5 for antiprotons.

Other beams are — Beam 6 which is used for setting up and checking equipment (it has a momentum range of 0.8 to 20 GeV/c with an intensity of 10^6 at 2 GeV/c) and Beam 7 which is the long beam-line to feed the Mirabelle bubble chamber. Units, such as magnets, lenses, vacuum chambers and collimators, have already been tested and some have been installed. It is scheduled to come into operation with diffractionally scattered protons about the end of this year. Some preliminary work is also going on to have positive particle beams drawn from the internal target feeding Beam 2.

Recent studies have revealed the possibility of having an electron beam at a momentum of 30 GeV/c with an intensity of 10^4 to 10^5 electrons per cycle and an electron beam-line will be installed.

Recent experiments

The results from Serpukhov which raised the most excitement were those from the first CERN-Serpukhov experiment (reported in vol. 9 page 232). Total cross-section measurements with negative particles (pions, kaons and antiprotons) on hydrogen and deuterium targets were well out of line with what was expected from the measurements previously carried out at lower energies.

The Serpukhov component of the joint team have now repeated the experiment using a liquid hydrogen target which enables more precise and more carefully controlled measurements to be made than with the gaseous hydrogen target of the joint experiment. The results are in good agreement with those from the joint experiment. The total cross-section curves at high energies remain much flatter than expected.

Deductions of the difference between the cross-sections of negative and of positive particles can be made in a round about way via the measurements on deuterium. Theories predict that these should become equal but the measurements show that this does not happen at least until at extremely high energies. These results put the Pomeranchuk theorem and the Regge pole model in disarray.

It is important to check the indirect deductions regarding positive particles and this will begin when positive particles are available about the end of this year.

An experiment on charge exchange of negative pions on hydrogen

$$\pi^- + p \rightarrow \pi^\circ + n$$

is now at the stage of analysing data. Optical spark chambers and scintillators counters are used. The direction of the gamma rays from the neutral pion and their energies can be estimated from the shower width observed in the chambers.

A complex experiment to study scattering amplitudes of neutral kaons on protons (in the momentum range 15 to 25 GeV/c), being carried out by a team from Dubna, started taking data in May of this year. The detection equipment includes a spectrometer with magnetostrictive spark chambers placed before and after the magnet, all operating on-line to a BESM-3 computer. The system is triggered by hodoscope counters. 100 000 triggers had been registered prior to the shutdown at a rate of twenty per cycle and preliminary results on the regeneration cross-section may be presented at the Kiev Conference.

An experiment on elastic scattering of negative particles on hydrogen using a hodoscope system of scintillation counters has begun taking data and has some preliminary results.

The study of elastic proton-proton and proton-deuteron scattering, using the internal beam of the synchrotron, has been completed. This experiment used the gas jet target developed at Dubna (see vol. 10 page 190) together with semiconductor detectors and had very low background.

A search for new heavy particles and antinuclei with lifetimes in excess of 10^{-8} s is in progress using time-of-flight techniques.

Observation of antihelium—3 in an experiment which finished at the end of last year has already been reported. Five such nuclei were detected, for the first time, from among 2×10^{11} particles, using Cherenkov and scintillation counters.

More recently, experiments with antiprotons and antideuterons were completed measuring such things as the mass, absorption cross-sections and binding energies for the antideuteron. The total cross-sections of antiproton-deuteron and antideuteron-proton have been compared as a check of CPT invariance. No difference between the cross-sections was detected within the limits of the experimental errors.

The missing mass spectrometer experiment (the second CERN-Serpukhov experiment which was described in vol. 10 page 78), has begun well. On 18 May all the equipment was assembled and the first data taking run began on 28 June using a pion beam set at 25 GeV/c to scour the missing mass range from 2 to 3.5 GeV. The quality of the beam has been very good and it is hoped to have recorded several million triggers before the end of the year. There have been difficulties at the Geneva end of the 'aeroplane-on-line' system, whereby it had been hoped to have very rapid turn-round of the data tapes from the experiment brought daily to CERN for analysis on the CDC 6600, but the use of a telex print-out from CERN to the local control room in the Serpukhov experimental hall has given a 24 hour feed back of results. A link between the CDC 3100, which is used on-line in the experiment, to the BEMC 6 large computer at Serpukhov is being developed so that the Serpukhov scientists in the collaboration can participate more fully in the analysis stage. The collaboration is going extremely well.

