CERN

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European Organization for Nuclear Research

The cover photograph was taken during one of the lectures in the series 'Science for All' given by Rafael Carreras. These general lectures are organized, by the Training and Education Services, for CERN staff who are not professionally trained in science. They have proved very popular, attracting an average audience of over 400 people. An interview with Guy Vanderhaeghe, head of the Training and Education Services appears on page 226.
(CERN/PI 131.12.66)

Comment

CERN is in transition from a Laboratory built for the 1960s to a Laboratory built for the 1970s. The existing accelerators, the 600 MeV synchro-cyclotron and the 28 GeV synchrotron, were the product of the state of sub-nuclear physics and of accelerator technology ten years ago. With these machines, the physics has been pushed much further; it now calls for higher energies, more intense beams and more versatile use of accelerators to answer the questions which have arisen.

In parallel, accelerator technology has advanced so that we can now design a 300 GeV machine, can build storage rings for high energy particles, can cope with higher intensities, and can use accelerated beams in a variety of ways. Particle detection techniques have developed in step, so that use can be made of the increased capabilities of the accelerators. The technology and the physics are so interrelated that it is a 'chicken and the egg' question as to which comes first.

Thanks to the confidence of the Member States, CERN is being financed to reconstruct and to add to its facilities, taking advantage of the advances in technology to meet the physics requirements of the 1970s. The first phase — including increasing the repetition rate of the proton synchrotron and providing new facilities for neutrino research — is nearing completion. The second stage — including a large hydrogen bubble chamber, a new injection system for the synchrotron (see page 223), new equipment for electronics experiments and a new experimental hall — will follow. In addition, the intersecting storage rings are being built, and collaboration with Serpukhov is opening up.

This is a heavy programme of investment in research equipment and while it is being carried out, the demand for use of the existing CERN facilities is exceeding predictions. It is not easy to balance available resources between meeting the immediate demand and preparing for the future. But when the programme is completed, European physicists will continue to have first class equipment at their disposal at CERN until the proposed 300 GeV Laboratory could be well under way.

Contents

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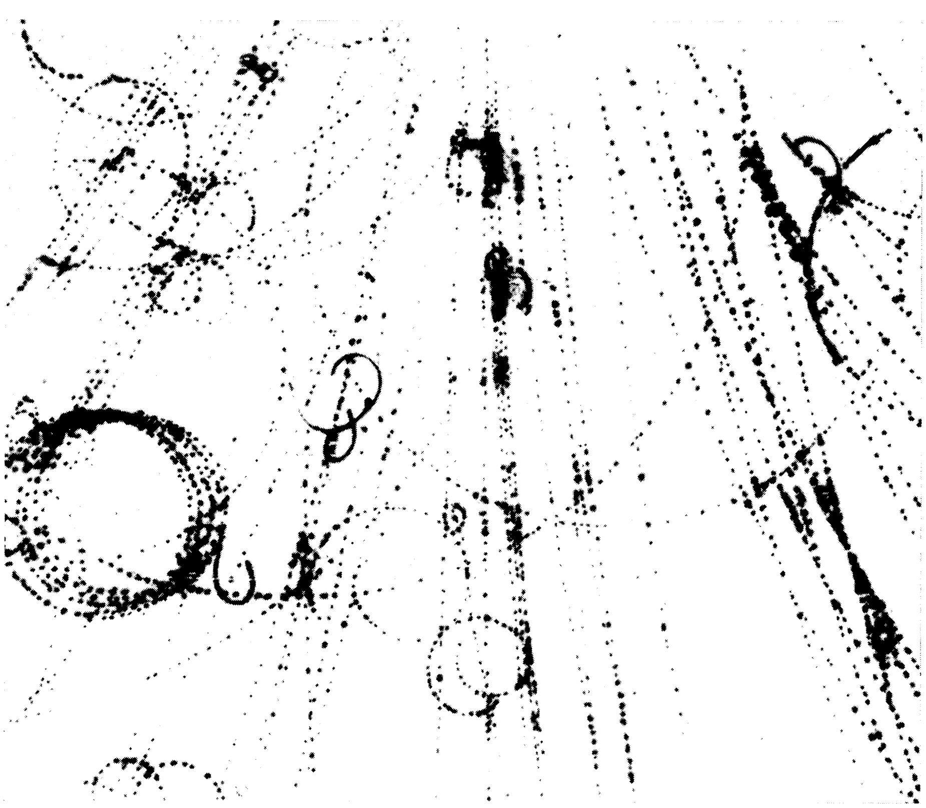
CERN, the European Organization for Nuclear Research, was established in 1954 to '... provide for collaboration among European States in nuclear research of a pure scientific and fundamental character, and in research essentially related thereto'. It acts as a European centre and co-ordinator of research, 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.

CERN News



This remarkable photograph, which could easily be mistaken at first glance for a bubble chamber photograph, was taken by G.E. Chikovani in a 'wide-gap streamer spark chamber' set up in a magnetic field.

Wide-gaps at the PS

An array of wide-gap spark chambers has been installed at the 28 GeV proton synchrotron for a boson spectrometer experiment which has just been set up on an unseparated pion beam (q5) in the South Hall. The experiment uses a magnetic spectrometer (see CERN COURIER vol. 7, page 31) to look at the mass spectrum of negative bosons. It involves a new experimental method and new detection techniques. The experiment is being done by a mixed team from Berne, Geneva and CERN. This first run on the q5 beam is to test the equipment and the method before using a high momentum beam, to explore the mass range up to 5 GeV.

The wide-gap spark chamber is a further stage in the very rapid evolution of the spark chamber technique. The 'conventional' spark chambers were developed in the late 1950s. They consist of a series of thin, parallel plates of metal separated by gaps of a few millimeters filled with a gas such as a mixture of neon and helium. High voltage pulses (a few kV) are applied to alternate plates and the ionization, created in the wake of a charged particle travelling through the chambers, causes sparks to leap between the plates where the particle passed. The position of these sparks and hence of the particle track can be recorded either photographically (optical spark chambers) or by detecting the sound of the spark (sonic spark chambers).

Optical spark chambers have also been set up in a magnetic field (by a team lead by A. Michelini at CERN) where the tracks of charged particles are curved, as in the bubble chamber, and observation of the sparks then gives momentum measurements.

Quite recently, it has become possible to replace the metal plates by planes of wires, which makes direct electronic detection of the spark positions feasible and enables sparks to be recorded in quick succession.

The advantage of spark chambers vis-à-vis bubble chambers is that they can be triggered by counters so that only events of interest are recorded. Up to now, they have not however been capable of giving complete reconstructions of events as is possible in bubble chambers. They could not record tracks parallel or nearly parallel to the plates, as opposed to the isotropic detection capabilities of bubble chambers, and were ineffective for detecting events occurring within the volume of the spark chamber. Two recent developments indicate that these limitations will be overcome.

In 1961, a group in Moscow, led by B. I. Dolgoshein, invented the 'wide-gap' spark chamber. With a gap of several centimeters between the plates, across which a much higher voltage is applied, a continuous spark can be detected, rather than a series of short sparks in an array of conventional chambers; much higher accuracy in determining the track position becomes possible, some events occurring within the gap can be detected, and, most importantly, several sparks occurring at the same time can be identified. In 1963, another USSR group led by A. I. Alikhanian, successfully operated a 'wide-gap' spark chamber in a magnetic field.

Soon after this, a Russian group under G. E. Chikovani (who is now in the group at CERN doing the experiment using wide-gap chambers) announced what may prove the most significant development of all. They developed what they called a 'wide-gap streamer chamber'. Here a very high voltage pulse, about 10 kV per centimetre, is applied across widely spaced plates for a few nanoseconds. Sparks are not given time to develop right across the gap between the plates but appear only along the tracks of the charged particles as a streamer of tiny sparks (see the photograph). Tracks can be observed going in any direction and events occurring within the volume are seen. Any number of sparks can be observed.

A very large chamber of this type (2.3 m long, 1.5 m wide and 0.6 m high) is in operation at the 20 GeV electron linear accelerator at Stanford, USA. A 600 kV pulse is applied for 10 ns to a centre plane of wires with two outside planes earthed. It can be operated on each pulse (360/s) of the accelerator. The chamber is in a field of 15 kG and photographs are taken through the wires. The target in the experiments is a thin tube

