# CERN
# COURIER

No. 2 Vol. 9 February 1969

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 scientifice 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 2650 people and, in addition, there are over 400 Fellows and Visiting Scientists.

Thirteen European countries participate in the work of CERN, contributing to the cost of the basic programme, 235.2 million Swiss francs in 1969, in proportion to their net national income. Supplementary programmes cover the construction of the ISR and studies for a proposed 300 GeV proton synchrotron.

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# Comment

On 13 February, a new field of European co-operation, was formally opened when twelve countries signed an agreement establishing the European Molecular Biology Conference (see page 38).

Molecular biology is currently one of the most fascinating fields of research aiming to understand the fundamental units and mechanisms of life. The subject flared into prominence in 1953 with the discovery, due particularly to the research of F.H.C. Crick, R. Franklin, J.D. Watson, and M.H.F. Wilkins, of 'the double helix' — the elegantly simple mechanism whereby hereditary characteristics are transmitted from one generation to the next. Since then more pieces of the genetic code have been deciphered.

Molecular biology is unusual in demanding expertise from a variety of disciplines — in biology, chemistry and physics — and the main purpose of the newly established Conference is to pool this expertise on a European scale. Many molecular biologists had hoped that co-operation would extend to the foundation of a European Laboratory, but not all governments are ready to commit themselves so far. The Conference is a start.

Any advance in European co-operation, where there is a well-defined aim and a clear need for countries to get together, merits every encouragement.

It has been a pleasure and an honour for CERN to have been the scene of this new agreement and we wish the Conference every possible success. It should help to sustain Europe's prominent position in this vital subject.

Molecular biology is still in its infancy and the coming years will probably see many further advances in the understanding of the basic processes of life. In the long term, co-operation between countries will be of supreme importance in the complex task of evaluating and controlling the social consequences of these advances in understanding.

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*Cover photograph : The first of many. On 30 January, a magnet for the intersecting storage rings was transported to the completed octant of the ring tunnel (Octant 3) and is seen in the photograph being manoeuvred into its position. From now on, magnets which have been assembled and tested in the West Hall are being moved into the ring at the rate of about one per day. (CERN/PI 475.1.69)*

# Project Omega

*A description of the large new instrument for electronics experiments which is to be built as part of the second stage of the improvement programme at the 28 GeV proton synchrotron.*

The improvements programme for the proton synchrotron received the blessing of CERN Council at the end of 1965. From 1966 through to 1972, a series of developments are taking place, absorbing advances in technology in equipment on and around the PS, to ensure that European physicists continue to have top quality facilities for sub-nuclear research at their disposal for another decade.

These developments are concerned not only with improving the performance of the synchrotron itself (increase in repetition rate and intensity per pulse) but also with providing new equipment for experiments ; particle detection techniques have evolved very rapidly in recent years.

For bubble chamber physics two new chambers (one heavy liquid and one hydrogen) are being built on a much bigger scale than those currently in operation (see CERN COURIER vol. 7, page 143 and vol. 8, page 95). For electronics experiments (those using counters and spark chambers) the need for larger magnetic spectrometers became evident. On the one hand, unlike bubble chamber physics where a single large instrument serves for a whole range of experiments, counter physics has up to now involved a virtually unique assembly of detectors for each experiment. But increasing size and cost led to the design of an instrument to cope with a wide range of experiments. On the other hand, the choice was difficult because several systems were possible. The evolution of spark chambers particularly has been extremely rapid ; for example, wire chambers, wide-gap chamber, and streamer chambers are all devices which have become familiar only in recent years. Some variant of any of these could have been the basis of the new system.

However even in 1965 it seemed likely that the choice would fall on a spark chamber array built in a magnetic field. One reason for this was the successful experience at CERN with a magnet built in collaboration by CERN, ETH Zurich and Imperial College London initially for use with a Wilson cloud chamber. This is a magnet with a wide aperture which was converted to take optical spark chambers inside the magnetic field. It has served very well in several experiments, including the famous experiment on the decay of the eta meson which restored faith in charge symmetry in the electromagnetic interaction (see CERN COURIER vol. 6, page 171).