Among the experiments which are in course of preparation are a search for the W boson, a search for Dirac monopoles, a study of polarization effects in high energy negative pion-proton scattering (a Saclay/Serpukhov experiment) and a study of pion-electron scattering which will be carried out by scientists from Dubna, Serpukhov and several Laboratories in the USA. (This is the first Soviet-American collaboration in an experiment involving equipment transfer. The USA component of the joint team will be led by D. J. Drickey of the University of California Los Angeles. Also, two Soviet scientists, P. Ermolov and A. Mukhin, are at Batavia and Soviet teams will be able to propose experiments for the USA 500 GeV accelerator.) The experimental programme of neutrino research is still being evolved. It will use the heavy liquid bubble chamber, SKAT, which is scheduled to be in operation by the end of 1972. The other main component of the bubble chamber programme will involve Mirabelle and has been described before in CERN COURIER (vol. 10, page 118).

BATAVIA
66 MeV linac beam

On 30 July the first three linac tanks were all in operation to produce a proton beam accelerated to 66 MeV. Of the remaining six tanks — tanks 4 and 5 are completed; tanks 6, 7 and 8 are being assembled; the last components for tank 9 are expected to be delivered soon. The linac's next big date is 1 October when it will deliver a 139 MeV beam to the 8 GeV Booster.

A quarter of the Booster ring is installed and has been powered. Part of the injection line, which will bring in a 200 MeV beam when the linac is completed and is in operation, controlled and adjusted via a computer. The first two r.f. cavities for the Booster were moved into place on the scheduled date of 24 July. (These scheduled dates, known to some by the resounding name of 'mile stones', are referred to by those responsible for meeting them as 'mill stones'. But they haven't missed many yet.)

The first five cells of the main magnet ring were installed by the end of July. A hundred magnets had been completed by then and manufacture, by the Laboratory itself, of the inner coils which need more careful control is ahead of schedule and ahead of the rate at which outside manufacturers are producing the outer coils.

OXFORD
Fast PEPR System

In the course of measuring its first 13 000 production events, a PEPR device constructed at Oxford University in 1966-67, has measured film of 740 MeV/c negative pion-proton interactions at rates of between 150 and 430 events per hour. The upper rate is obtained when measuring two prong events (on average one event per 4 frames) for which frame number, topology and vertex guidance (to 1 mm accuracy on film in *one* view) have been defined by an operator at a conventional scanning table. While the experiment was chosen to be a simple one to measure and the total number of events in it was small, the Oxford group believes its results are a foretaste of the high measur-

Table: — Vital statistics for the measurement of a 10 000 event batch of two prong events on film of 740 MeV/c negative pion-proton interactions.

Vertex position in one view zoned to:	4 mm
Elapsed time:	80 hours
PDP6 time:	64.6 hours
Auto events:	8728
Helped events:	1370
Total events:	10 098
Total events/PDP 6 time:	156 events/h
Helped events/total events:	13.5 %
MATCHING/ GEOMETRY failures:	13 %
Kinematics failures:	1.5 %
Helix fit statistics:	
Peak:	7 μm
1 % tail beyond:	25 μm

ing speeds that CRT devices will be reaching routinely in the next year or so.

PEPR is a CRT line digitiser of the type first proposed and constructed by L. Pless at MIT. The Oxford system is similar to that of MIT except that a PDP6 computer is used rather than a PDP10, and an improved CRT has been developed to give a smaller and brighter line on the film. The programs used at Oxford occupy 30 K words of storage with the general strategy derived from the successful POLLY system at Argonne (CERN COURIER vol. 9, page 275) which enables tracks associated with a vertex to be rapidly distinguished from all others in the zone of interest. The main difference from POLLY is that all detection, following, and measurement of tracks is done by using a 1 mm long line image on the film (formed by the action of quadrupoles on the electron beam of the CRT).