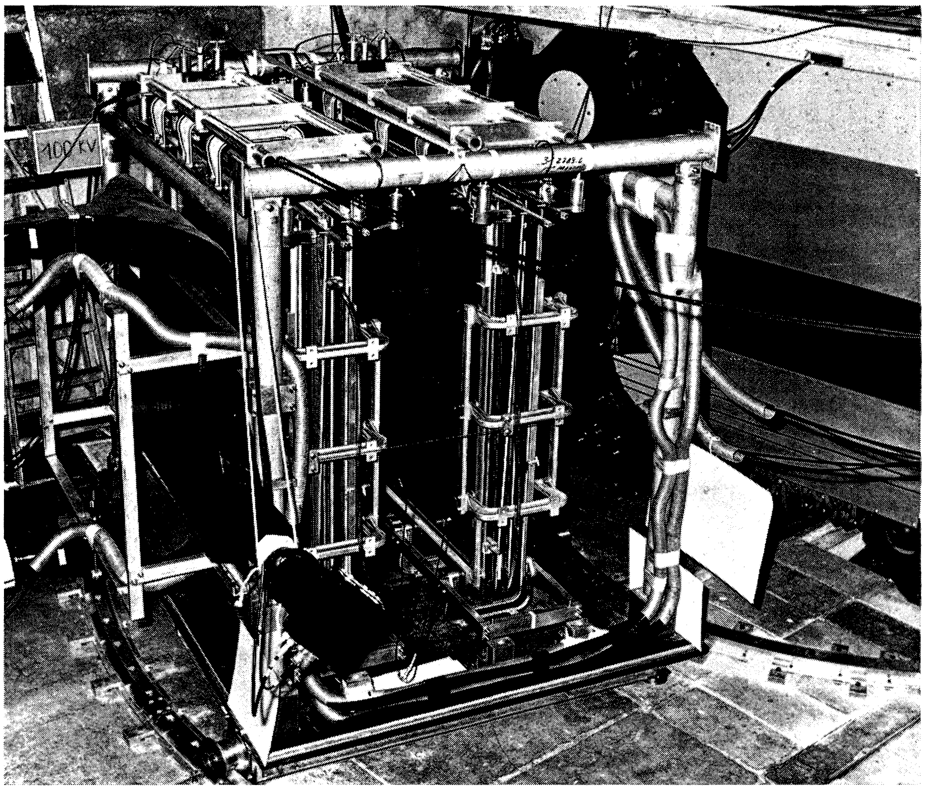
One of the arrays of wide-gap spark chambers in the boson spectrometer experiment. The large magnet can be seen on the right, and the black-covered scintillation counter, which triggers the chambers, on the left. Also visible are the tracks of the turntable which enables the spark chambers to be moved to examine different parts of the boson mass spectrum.

Shortly before the counting of the votes cast in the Swiss elections was performed on the CDC 3800 computer, a dress rehearsal was held at CERN. In the photograph, various representatives of the Geneva Cantonal Administration and of the political parties can be seen in the computer room.

of hydrogen, running parallel to the wire planes, through the centre of the chamber. The capabilities of such a chamber are obviously very similar to the largest bubble chamber at present in use, with the advantage that the streamer chamber can be triggered to record only the events of interest.

Digitized wide-gap spark chambers were developed here at CERN by G. E. Chikovani, G. Laverrière and P. Schubelin. The boson spectrometer team used these chambers in an experiment earlier this year when they achieved direct electronic read-out from this type of chamber for the first time. In the experiment now mounted at the proton synchrotron, there are two wide-gap spark chamber arrays, each with four 5 cm gaps across which 50 kV is applied. Planes of wires are used and the co-ordinates of the particle tracks can be tapped off directly from the wires between which the sparks occur using magnetostrictive read-out (see CERN COURIER vol. 6, page 43). The chambers were built at the Physics Institute of Bern University.

The spark chamber arrays sit either side of a large magnet which will bend the forward proton produced in the interaction — pion plus proton gives negative boson plus proton. With this system, very accurate determination of the proton momenta is obtained making it possible to resolve the fine structure in the boson mass spectrum much better (within 6 to 7 MeV) than in previous experiments of this type. Extremely good detection efficiency is achieved — 99 % for single sparks and over 90 % for three sparks compared with 50 % for single sparks in an equivalent array of sonic chambers which was previously used.



CERN/PI 36.11.67

Counting votes at CERN

A CERN computer, the CDC 3800, counted the votes registered in the Canton of Geneva for the Swiss elections to the 'Conseil national' and the 'Conseil des Etats' on 29 October. This operation was carried out under a contract between the Geneva Cantonal Administration and CERN.

CERN/PI 171.10.67

Starting at mid-day for advance votes, but mainly during the evening of the Sunday of the elections, the voting papers were collected together at the Palais des Expositions in Geneva, and the votes were transferred to punched cards. The cards were then brought to CERN by police car and fed to the computer. Two punched cards were completed for each voting paper, so that cross-checking was possible to guard against mistakes. The data was read by a card reader, at the rate of 1200 cards per minute, onto two magnetic tapes. This data was then compared in the computer card by card, and any differences were corrected by repunching the appropriate cards. The total for each polling centre was also recorded on tape.

The computer then calculated the results for each commune, and for the whole canton. A fast line-printer (1000 lines per minute) fed out the figures. The computer was also used to calculate various statistics concerning each candidate and each party.

In the computer room, which was open during the counting only to those with a special pass, the polling officers were present to ensure that everything was in order.

It was not possible to produce all the results by midnight as was hoped but the computer itself did not cause the delay. Faulty punching of cards was the main problem, as considerable time was involved in repunching them correctly. Nevertheless, completely checked results were available by early the following morning. This electronic counting of the election votes was the result of close collaboration between CERN (which made the computer available), the University of Geneva (which did the programming) and the Geneva Cantonal Administration (which looked after the organization and coordination).

The moment of lambda

One of the most difficult and complex nuclear-emulsion experiments ever undertaken, finished its exposures at the proton synchrotron on 19 October. It concerns the measurement to high precision of the magnetic moment of the lambda hyperon. (For a full description of the experiment see CERN COURIER vol. 6, page 85.)

The experiment used a negative pion beam, derived from the fast-extracted proton beam in the East Hall, producing lambdas in a polyethylene target. They were passed through a very high magnetic field, which rotated the direction of their magnetic moment, before being detected in nuclear emulsion as they decayed into a pion and proton. Measurements of the pion and proton directions in the emulsion make it possible to determine the average amount by which the direction of the magnetic moment has been rotated, and thus, knowing the strength of the magnetic field, the value of the magnetic moment itself.

The pion beam is thought to have been the most intense ever produced in terms of flux per cm^2; over 10^7 pions were focused onto the target in a spot a few mm^2. This was not far from an optical image of the target in which the pions were produced and was achieved after a great deal of work with the beam optical system. A pulsed magnet was used to produce the very high field; the average field was around 210 kG and some of the exposurers were taken with a field of about 230 kG. (The charging time of the condenser bank providing the current pulse, and heat problems connected with the pulsed magnet restricted the experiment to 1 pulse in 10 from the synchrotron.)

The emulsions, 1.2 mm thick, were assembled in tiny stacks (about the size of a chocolate) and 120 of these stacks were exposed. The emulsions have now been peeled apart, developed, mounted on glass and distributed to the various centres — Ankara, CERN, Lausanne, Munich and Rome — involved in the experiment. It is expected that the scanning and analysis will take rather more than a year. A preliminary examination of some of the emulsions indicates that the number of lambda decays which have taken place in the emulsions is close to that expected and the experiment will yield a value for the moment of the lambda much more precise than achieved before.

Before the beam-line to the lambda experiment was dismantled, a further nuclear-emulsion experiment, which required only a few hours of synchrotron time, took advantage of the intense flux of pions and extremely good optics of the beam to examine the elastic scattering of pions on helium nuclei.

The beam was directed into a helium target in which nuclear-emulsions were placed to record the energy and direction of the recoil helium nuclei (which are doubly charged and hence can be easily distinguished). The experiment was carried out by a joint CERN/Clermont-Ferrand team. It will test the 'multiple scattering' theory of elastic collisions of particles with nuclei put forward by R. J. Glauber.

Scooterized stores

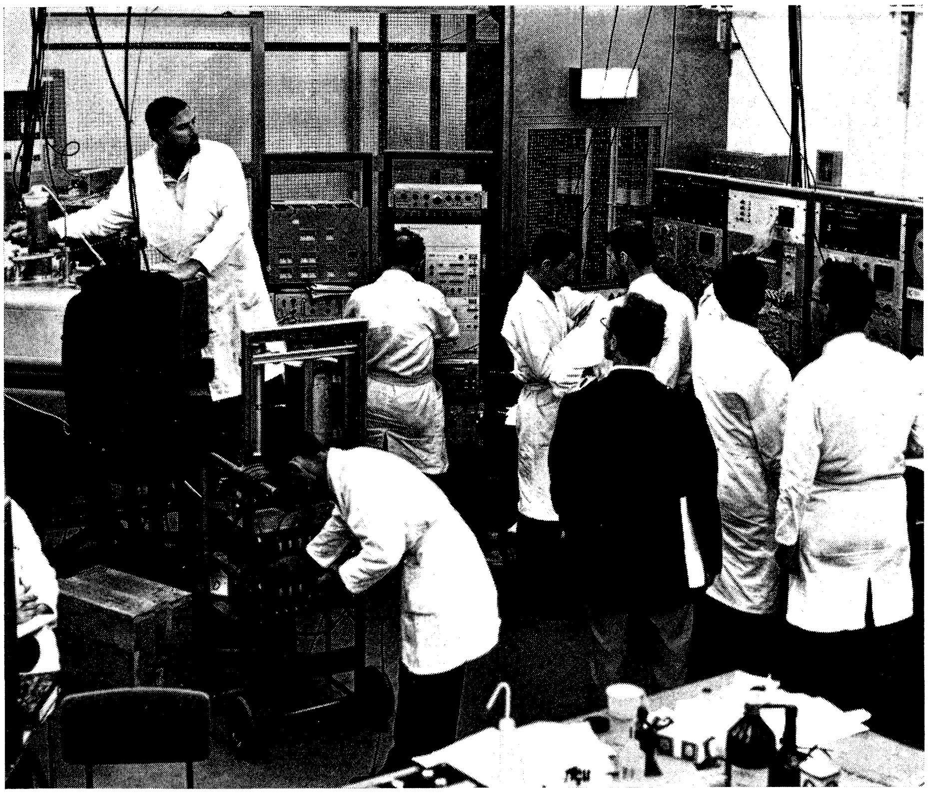
About two years ago, it was decided to construct a Central Store which would concentrate the goods reception points and the stores which are at present distributed around the site. A thorough study was carried out to decide on a scheme which would meet CERN's requirements until well into the 1970s. The scheme which evolved will provide CERN with one of the most modern stores in Europe.