In the last few years there has been extensive use of spectrometer magnets in association with spark chamber systems but, because of small magnet apertures, they have been limited to the detection and measurement of only a few particles produced in an interaction. To improve their capabilities large aperture is needed to detect and measure many secondary particles.

The decision has therefore been made to construct an instrument on a bigger scale and in a more sophisticated way. The project became known as the Omega project. In April 1967 an 'Omega Project Working Group' was set up and in May 1968 they presented a 'Proposal for a large magnet and spark chamber system' (NP Division Internal Report 68-11). The proposal was supported by the Scientific Policy Committee at its meeting of 14 May.

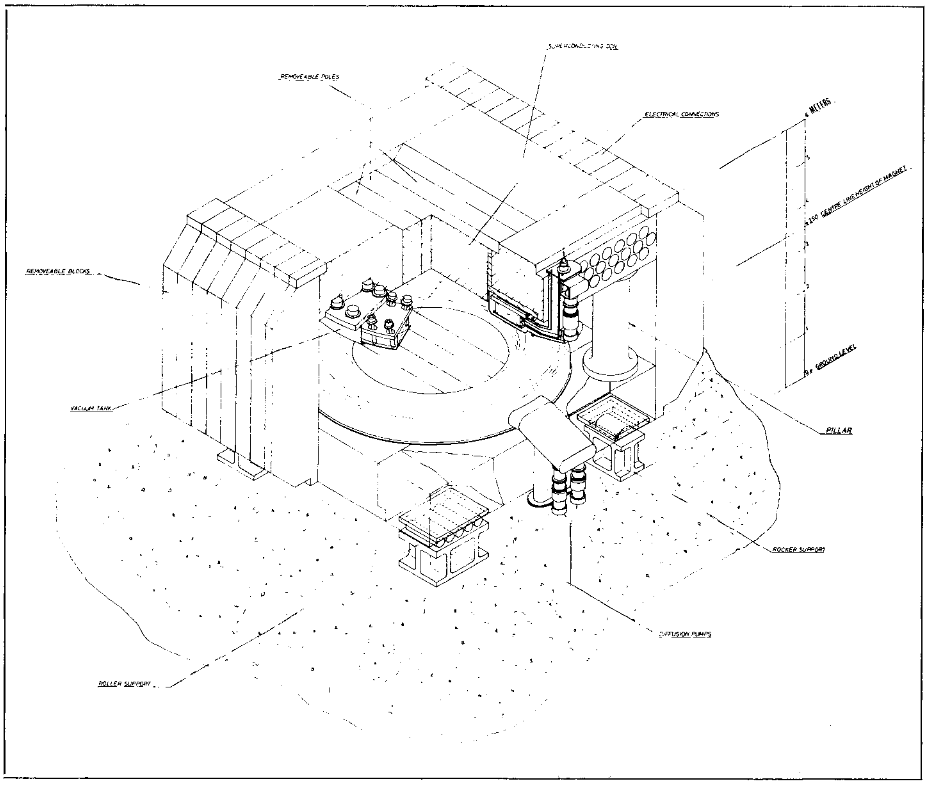
Since then tests have been carried out on some components so that the design can be finalized. The following is a description of the assembly and a brief report on the work so far.

## The design

The Omega can be considered in three parts — the magnet, the spark chambers, the data-handling system. In all three, flexibility has been a major consideration in the design to ensure that Omega can be adapted easily to the variety of experiments it can expect to serve over more than ten years.