The line is handled by basic scanning routines, which are the only part of the program not written in Fortran IV. A particularly fast track-following program has been written, which maintains the line tangential to the track while predicting along its length. A typical beam track from the 80 cm hydrogen bubble chamber can be followed and completely measured in about 60 ms. The program outputs 'master points' on all tracks which it has associated with a vertex in a given view. A specially written off-line MATCH program matches the track images from all three views, labels them, and discards any redundant tracks which may have appeared to intersect the vertex in some view. The remaining tracks are ready for input to the geometrical reconstruction program where they are indistinguishable from manual measurements — except that, as with HPD and other automatic machines, the helix fit residuals are found to 'peak' some 3 μm lower.

The PEPR programs include 'HELP' facilities using a monitor CRT on which the program presents to the operator a local scan of any area of film in which some doubt or ambiguity has arisen. The operator can then indicate exact vertex position, clear points on tracks, etc. using a light pen. However, allowing the operator to intervene and attempt to rescue all doubtful events on-line, reduces the measuring rate to only 150 events/hour.

In future production runs, a compromise may be adopted in which events whose beam track is not clearly distinguishable from other beam tracks in at least two views (by 100 μm for at least 5 mm) are detected in the pre-scan and not presented to PEPR at all. This will reduce the need for operator intervention to around 5 % of events measured, so that a measuring rate of 200-300 events per hour is maintained.

The next production run will be some 100 000 events on film from the CERN 2 m hydrogen bubble chamber of 3.6 GeV/c negative kaon-proton interactions. Experience 'tuning up' for this run indicates that four and six prongs are measured as fast as two prongs. New programs have been included to measure ionization of all tracks and end points of stopping tracks. Both use the spot (instead of the usual line), scanning it across the track at 10 μm or 20 μm intervals. Preliminary measurements on minimum ionizing tracks show a standard deviation of about 10 % on the measured ionization: this measurement takes about 100 ms extra per track output.

Once the negative kaon-proton experiment is solidly in production, development work will begin on dispensing with the prescan information altogether for experiments in which the film quality is good (i.e. uniform illumination and beam distribution). At the same time, a three-view PEPR is being constructed to allow immediate access to other views of a given track, to avoid the disadvantages of doing a 'post mortem' match as at present.

The PEPR system for the automatic measurement of bubble chamber film constructed at Oxford University. It is currently measuring film at rates in excess of 150 events per hour and could be capable of development to very high measuring speeds.

(Photo Oxford University)

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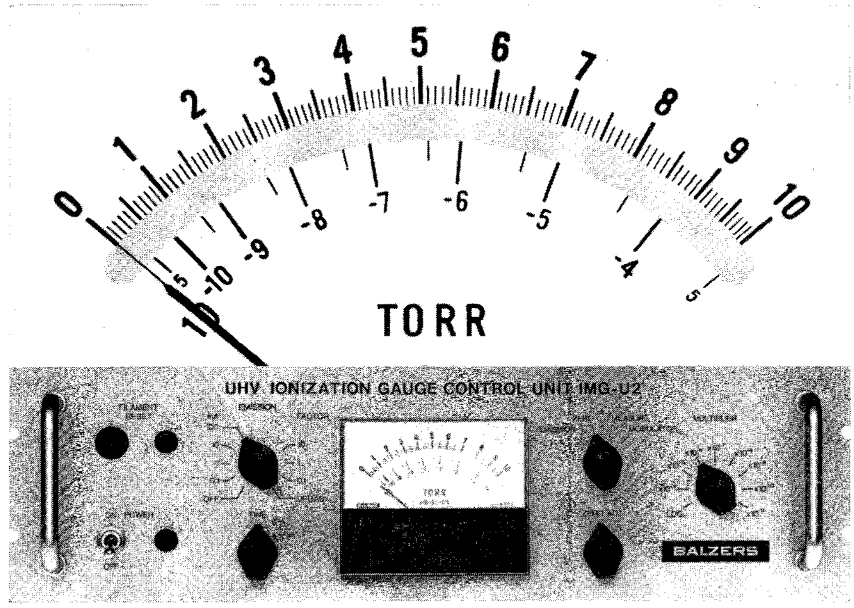


This instrument is compact, reliable and extremely accurate. It is the ideal instrument for exacting requirements in laboratory and production applications where the success of any vacuum process depends on accurate and reproducible indication of the pressure in the high and ultra high vacuum range. For example, in nuclear research, in space simulation chambers, in the investigation of absolutely clean surfaces, and in UHV coating plants etc. In developing the IMG-U 2, which has evolved from the well-known IMG-U 1 — the aim was to construct a hot cathode ionisation manometer so reliable in operation that the major advantages of this principle, namely, accurate and reproducible indication of pressure, could be ultilised to the fullest possible extent.