A solution was sought which would make it possible to stock both large and small items in this Central Store and to improve the efficiency of stores handling without a corresponding increase in the number of staff involved.

An invitation to tender was sent to firms in Europe on 5 May 1967 and seven offers were received. After considering the various possibilities, the Finance Committee awarded the contract to the UK firm, Dexion Ltd., at a cost of about 800 000 Swiss Francs.

Their proposal is for a storage hall of a light metal structure with storage racks forming part of the footings. The system of storage is in pallets served by two stackers with lateral forks, mounted on overhead travelling cranes. The movable racks can be dismantled and will have a maximum height of 8 m. The Central Store will have a volume of 13 000 m^3 and a storage capacity of 6 000 m^3.

In the initial phase, the system of handling will be semi-automated and it will be



CERN/PI 148.10.67

Members of the ISOLDE team from Sweden and CERN at work during their first very successful test run during which they observed several new short-lived radioactive nuclides.

CERN/PI 82.11.67

The 'Conseil Suisse de la Science', which is responsible for science policy in Switzerland, visited CERN on 8 November. Members of the Council including the President, Mr. M. Imboden, discussed the 300 GeV accelerator project with senior staff from CERN. The photograph was taken during a tour of the Laboratory and shows the Council listening to Professor Ch. Peyrou in the Control Room of the 2 m bubble chamber.

possible to make it subsequently more fully automated at little extra cost. Even the store-keepers will become semi-automated since each of them will be provided with a small scooter. These will move at a speed of 15 km per hour and will carry a maximum load of 200 kg. It is estimated that they will save the store-keepers' shoe leather to the extent of some 10 km per day.

The overall plan for reorganizing the Stores Service includes four other smaller stores on the Site : a North Store for Track Chambers and Technical Services and Buildings Divisions, a South Store for Proton Synchrotron and Nuclear Physics Apparatus Divisions, an East Store for Nuclear Physics, Synchro-cyclotron and Data Handling Divisions, a West Store (to be built on the French site in 1968) for Intersecting Storage Rings Division.

The foundations of the Central Store and its associated administrative block are being constructed by the Technical Services and Buildings Division; excavation began on 1 July near the present general store, and the installation of the prefabricated metal structure, the fittings and the storage equipment started at the beginning of October. Installation of the movable pallet racks will begin in January 1968 and all the work will be completed by May next year. The new Central Store will be commissioned in July 1968.

It is intended that this reorganization should solve the storage problems on the site until 1975, about 4 years after the storage rings come into operation.

ISOLDE in operation

We announced briefly in the October issue that the isotope separator on-line, ISOLDE, had received its first proton beam onto a target and that the first observation of separated isotopes had been made on the night of 16 October. We can now add some more information.

On 2-3 November, a seminar was held at CERN on 'ISOLDE Chemistry Problems' attended by about 50 scientists from 10 countries, including Israel, USA and USSR. At the opening talk, G. Rudstam reported on the first test run. In this run, some short-lived radioisotopes were observed for the first time and some measurements of their properties were carried out.

ISOLDE uses a proton beam from the 600 MeV synchro-cyclotron to produce radioactive nuclides in specially prepared targets. The isotopes can be separated by chemical and electromagnetic techniques and the individual isotopes can then be studied. By having the production, separation and measurement stages all linked directly together, it is possible to investigate some radioactive nuclides with much shorter half-lives (down to the order of a few seconds) than was previously possible. This work will provide more knowledge of the properties of the nucleus. (For a full description of the project, see CERN COURIER vol 7, page 23).

Very good beams from the synchro-cyclotron have been achieved onto the target (about 3×10^{11} protons per second focused to a few cm^2). They have to be guided down through the foundations of the synchro-cyclotron building to the underground laboratory where the ISOLDE

A photograph of the ejected proton beam in the neutrino beam-line passing through (top to bottom) argon, helium, helium-neon mixture, xenon, helium at a pressure of 100,10 and 1 torr, and air. The photograph was taken during 200 pulses from the synchrotron.
The series of neutrino experiments, which proved very successful, came to an end in November. Further information on the experiments will appear in the December COURIER.

equipment is installed. The laboratory has been constructed underground to keep radiation levels outside within the permissible limits.

Isotopes of xenon, iodine and krypton were measured during the run. For these elements the chemical separation stage was necessary. The isotopes Xe^{116} and Xe^{117} were observed for the first time and their half-lives were measured as around 50 s. Traces of another previously unobserved isotope Kr^{73} were also seen but were insufficient for measurements. The experience it has provided will make it possible to optimize various components ready for the start of more detailed experiments in December. The achievements of this first run are very encouraging signs for the success of the project.

ISOLDE involves many universities and research institutes throughout Europe as well as the CERN Nuclear Chemistry group. They include Aarhus and Copenhagen in Denmark, Heidelberg in Germany, Oslo in Norway, Gothenburg, Stockholm and Studsvik in Sweden, and Orsay in France.

Booster synchrotron

The study group which has been examining the possible schemes for increasing the injection energy into the proton synchrotron have recommended the construction of a 800 MeV booster synchrotron. The construction of a new injection system is part of the second stage of the improvement programme for the 28 GeV machine. The higher injection energy will permit an increase in the intensity of the proton beam accelerated at each pulse.

The proposed Booster consists of four stacked rings, 50 m in diameter. It would make it possible to increase the average intensity of the large synchrotron to 3 x 10^{12} protons per pulse, and 10^{13} protons per pulse for limited periods. The particular advantage of the selected scheme is that it could give collision rates in the intersecting storage rings about 100 times higher than was previously anticipated.

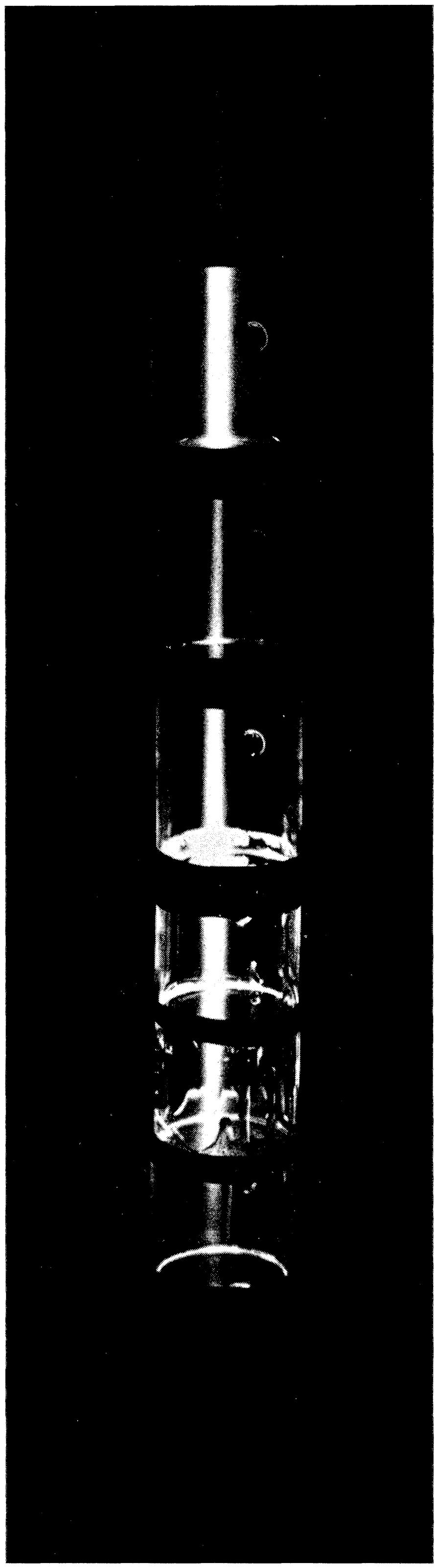
The estimated cost of the improvement is 69.5 million Swiss francs (at 1968 prices) ; 36.6 million for the booster itself, with other costs including such things as modifications to the existing 50 MeV linear injector and a new radiofrequency system for the proton synchrotron. If the proposed scheme is agreed by the end of this year, it is planned to have the new injector in operation towards the end of 1972. An article on the Booster will appear in the January 1968 issue of CERN COURIER.

On to positive muons

The experiment using the muon storage ring to measure the value of g-2 for the muon with very high accuracy is now well in to its second phase. This measurement is a test for any small difference between the magnetic behaviour of the muon and the electron and a test of the very successful theory of the electromagnetic force down to extremely small distances. (See CERN COURIER vol. 6, page 152.)

The first series of measurements were carried out on negative muons and sufficient data was collected to enable g-2 to be calculated with an accuracy better than one part in 2000, or about ten times more accurately than before. It proved possible to observe muons stored in the ring for times as long as 150 μs and the experiment has thus, incidentally, confirmed the prediction of 'time dilation' from Einstein's relativity theory, for particles moving in a circular path. The muon at rest has an average lifetime of just over 2 μs before decaying into an electron. But because the muons in the storage ring have velocities close to that of light, we see them living longer ; their 'clocks' which tell them to decay after 2 μs are going slower. The observation of the muon decays are in accordance with Einstein's theory.