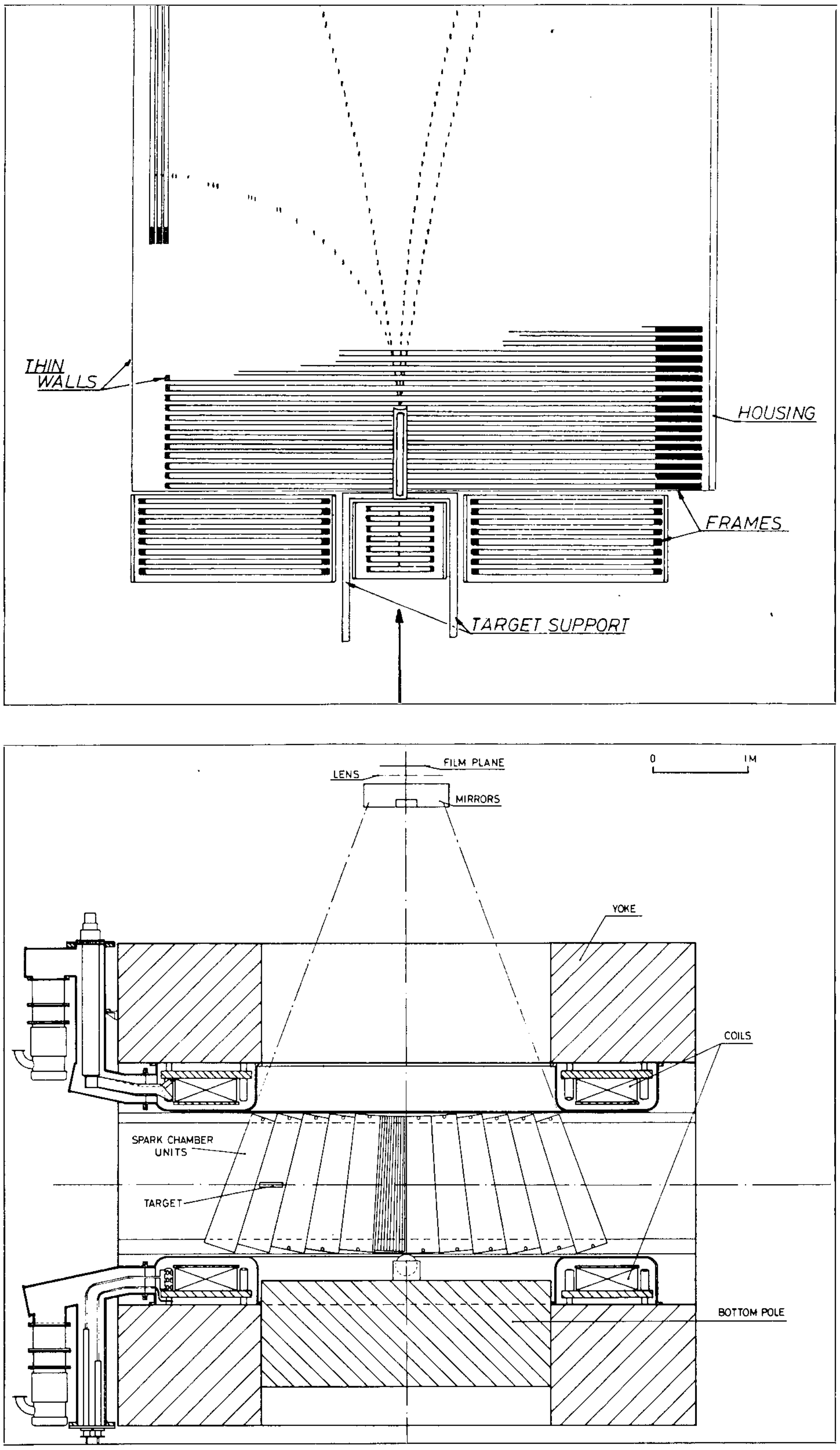
### *Magnet*

To achieve maximum flexibility in the experimental set-up, the vertical (side) yoke of the magnet is composed of modular elements 50 cm wide which can be assembled in different geometries. The coils, the horizontal yoke and four vertical spacers are fixed. Thus spark chambers, targets and counters can be mounted in different configurations in the magnetic field.



*An isometric view of the large Omega magnet. The inner diameter of the circular coils is 3 m and the gap between the poles of the magnet is 2 m. In this large aperture spark chamber assemblies can be installed in a wide variety of ways.*

*Two possible configurations of parallel plate spark chambers within the Omega magnet. The first diagram is a view from above of part of a target and optical spark chamber assembly. The spark chamber planes are perpendicular to the beam direction. The second diagram is a view from the side of an alternative arrangement of twelve units of ten gaps each which can all be viewed by the camera without the use of prisms. The chambers are still parallel plate but with wedge shaped frames between adjacent gaps.*



When optical spark chambers are used they can be photographed through the top pole of the magnet. A rectangular window (3 x 1.5 $m^2$) is cut in the horizontal yoke to give access for cameras. This window can be filled by removable pole pieces. Apertures can also be provided at the sides by mounting the vertical yoke in different ways, as mentioned above, so that particles can be detected outside the magnetic field.