Not only does the IMG-U 2 fulfil this basic aim, but also:

- its measuring range is extended in the ultra high vacuum range;
- it has an additional logarithmic measuring range;
- it can be operated with any Bayard-Alpert gauge head.

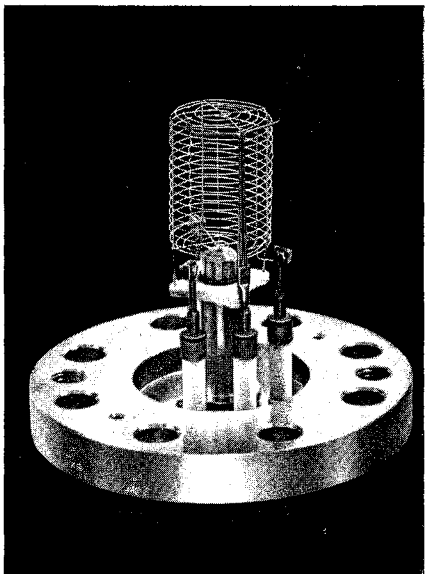
Other features:

- very wide measuring range, total pressure indication over 11 linear decades;
- continuous pressure indication from 5×10^{-4} to 5×10^{-11} on logarithmic scale, respectively 5×10^{-5} to 5×10^{-12};
- extended emission range, with stabilised, infinitely variable emission current;
- high stability of the measurement amplifier with minimum zero point drift;
- gauge factors adjustable, fixed at C = 5, 10 and 25, infinitely variable from 5—30;
- selector switch provided for operating gauges with a modulator;
- filament protection relay which switches off the filament in the event of excessive pressure rise (provided with an additional make and break contact for other monitoring or control functions);
- signal outputs of 10 and 100 mV allow connection of additional instruments for monitoring, control and regulating;
- the IMG-U 2 can be used as a 19" rack module, or if provided with side panels, as a bench model which can be stacked.

Gauge Heads for use with the IMG-U 2

Any Bayard-Alpert ionisation manometer gauge heads (either with or without modulator) can be operated with this instrument, but to obtain the guaranteed performance of the IMG-U 2, it is advisable to use gauge heads either built or recommended by BALZERS:

- glass gauge heads with 2 pure metal (W), or burnout proof oxide cathodes with hard glass seal suitable for connecting to pyrex glass;
- highly sensitive immersion gauge heads on metal flanges, with interchangeable tungsten cathodes and either with or without a modulator, depending on the gauge head type.



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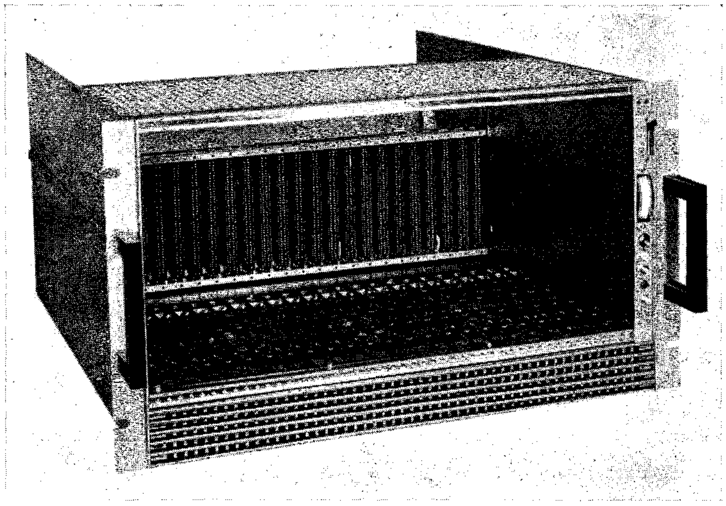