The magnetic field in the ring has been reversed in direction so that positive muons are now stored. The first runs have confirmed that the performance of the experimental equipment is as good as it was previously, so that a measurement of g-2 for positive muons to the same high accuracy is feasible.



CERN/PI 198.8.67

Tribute to Marie Curie

An introductory talk for the Marie Sklodowska Curie centennial given in Warsay on 17 October by Professor V.F. Weisskopf. (Professor Weisskopf, former Director General of CERN, is now at the Massachusetts Institute of Technology, USA). Marie Sklodowska Curie was born in Warsaw on 7 November 1867.

The century that has passed since the birth of Marie Sklodowska Curie has witnessed many events, changes, revolutions, and upheavals, which have left deep imprints on human society. Perhaps the most far-reaching change was the new insight which man has acquired during this period into the basic working of nature. It was in that century that the problems of the structure of matter were seriously attacked and, to a surprising extent, also solved. We know today, and we did not know a hundred years ago, many of the basic principles on which the behaviour of matter is founded. We have acquired a far deeper understanding of what is going on in our environment ; this knowledge also has enabled us to deal with our environment in a vastly more efficient way than before. It laid the ground for modern technology which has thoroughly revolutionized our way of life. The discoveries of Marie Sklodowska Curie initiated this development and are therefore in many ways symbolic for the new spirit of physical science.

One hundred years ago, physics was, to a large extent, a descriptive science. The question asked was 'how', and not 'why'. Examples are the description of the motion of solids or liquids in mechanics and hydro-dynamics, the description of the behaviour of electric and magnetic fields by Faraday and Maxwell, the behaviour of substances in chemistry. The chemists of that time described the reactions of atoms and molecules without explaining them.

During the lifetime of Marie Sklodowska Curie, the question 'why' was attacked in the study of material behaviour. Physics changed from description to explanation. A great development took place — the discovery of the quantum of action, of the nuclear atom, of quantized orbits and, finally, of quantum mechanics, which is the way in which atomic behaviour can be described and understood. The dynamics of the atom was discovered and cleared up, and, with this insight, all phenomena of the world of atoms and their aggregates, the fact of spectroscopy, of chemistry, of solid state, of material science, fell into place and could be explained and understood as the effects of one fundamental interaction: of the electric force between atomic nuclei and electrons. Against the background of this development, let us look at Marie Sklodowska Curie's work.

We know what important role radioactivity played, since it provided the necessary tool which enabled Rutherford to find the nuclear atom. But it was much more than this. Marie Sklodowska Curie's discovery was an anticipation of the next step which physics took more than thirty years later, a step which could only be taken after having gained insight into the workings of the atom: the search for the structure of the atomic nucleus. It introduced a new aspect into physics. When Marie and Pierre Curie isolated radium in that famous shed in the School of Physics in Paris, when they were awed by the uncanny gleam of that substance in the dark, they were looking at an extra-terrestrial phenomenon, a phenomenon which goes beyond the ordinary atomic world of our environment. We know today that what the Curies saw, was a remnant of the times when terrestrial matter was in a very different environment, in 'an exploding star. The natural radioactive substances are the last witness, the last embers still glowing, of the eventful times at which our elements were formed.

Thus Marie Sklodowska Curie's work initiated a third period in physics. It is the period which started in the 1930's, after quantum mechanics had explained the world of atoms. Then physics took a new step which we may call *the leap into the cosmos.* It started with Marie Sklodowska Curie's discovery, but it really gathered momentum only after 1930, when systematic research was done, to get at the inner structure of the atomic nucleus, to discover its composition, protons and neutrons, its dynamics and its basic laws. A new force of nature revealed itself, the nuclear force between protons and neutrons, much stronger than other forces with strange and apparently rather involved properties.

We should be aware that the processes and reactions revealed by this new branch of physics do not occur naturally on earth, except in those few processes found by Marie Sklodowska Curie. It is largely a man-made world, produced by our technical devices. But we have strong reasons to believe that this world plays a fundamental role in the universe; it is as essential for the interior of stars as atomic physics is for the surface of the earth. In terms of quantity of matter and energy, nuclear processes are relevant for a vastly larger part of the universe than atomic phenomena.

The end is not in sight yet of the leap into the cosmos by modern physics. Today our new accelerators penetrate into the sub-nuclear realm, into the internal structure of the nuclear constituents themselves. One discovers a new world of phenomena which lies beyond the world of nuclear processes; one finds excited protons, mesons and heavy electrons; all this will lead to a deeper insight into the basic laws of matter.

When it will be better known what is going on within the proton and the neutron, we may understand better the nature of the nuclear force; it may be reduced to a simpler and more fundamental interaction, just as the chemical force was explained by the simpler and more fundamental electric interaction. Nuclear physics may become the 'chemistry' of a new physics of elementary particles.

Today, we are only at the beginning of this great new development, which was initiated by Marie Sklodowska Curie's work. She and her collaborators and successors were able to deal with cosmic processes here on earth; they recreated such processes in our terrestrial environment. The investigation of these new phenomena was of tremendous importance for gaining new insight into the basic structure of matter and its behaviour at high energy. But it has also another important aspect: the confrontation of nuclear processes with our terrestrial environment creates new effects and phenomena, which are of great scientific and practical interest. It must have been of great significance to Marie Sklodowska Curie that this confrontation did lead to practical consequences, even at the very beginning of this new science, when exposing living tissue to radioactive radiation led to such promising results. The treatment of cancer by the newly discovered rays should be a reminder to those people who believe that science should be interested only in the immediate environment of man and should not look for new phenomena, far removed from our daily experience.

But it happens rarely that application follows so quickly after discovery as it did in Marie Sklodowska Curie's work. Perhaps we were spoiled by this case and by the speed in which the application of nuclear energy followed the discovery of nuclear structure. In most instances a long time must pass before new discoveries are well understood and well in hand so that their interaction with our environment can be applied and made useful for other purposes. Imagine how long it would have taken to produce nuclear energy if there were less than two neutrons emitted per fission. A new and unusual field of research stands alone at the beginning and has no connections yet with other fields of interest. But whenever a completely new realm of phenomena is discovered, as it was in nuclear physics, as happens today in high-energy physics, there comes a time when the confrontation of these phenomena with our environment will lead to unexpected effects and to a broader involvement with the rest of our scientific and technical interests.

This is why it is short-sighted to judge the importance of a new field of research by its present state of application or relevance for other sciences. Science must proceed undirected, independent of any aims at application, in particular, in those fields where it penetrates into new and unexplored regions. It was the drive to find out where the radiation comes from in pitchblende that made Marie and Pierre Curie discover radium. They were led by the great curiosity of the true scientist for what goes on in nature. But Marie Sklodowska Curie's curiosity was paired with a deep concern for the human fate. She was the great discoverer in the shed of the School of Physics *and* the driver of an ambulance in the battlefields of the first world war. Human existence is based upon two pillars: compassion and curiosity. Compassion without curiosity is ineffective; curiosity without compassion is inhuman.

Her life and her interest point to another human element in science: the supranational nature of science. I expressly use this term instead of 'international'. Science springs from a deeply human urge: to know and understand what happens around us. It is a language, common to all human beings and therefore is above any nationality. Marie Sklodowska Curie was aware of this, right from the start, with her double nationality, Polish and French. In her later years she actively worked for the cause of international understanding by scientific collaboration. She saw that science is most potent in bridging over the divisive forces of nationalism, racism, and different political systems. We may say without undue pride that the scientific community was to a large extent immune to prejudices of this kind and was most efficient in collaborating across geographical, racial and political boundaries. Let me quote a statement by Marie Sklodowska Curie: 'I believe that international work is a heavy task but that it is nevertheless indispensable; it must be pursued at the cost of many efforts and also with a real spirit of sacrifice. However imperfect it may be, the work of Geneva has a grandeur which deserves supports'.

Of course, she had in mind the League of Nations which collapsed soon after. Perhaps there might be a consolation in the thought how much she would have approved CERN, the new European Laboratory for high-energy research in Geneva, which is a truly supranational laboratory run by many nations, where scientists of the different countries work closely together and where any national origin vanishes when they enter the door. CERN is not the only one of such hopeful beginnings. There is a similar institution in Dubna north of Moscow run by a large group of nations.

But this is not enough; we must follow Marie Sklodowska Curie's great appeal and make our contacts between all centres of science stronger and more durable. There must be more interchange and common work between scientists from different parts of the world. The new tasks which science faces are so great that they require a common approach by all those who are participating. The costs are so high that they should not be wasted by lack of mutual help. Some steps were already taken in this direction: as an example, let me mention the close collaboration between CERN in Geneva, the Saclay Laboratory in France, and the new high-energy centre in Serpukhov, in which the Western European physicists join their skills with the Soviet physicists in order to exploit most efficiently the new 70 GeV proton accelerator at Serpukhov. But this is not sufficient; why are there still so few so-called 'Western' scientists working in so-called 'Eastern' laboratories and so few from the East in the West ? Why is the collaboration of American and Soviet scientists still subject to the vagaries of day-to-day politics ? Why is there no Chinese physicist anywhere with us here ?

The significance of scientific collaboration far exceeds the narrow aim of a more efficient prosecution of our scientific endeavours. It stresses a common bond between all human beings. Scientists, wherever they come from, adhere to a common way of thinking; they have a common system of values which guides their activities, at least within their own profession. New ideas for bringing nations together can perhaps be discussed with more ease within this community, some political misunderstandings can be cleared up, and dangerous tensions reduced. As an example, we recall that the agreement to stop the testing of nuclear bombs above ground stemmed in part from prior meetings between scientists.