The main parameters of the magnet are —

| | |
|---|---|
| Maximum field at the centre (with top pole removed) | 18 kG |
| Inner diameter of circular coils | 3 m |
| Free gap between coils | 1.5 m |
| Free gap between poles | 2 m |
| Weight of magnet | 1300 tons |

It has not yet been decided whether to have conventional or superconducting coils (the main parameters will be the same in both cases). Both solutions have been studied and tests on the possibility of using superconducting coils with forced cooling are mentioned below.

For each of the possible assemblies of the magnet the magnetic field configuration within the aperture will be different. It will be necessary to measure the field after each assembly. Field mapping equipment, aiming for an accuracy of better than 5 x $10^{-4}$, is being developed for quick and thorough measurements. Taking a measurement every 1000 $cm^3$ will involve $10^5$ readings for the entire field volume. Repeating this for three values of the magnet current at a rate of 5 per second with time for mounting, etc. will involve about 24 hours for each field mapping.

Since the magnet is so large and heavy and since the whole assembly will require considerable services — power, cooling, etc... — the Omega will be a fixed installation (in the new West Hall). For the first time in electronics experiments, particle beams will be brought to Omega, as they are to a bubble chamber, rather than taking experiments to beams.

## *Spark chambers*

The use of large arrays of optical spark chambers in a magnetic field is by now a well-established technique and it is probable that the first experiments with Omega will use such a spark chamber system. Optical spark chambers are likely to be always in favour for rather complicated events where many secondary particles are produced and for low event rates.

Optical chambers can be of various types — 'sampling' spark chambers having many gaps of about 1 cm spacing, wide gap spark chambers with gaps of 10 cm or more where the spark follows the particle trajectory, and streamer chambers. The chambers may also have various 'geometries' (planes, cylinders, etc...) and chamber planes may be opaque (foils) or transparent (wires). Omega is designed to cope with as many of these variations as possible.

Two conceivable arrangements of foil, parallel-plate spark chambers are shown in the diagrams. The sparks will be photographed on 70 mm film putting two stereo views side by side. The optical distance of the film from the beam height is 5 m and the stereo angle 17°. The rate at which events can be recorded is likely to be limited by the speed with which the camera can take photographs. Work on this problem is reported below.

For simpler events and high event-rates wire spark chambers, which read-out the spark positions automatically without going through the stage of photography and measurement of photographs, are the obvious answer. They have the further advantages of giving on-line control of the experiment and, since there is no need for a window in the top of the magnet, of operating in a 10 % higher magnetic field. However, wire chamber arrays are, so far, less accurate in positioning the spark (to 0.3 mm) than can be expected of the optical chambers (0.2 mm) and, moreover, a method of drawing the signals from the wires in a strong magnetic field has not yet been clearly demonstrated.

Conventional 'read-out' techniques using ferrite cores or magnetostrictive wires are less suitable for operation in a strong magnetic field. Other techniques, such as 'sparkostrictive' read-out (detecting, by piezoelectric crystals, the shock wave produced as the spark hits the wire) or 'capacitive storage' (where the spark charge is stored in capacitors, which can be read, connected to the sparking wires), may be refined to sufficient accuracy and reliability.

The advantage of electronics experiments compared with bubble chamber experiments is that the detectors can be triggered to select only the required events. In Omega, scintillation counters can be used to trigger the spark chambers by having long light-guides (1 to 2 m long) to take the pulse of light, produced in the scintillator by the passage of a charged particle, to photo-multipliers which need to operate outside the magnetic field. Development of the multi-wire proportional counter, invented by G. Charpak (see CERN COURIER vol. 8, page 220), may prove very valuable since it could indicate the exact number of charged particles produced in an interaction and give their positions with good accuracy.

### *Data handling*

If Omega receives particles from 4 x $10^6$ pulses of the proton synchrotron per year, estimates of maximum annual data production are :

12 x $10^6$ pictures using optical spark chambers (of which about 4 x $10^6$ may need to be measured) or

50 x $10^6$ events recorded on tape from wire spark chambers (of which about 20 x $10^6$ may need to be analysed).