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Plage de réglage	± 2 %	± 2 %	+ 5 à —15 %	+ 5 à —15 %	± 10 %
Précision du réglage	$\pm 5.10^{-4}$	$\pm 5.10^{-4}$	$\pm 10^{-3}$	$\pm 10^{-3}$	
Taux de régulation en fonction du réseau (+10 % à —12 %)	$\pm 5.10^{-4}$				
Régulation pour 100 % de variation de charge et des variations du réseau (+10 % à —12 %)	$\pm 10^{-3}$				
Stabilité globale (réseau-charge-température)	$\pm 5.10^{-3}$	$\pm 10^{-2}$	$+2{,}5.10^{-2}$	$\pm 10^{-2}$	$\pm 10^{-2}$
Coefficient de température de +10 °C à +45 °C	5.10^{-5}/°C	2.10^{-4}/°C			3.10^{-4}/°C
Dérive en fonction du temps 8 h 24 h. 6 mois	10^{-3} $\pm 3.10^{-3}$ $\pm 5.10^{-3}$				
Fluctuations en sortie crête à crête	⩽ 2 mV	⩽ 2 mV	⩽ 5 mV	⩽ 5 mV	5 mV
Réponse transitoire (overshoot et undershoot ⩽ 10 %)	⩽ 20 µs				
Stabilisation thermique	⩽ 30 mn				
Plage de température	0 °C à +55 °C				
Impédance dynamique de sortie jusqu'à 100 kHz	⩽ 0,3 Ω				
Sécurité électronique en courant	individuelle par limitation de courant				fusible
Disjonction de l'alimentation provoquée par des surtensions de:	+15 %	+15 %	+25 %	+15 %	
Protection thermique	2 vigithermes: 0 max. —20 °C: voyant blanc 0 max.: coupure de l'alimentation				
Réseau	220 V 50 Hz (possibilité 117 V)				

SAPHYMO-SRAT

DÉPARTEMENT ALIMENTATIONS

SERVICES COMMERCIAUX

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75-PARIS XIII[e]
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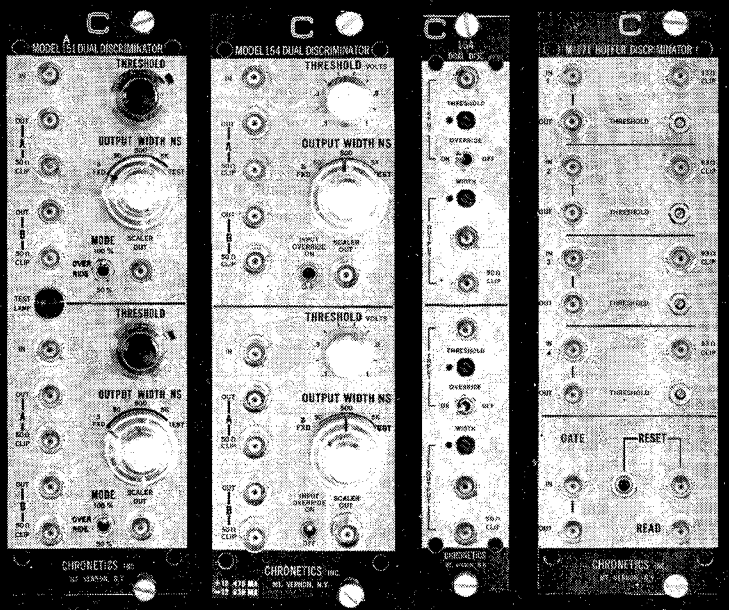