We must keep the doors of our laboratories wide open and foster the spirit of supranationality and human contact which the world is so much in need of. The present deterioration in the political world is a reason stronger than ever for closer scientific collaboration. The relations between scientists must remain beyond the tensions and the conflicts of the day, even if these conflicts are as serious and frustrating as they are today. We need this community as an example for collaboration and understanding, as an intellectual bridge between the divided parts of mankind, and as a spearhead towards a better world.

Back to school...

The work of the Training and Education Services

CERN has assembled around its accelerators some of the elite of European subnuclear physicists, as well as highly qualified engineers and technicians. Nevertheless, almost every day a large number of its staff go 'back to school' ... not, of course, to a conventional type of school to become qualified in the various specialities that the work of CERN involves, but rather to follow a variety of instructional or further training courses. More precisely, these are designed to help them :

— to keep abreast of scientific and technical developments in their own field at their respective levels ;
— to extend their capabilities by acquiring knowledge outside their own speciality;
— to have an over-all picture of the work of CERN so that they can see how their own work fits into the picture.

For this purpose the Training and Education Section was set up in 1963. It is, at present, one of the services in the Personnel Division.

It was in one of the exhibition centres set up for the Family Day on 23 September that we met the five members of the 'high command' of the CERN Training Services. Dr. Vanderhaeghe, who has been Head of the Section since it was formed, opened the interview with an outline of their work:

I should first like to explain that we are limited, in fact, to this 'high command' as you call it, assisted by a Secretariat and one technician. Our main task is not teaching but rather the coordination and organization of courses and lectures which are given by other members of the CERN staff or by specialists invited from outside, whose normal duties ensure both that they are professionally qualified and that they are up-to-date in their field. (This does not, however, prevent members of our section also being called upon to teach in certain cases.) A second characteristic of our work is the absence of fixed programmes and diplomas intended to be equivalent to those awarded by educational institutions in the Member States or elsewhere. This is the result of the deliberate aim of our training scheme. Our programmes are drawn up each year in relation to the needs of the Organization by committees composed of members from the various Divisions who are experts in the main fields covered at CERN. At present, one such committee deals with academic training and another with technical training.

You have just mentioned that your Services are divided into various categories ; these are academic, technical, general and management. Could you say something about them.

Academic Training, with which I am particularly concerned, is intended for scientific staff, engineers, fellows and visitors. It consists mainly of courses at post-graduate level on high-energy physics and on the advanced techniques developed at CERN, such as those concerning accelerators, particle detectors and data handling. This also includes introductory courses and refresher courses. Some of them are intended to enable scientific staff to follow the broad lines of what is happening at CERN in fields other than their own. (A case in question, for example, was the course on 'Fundamentals of Quantum Mechanics and Particle Physics' given last summer by Professor O.R. Frisch.) Other courses deal with fields not directly covered in CERN's research or development work but where advances or applications may have an interest for us (for example, superconductivity).

How many people follow the academic training courses as a rule ?

Attendance varies between about 50 and more than 200 according to the subject. Most of the courses consist of 5 or 6 lectures ; 10 or more lectures being exceptional. We arrange about a dozen such courses each year from November to June. Lectures in a given course are usually held once a week and the programme is arranged to avoid more than two lectures, on average, belonging to two different courses during the same week. It would probably be too much to offer more, since there are also several seminars and colloquia each week. I should add that, for most of the courses, notes are published as 'CERN yellow reports', forming monographs on the various subjects. Several thousand copies of these reports are distributed both in CERN and outside.

There seems, therefore, to be ample opportunity for scientists at CERN to keep themselves up-to-date or to improve their knowledge. Does the same apply for other categories of staff ?

The situation here is slightly different. Whereas following such courses is a natural and traditional part of a scientist's activity, it is sometimes difficult to give it appropriate emphasis in the work of technical and administrative staff. Before the creation of our Service, it was limited to 'on-the-job' training of technicians required to carry out certain particular duties ; for example, the training given to the accelerator operators. Mr. Butler will tell you now how far we have got with Technical Training, which has been his responsibility since last January.

With pleasure. It should first be pointed out that we encourage the staff to make use of opportunities for further training offered outside CERN, whether locally or not ('cours du soir' in Geneva, 'promotion du travail' in Grenoble, correspondence courses, etc.) but the practical difficulties and the length of time such studies usually take, make them impracticable for the great majority of staff. That is why we organize a certain number of courses at CERN itself. They are mainly intended for technicians, workshop and laboratory staff and are connected with CERN work. However, we also organize courses of more general interest in mathematics and physics to provide certain basic knowledge.

Without going into too many details, I should like to point out that the teaching is at two levels, 'intermediate' and 'advanced', and that we have been led to introduce two types of course. On the one hand, there are the 'basic courses' which are for all those who wish to revise or extend their knowledge, whether or not the subjects taught have any direct relation with their work. (Usually these courses take place only partly during working hours, with one lesson each week.) On the other hand, there are 'specialized training courses' which are primarily, or sometimes exclusively, intended for those who wish to further their studies in a branch in which they already work, as well as for those who may soon be required to do so. (These courses may take place entirely

An oscilloscope, with its component parts visible, used in the teaching of electronics.

CERN/PI 196.10.67

during normal working hours and consist of more than one lesson per week.) In all cases, the teaching includes a great deal of individual work and practical work.

You are displaying here some programmed instruction manuals and teaching machines. What are they for exactly ?

It is difficult to give you a complete answer in a few words. Briefly, it is material designed for individual study (self-instruction). The main difference from the conventional book is that it constantly stimulates active participation by the user since it asks him systematically to reply to questions so that he can check how much he has learnt. After some limited tests with these methods which have shown good results, we intend to develop their use, with some care, in our technical training.

I believe you also set examinations at the end of the courses ?

Yes, that is so, but they are entirely voluntary. Successful candidates are awarded a certificate, a copy of which is kept for future reference in their file in the Personnel Service ; failures, however, are not recorded there. It is interesting to note that of the total number of a thousand or so students who have followed one or other course since 1963 (consisting of about 500 people who followed one or more courses), about a third have taken the examinations and 90 % of these have passed.

Now we come to Mr. Carreras for information about the General Training section of which he is in charge.

This covers a variety of topics at an 'elementary level', intended for everyone but particularly for non-scientific staff. The topics include explanatory courses about CERN and its work and also introductory lectures on contemporary science. They should enable any member of the CERN staff to reply to two questions : 'What is actually done at CERN ?' and 'What connection is there between what I do and the Organization's activities?'. Several hundred technical and administrative staff have followed these courses for the past two years.

With a lecture series called 'Science for all', we hope to arouse and develop the interest of the staff in science, to make it more familiar to them. The success which these lectures have had encourages us to continue our work in this direction.

What are your plans in this field for the coming year ?

We are preparing a series of fifteen lectures based on a book which will, as it were, serve as lecture notes. No book seemed more appropriate than the one published a few years ago by Professor Weisskopf — 'Knowledge and Wonder'. It has just appeared in French also with the title 'Nature, Matière, Vie' (the translation was the work of a group of CERN colleagues). We hope that many of the staff will attend these lectures and, with this guidebook in their pockets, make an exciting 'grand tour' through the universe.

There is also a mathematician in the service. Can you tell us Mr. Louis what part you play ?

I am in a way the exception that proves the rule, since I am teaching every day. I was doing that already at CERN before joining the Section. As a full-time teacher, I am privileged to have several strings to my bow. In fact, I give several courses in mathematics and a course on computer programming as part of the technical training work, a programming course for scientific staff, and, finally, I am preparing a contribution to general training on the subject of calculating machines from the abacus to the large electronic computer. Furthermore, having overcome my initial reserves, I am becoming interested in the opportunities offered by programmed instruction and its logical extension — the use of computers for teaching.

Finally, let us turn to Mr. de Coulon to tell us about 'management training', the last of the four sections mentioned at the beginning of our interview.

In principle, this training aims to make more effective the relations between those who are carrying out a job and those who are responsible for it. It is for people at all levels in charge of any group of people within the Organization.

No programme has in fact been set up yet in this field at CERN. I have been asked, as a consultant, to present recommendations on the aim, the content and the form of such a programme for the particular needs of this Organization. The first investigations have been carried out and some limited training action has been initiated. A report will soon be submitted to the top management of CERN.

In conclusion, Dr. Vanderhaeghe emphasized that the time when a person could be trained once and for all in a particular field is past. To-day it is necessary, first of all, that the initial training for everyone should be more fundamental and broadly based rather than encyclopedic or highly specialized, and that education should not stop at this initial training but should be extended by what some people call, quite rightly, 'continuous education'.

In an Organization like ours which, by its very nature, is subject to rapid change in almost all fields of activity, it is very important to give everyone the chance to continue his training in parallel with his work. It is perhaps even more important that each person should be aware of the need for this further education and of the fact that it is up to him to take the responsibility for his own education.

News from Abroad

Performance of ACO

We mentioned in the report of the Cambridge Accelerator Conference that ACO (Anneau de Collision d'Orsay) had contributed, together with Novosibirsk, to the first important experimental results coming from storage rings. These concerned measurements particularly on the rho meson. Further details on the performance of ACO have now reached us.