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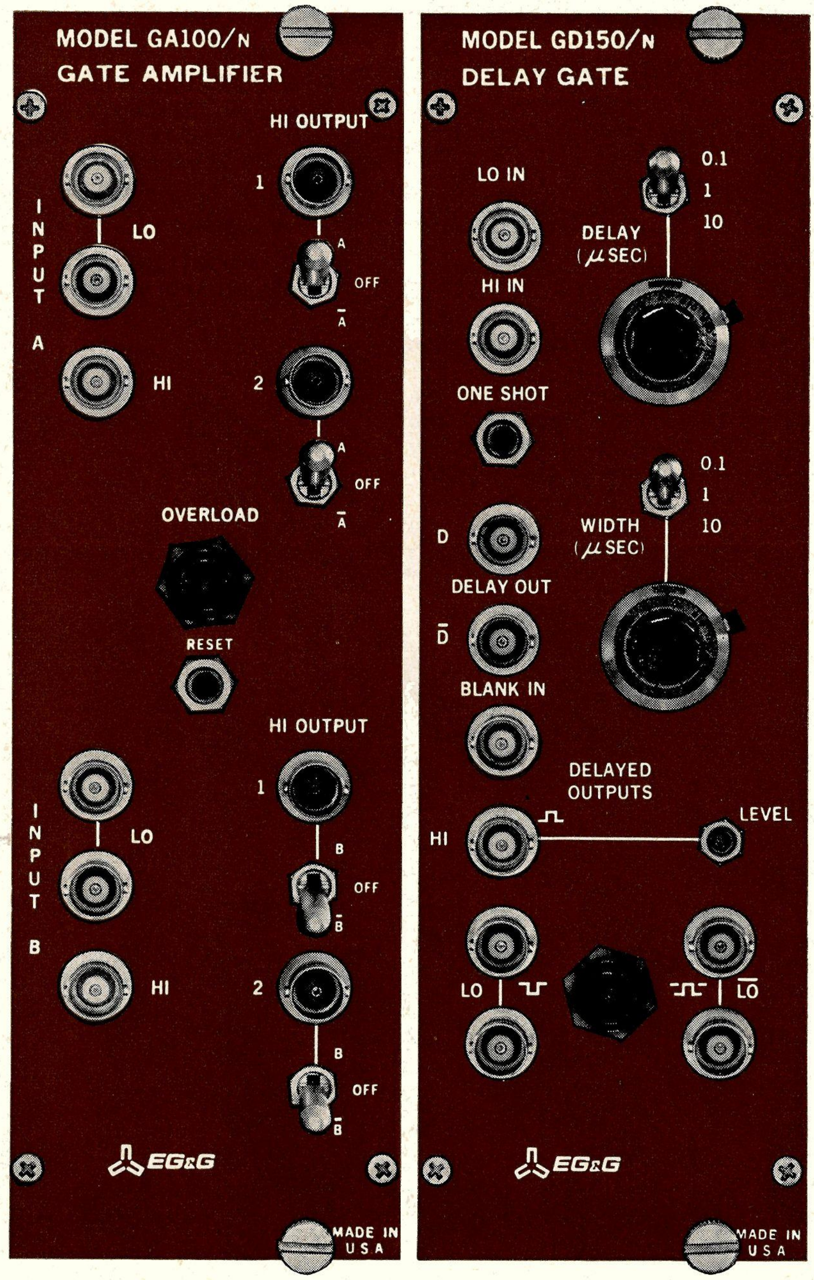
Gate problems stop here

The GA100/N
First gate amplifier module with built-in power supply to conserve premium bin power.

Inputs:
Lo In:
Direct-coupled "bridging" input for NIM-standard fast logic or complement logic signals.
Hi-In:
Direct-coupled for NIM-standard slow data transmission signals. Also accepts negative signals (—4 to —12V).

Outputs:
Fanout:
Two independent outputs per section.
Levels:
Normal or complement.
"1" = 10V at 250 mA max.
"0" = sinks up to 200 mA at output voltage <1 V.
Width:
Approximately same as input width.
Risetime:
100 nsec (can be changed to a minimum of 50 nsec).



The GD150/N
Precision delay and gate functions provided in one module.

Inputs:
Lo In:
NIM-standard fast logic signal of width wider than 2 nsec.
Hi In:
NIM-standard slow data transmission signals (+3 to +12V). Also accepts negative signals (—2 to —12V).
One Shot:
One and only one output per switch activation.
Blank In:
NIM-standard fast logic signals of width greater than 5 nsec. Delayed outputs are blanked for duration of blanking input.

Timers (delay and width):
Range:
0.1 μsec to 110 μsec.
Accuracy:
10 nsec or ±5% of setting.
Random jitter:
< 1 part in 10^4.

Outputs:
Delay:
One normal and one complement NIM-standard fast logic output for duration of delay interval.
Hi Out:
+2.5 to +10V, adjustable; for duration of width interval.
Lo Out:
One "dual" normal and one "dual" complement; for duration of width interval.