This first experiment was carried out at an energy of 385 MeV per beam (electron beam colliding with a positron beam). During an experimental run of 90 hours the average luminosity was 5.5×10^{30} per cm^2 per hour, the intensity of each beam was about 5 mA and the beam lifetime about 25 hours. The short length of the bunches of particles (18 cm) gave a well defined collision region in the centre of the experimental straight section where the detection system was most efficient.

About 500 events were detected: 137 were annihilations into two charged pions, 149 were elastic scattering of the electron and positron and these events made it possible to give a value for the branching ratio for the decay of the rho meson into an electron and positron ($6.2 \pm 1.0 \times 10^{-5}$). Also, 36 interactions emitting three particles (attributed to the production and decay of the omega meson), and interactions producing a positive and negative muon were observed.

The team at Orsay are now working to improve the luminosity of the beams to increase the interaction rate, and after the experience of this first experiment are modifiyng various items of equipment. When these improvements are completed, ACO will be used to measure the width of the rho meson and the branching ratio of the omega meson decay into an electron and positron.

New magnet at Stanford

A large superconducting magnet was successfully tested at the Stanford Linear Accelerator Centre in October. It gives a 70 kG field over an aperture 30 cm in diameter and 68 cm long. The design and construction of this magnet, the most powerful superconducting magnet in the world, by a group led by Dr. H. Brechna, took only 15 months. The cost of the project was about $150 000.

The magnet has six coils constructed from over 17 kilometers of specially designed superconducting cable, which consists of very fine filaments of niobium-titanium alloy (the superconductor) enclosed in a copper belt. Power consumption in normal operation is about 4 kW compared with about 18 MW which would be required for a conventional magnet of similar strength. The coils are immersed in 350 litres of liquid helium to achieve the temperatures near absolute zero where the niobium-titanium alloy becomes superconducting.

The group carried out an important experiment, when the magnet came into operation, to test whether the superconductivity could be 'quenched' without destroying the magnet. This involves suddenly allowing the system to 'heat up so that the superconducting property is lost; the high currents which the superconductors were carrying could then potentially generate extremely high temperatures and seriously damage the magnet. It was proved however that the special construction of the cables allowed the copper to take over carrying the 600 A currents without heating up too rapidly. This demonstration that large coils can be designed to cope safely with quenching is very encouraging news for the future of big superconducting magnets.

Since the initial design of this magnet, the Stanford group have developed even more efficient cables. They consist of copper tubes with the superconducting filaments embedded in the walls. Liquid helium can then be circulated through the tubes to achieve the necessary refrigeration, dispensing with the need for a helium bath surrounding the coils. This results in a considerable saving in the quantity of liquid helium, an expensive material, which is needed. They will probably use this type of coil for a 70 kG magnet with a larger aperture (1.5 m in diameter, 1.8 m long) which is now under study.

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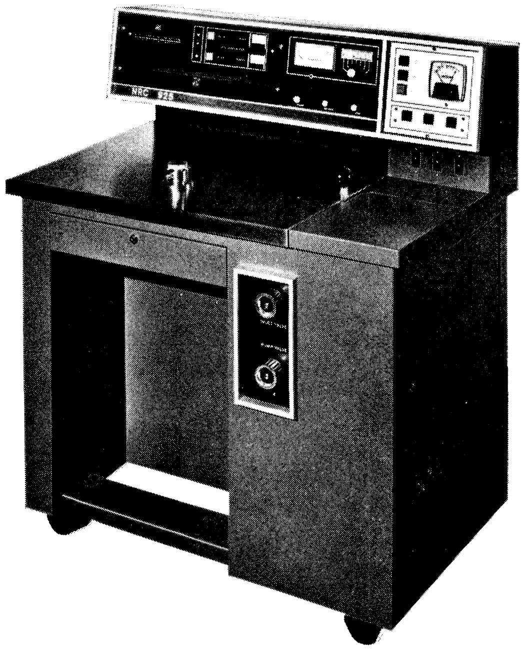

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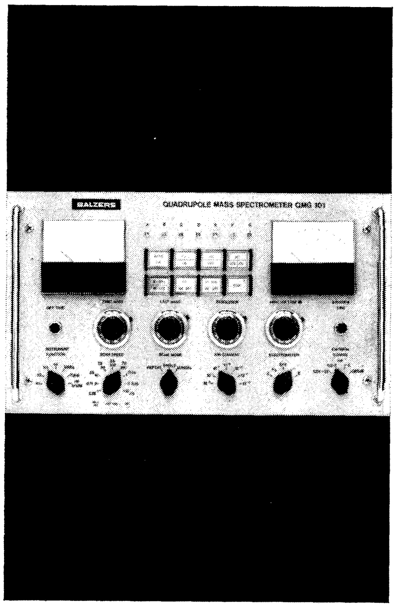

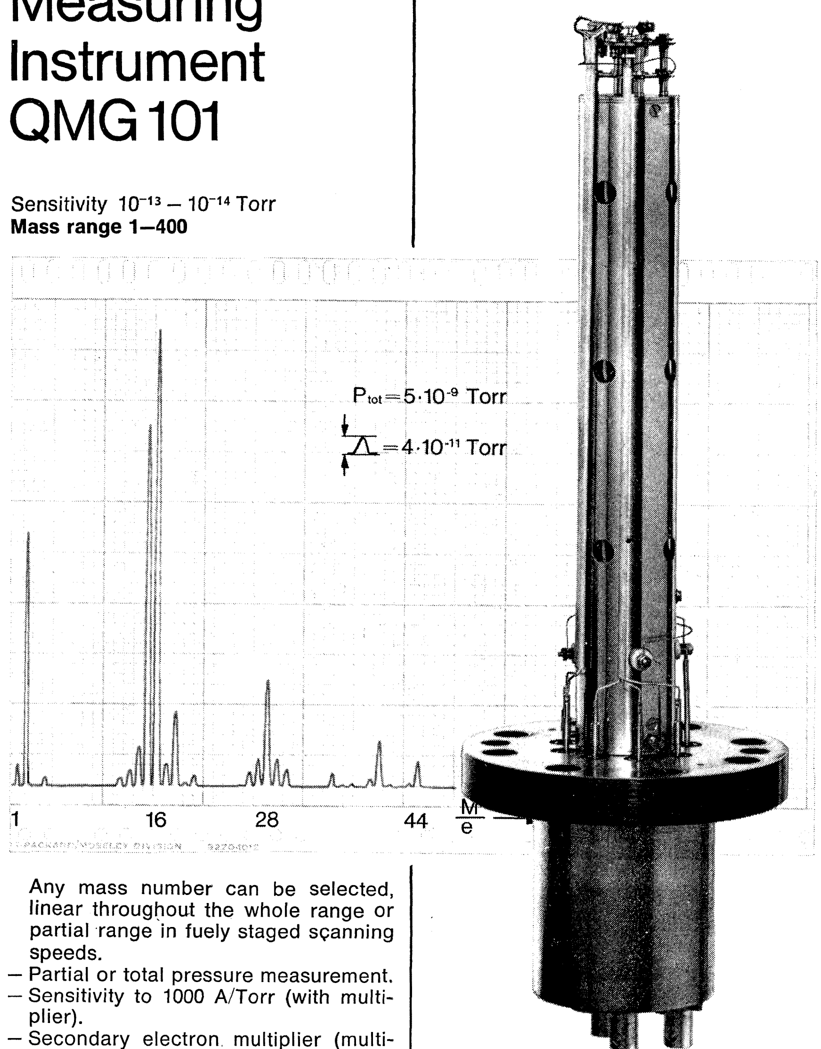

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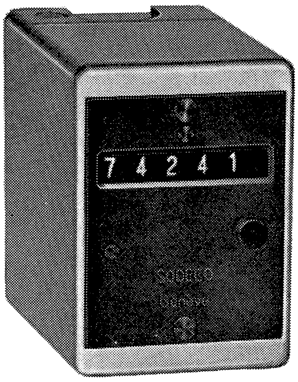

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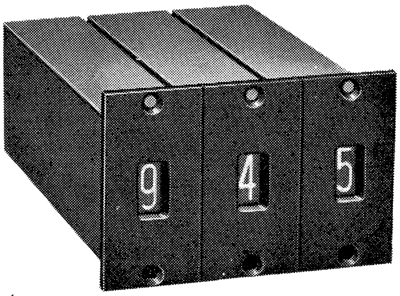

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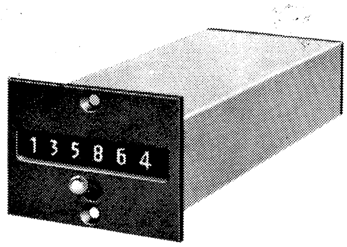

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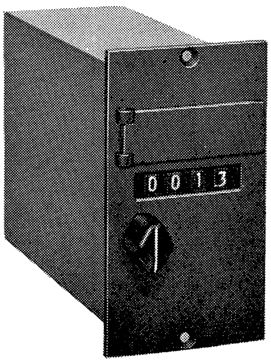