EG&G
NUCLEAR INSTRUMENTATION DIVISION

Make the most of the gating features of each — or combine them for greater fanout and more flexibility. For additional information on the solution of your gate problems, contact EG&G Inc., Nuclear Instrumentation Division, 36 Congress Street, Salem, Massachusetts 01970. Phone (617) 745-3200. Cable: EGGINC-Salem. TWX: 710-347-6741. Telex: 949469.

Tips + Topics

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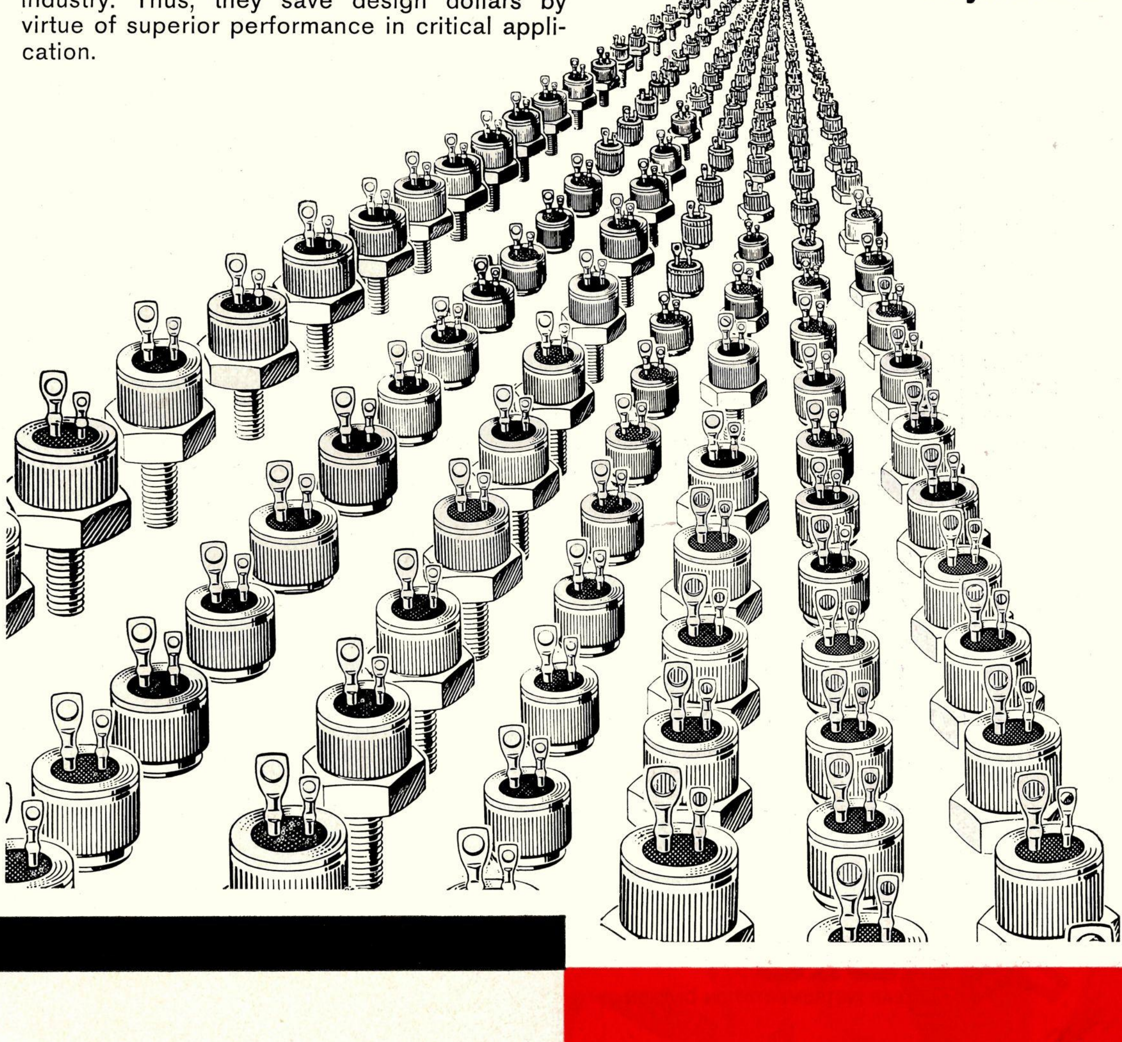

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