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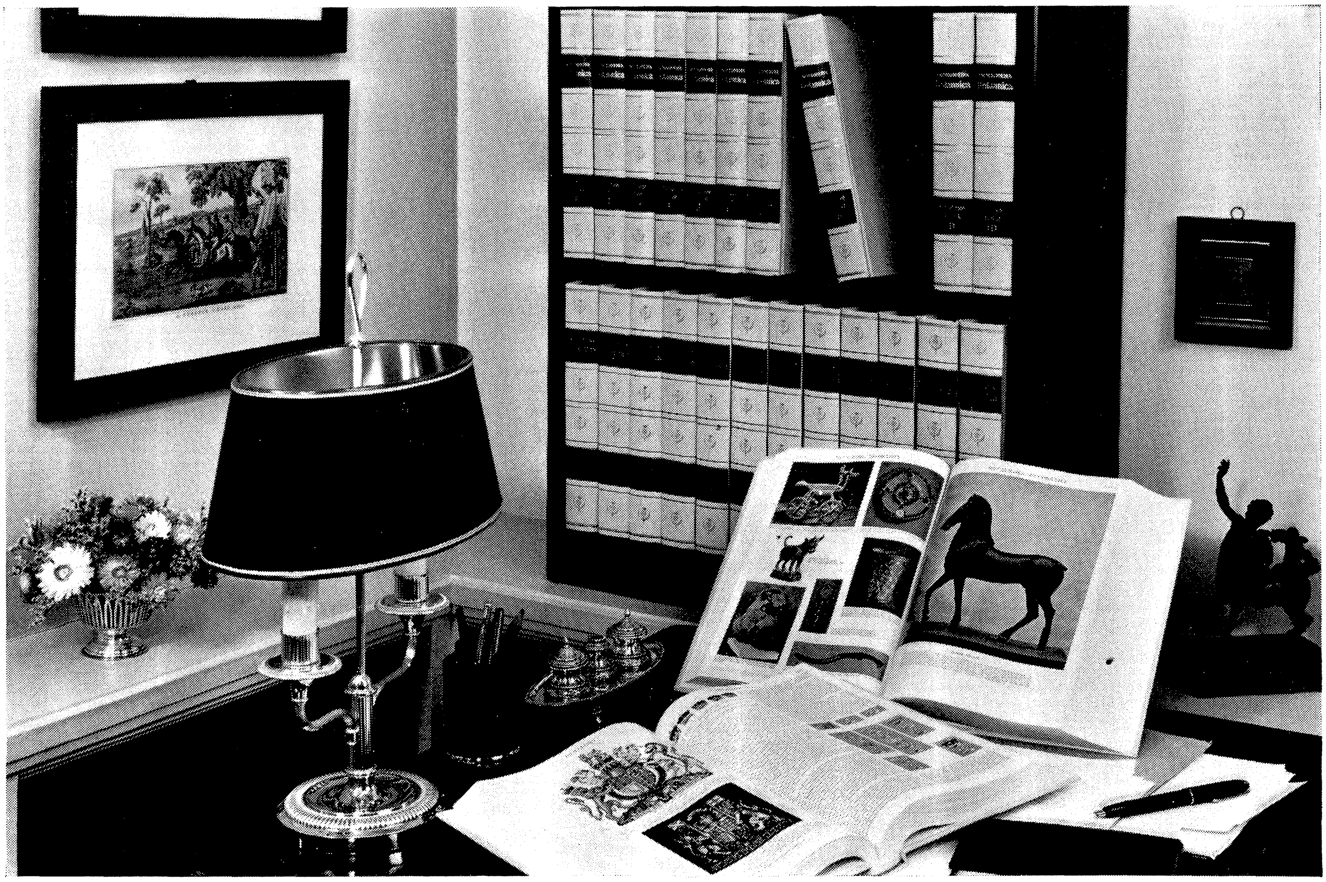

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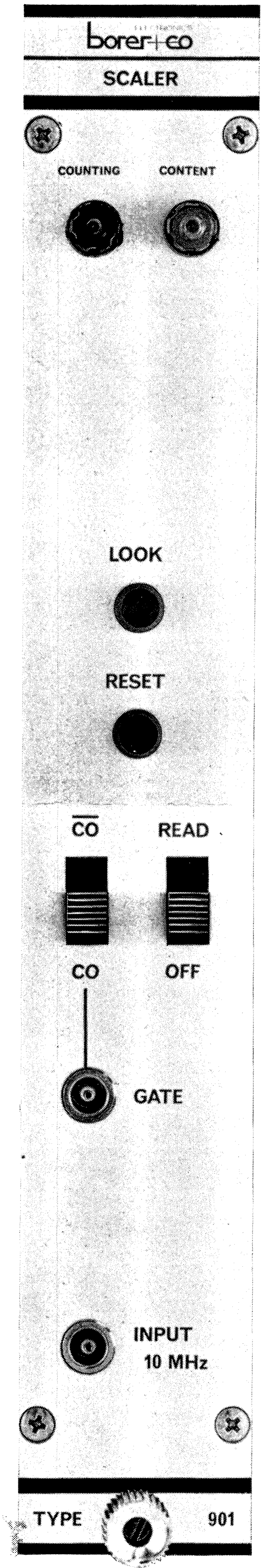

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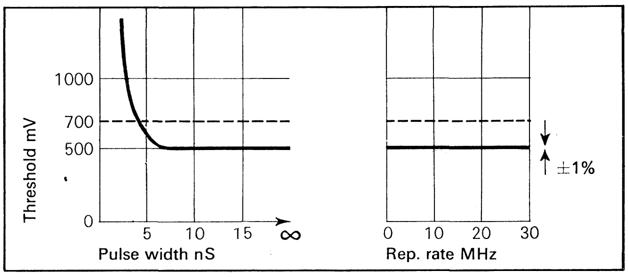

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gating facilities, coincidence or anti-coincidence

Please ask for full technical literature!

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borer + co

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Telephone 4305
Germany: Verkaufsbüro München, Kaiserstrasse 10, D-8000 München 23
Telephone 34 80 16
France: Sorelia Electronique, 150 rue de Chatou, 92 Colombes
Telephone 782.16.39-782.32.79
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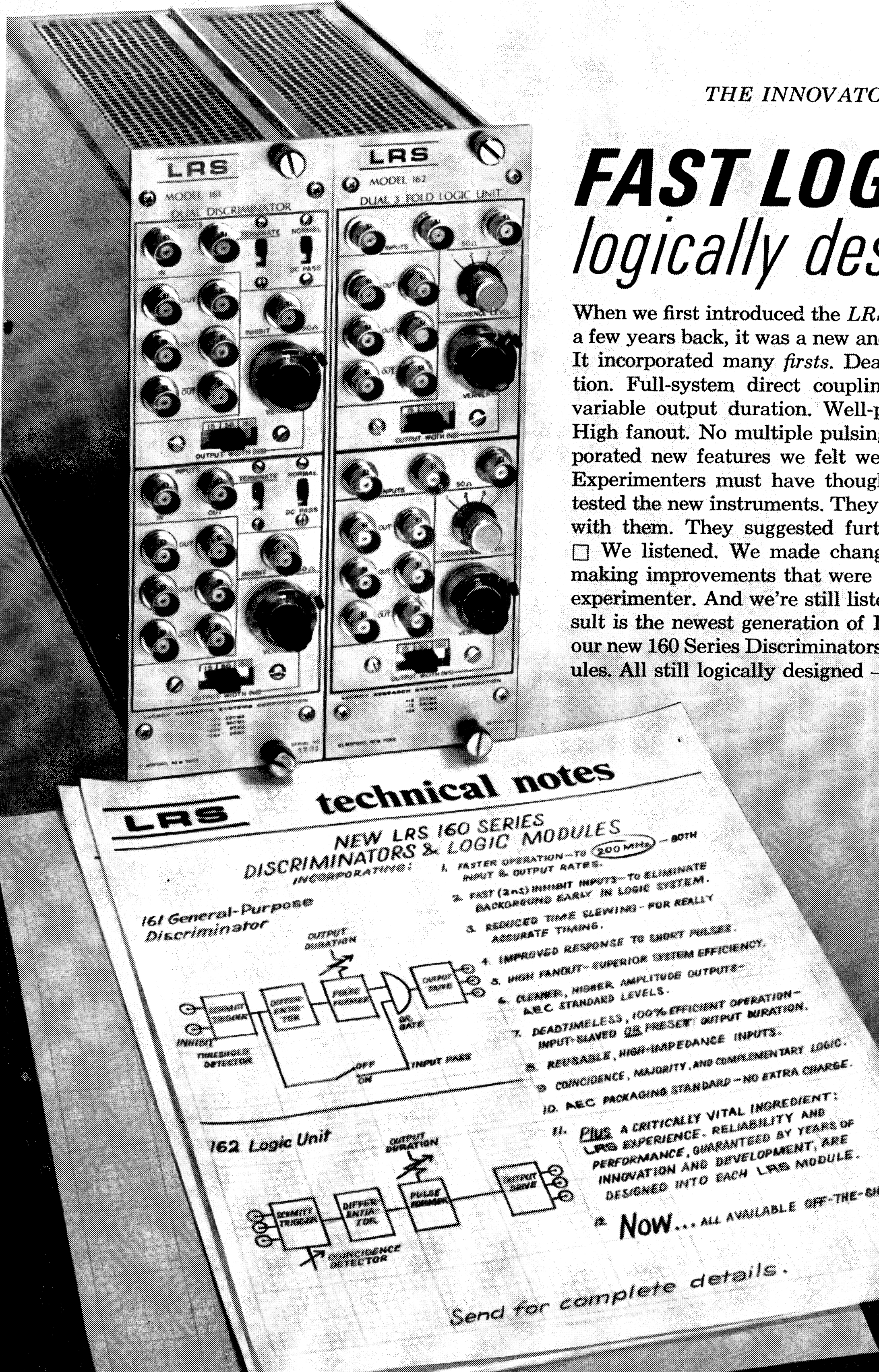
THE INNOVATOR LINE

FAST LOGIC...
logically designed

When we first introduced the *LRS Innovator Line* a few years back, it was a new and untried design. It incorporated many *firsts*. Deadtimeless operation. Full-system direct coupling. Continuously variable output duration. Well-protected inputs. High fanout. No multiple pulsing. . . . We incorporated new features we felt were important. □ Experimenters must have thought so, too. They tested the new instruments. They did experiments with them. They suggested further refinements. □ We listened. We made changes. We kept on making improvements that were important to the experimenter. And we're still listening. □ The result is the newest generation of LRS fast logic — our new 160 Series Discriminators and Logic Modules. All still logically designed — by experiment.



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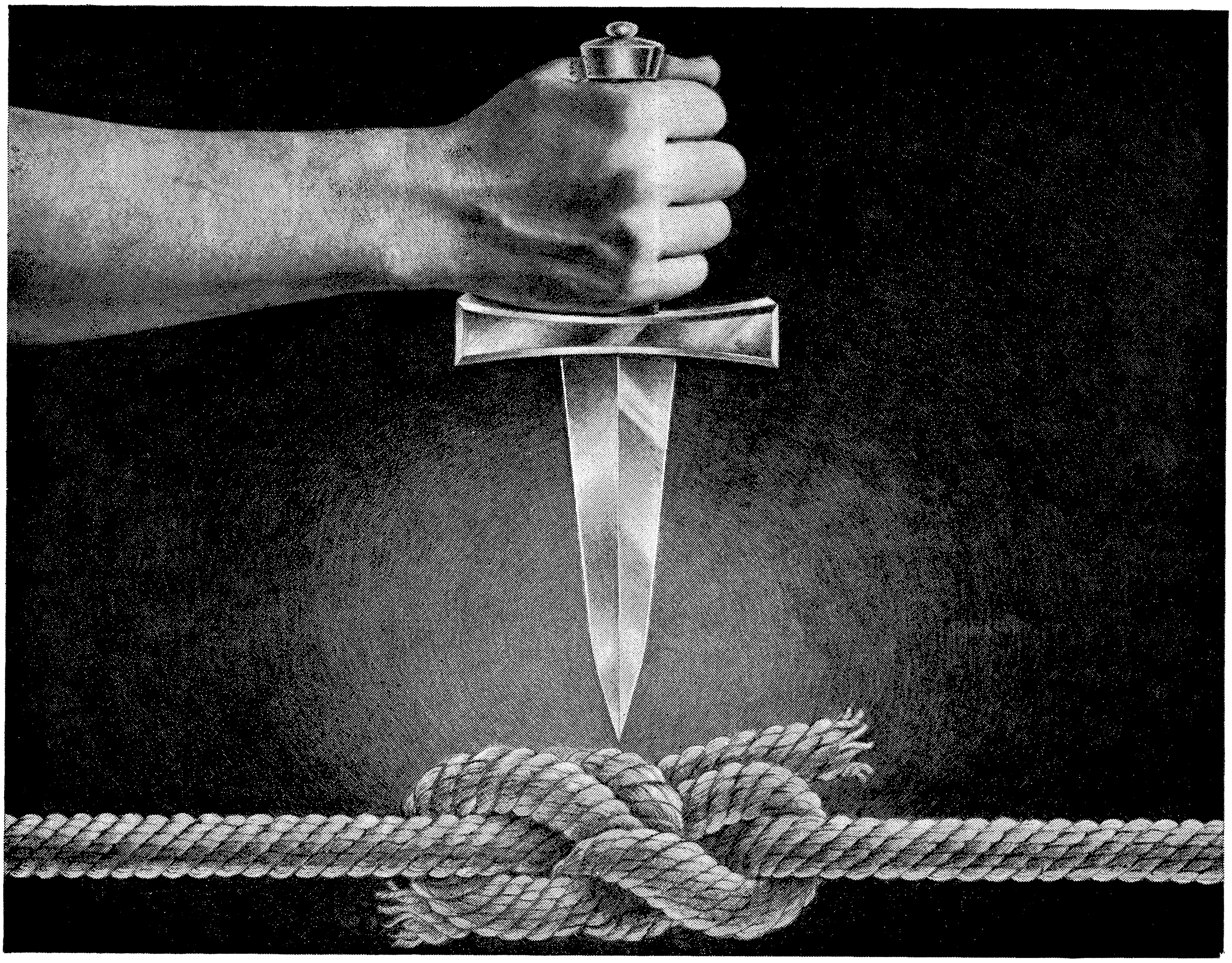
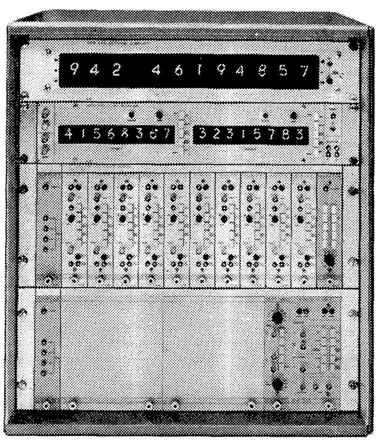


SEN 300 COUNTING EQUIPEMENT

with integrated circuits

100 Mhz

Unlimited applications • Up to 1000 channels • Scalers with visual display • Modular scalers • Automatic readout of the system: from the simplest printers to the most sophisticated output device



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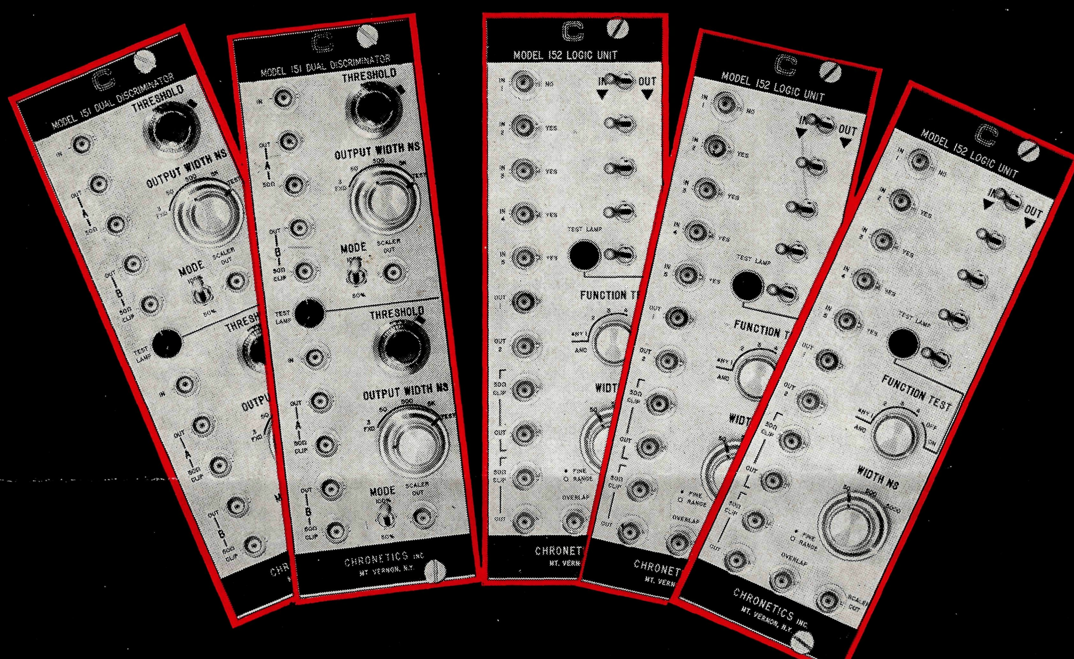

FULL HOUSE

We're raising the ante: Most modules of our splendid new NANOLOGIC 150, 200 MHz, AEC-compatible Counting System are now available **off the shelf.** We can ship from stock discriminators, logic units, amplifiers, linear adders, prescalers, fan-ins, fan-outs, linear gates, gates with stretcher/hold etc, etc, etc, etc. Just about any logic function in a NIM package you care to mention. Call our full house and everybody wins.

Observe, by the way, that NANOLOGIC 150 is a completely new System — not a repackage to meet TID-20893. A **new System. All new.** From the grounds up. All DC-coupled; normal or complementary outputs; output widths variable over a 1000:1 range. Much higher performance and greater operating flexibility. Care for a couple of examples?

Model 151, a dual, deadtimeless discriminator. Pulse inputs to better than 200 MHz with 50 mV sensitivity and a variable threshold, settable to 1% accuracy. Pulse pair resolution is better than 5 ns. One can switch-select updating, deadtimeless or deadtime modes. Five DC-coupled outputs per section (two logic pairs and a scaler out); one logic pair can provide either the complement or the normal output. Output width continuously variable 5 ns to 5μs with a 3 ns fixed position. Doesn't sound like a repackage, does it? It isn't.

Model 152 is to logic units what the 151 is to discriminators. MAJORITY, AND, OR, ANTI logic functions; all of them in one module. Coincidence resolving time better than 2 ns FWHM at 200 MHz. Any input (4 YES, 1 NO) can be switched in or out independently. Output width continuously variable over a full 1000:1 dynamic range and normal and/or complementary outputs. An overlap output is also provided.

We're not standing pat though. More new 150 modules are on the way. If you need counting/logic with the highest available performance, stability and quality call or write for technical literature or a demonstration.

Looking for a winning hand? Play these.

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