It is obvious that the provision of adequate resources to handle this large amount of data is an integral part of the project. Possibly 80 % of the analysis will be done at universities and research centres in Europe where data-handling facilities are growing considerably at present. It is anticipated that there will be adequate capacity installed in the early 1970s to take the data from Omega. At CERN itself a system to cater for both film and wire-chamber data will be installed.

It will consist of a computer connected on-line to Omega, and of a flying spot digitizer (an HPD which performs automatic measurement of particle events recorded on film). Final analysis of events will, as usual, be done on the main CERN computers. Overall, data from Omega may need over 2500 hours use of a CDC 6600 ; this is a considerable fraction of the present computing capacity but the capacity installed at CERN will probably be substantially higher in the 1970s.

The capacity of the Omega computer itself is dictated by the need to cope with the high data-taking rate of wire chambers. A memory size of 64 K 32-bit words is planned with the possibility of later extension.

## Present·work

A special group has been set up in the Nuclear Physics Division to carry out, together with the NP engineering groups work on several aspects of the project. A few topics of interest are selected here.

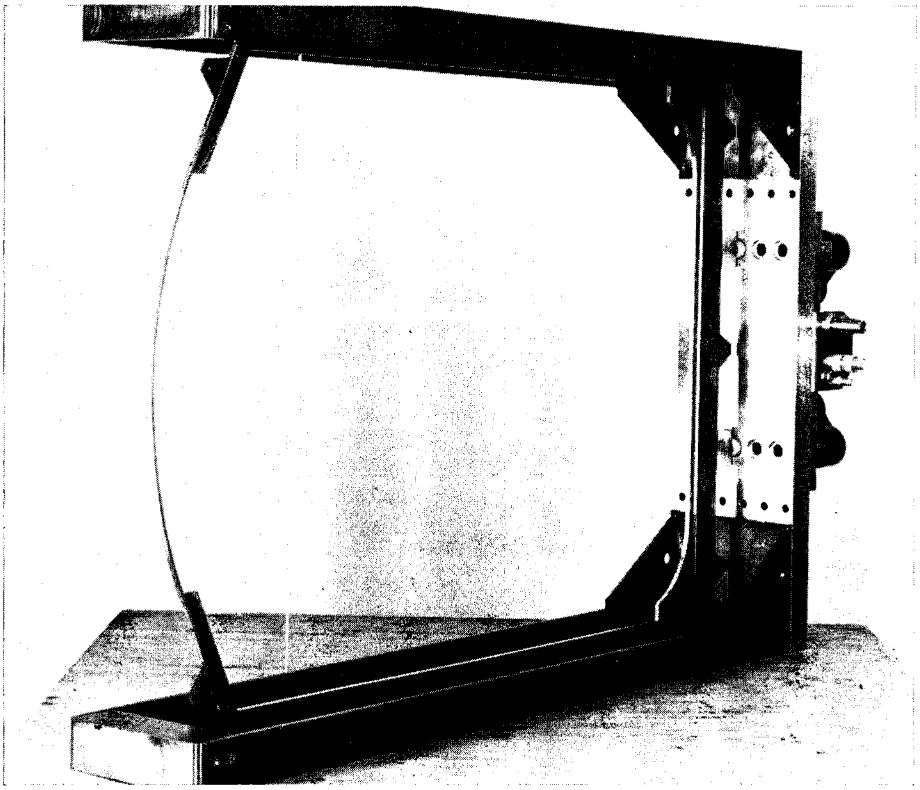
The choice between conventional and superconducting magnet coils is scheduled to be made in the near future. Capital costs are comparable in the two cases but the use of the superconducting coils would obviously save a considerable amount in operating cost (a conventional coil would require 7.5 MW of power). Also there is an inclination towards using a superconducting coil because of its interest as an advanced piece of technology.

At present, there is an investigation of the use of hollow superconductor through which liquid helium is circulated to maintain the coil at superconducting temperature. Coils are normally operated immersed in a bath of liquid helium but the forced-cooling method with hollow conductor should achieve more uniform cooling with a more compact coil and a simplified cryostat needing less helium. (Early work on this topic was announced in CERN yellow report 68-17.)

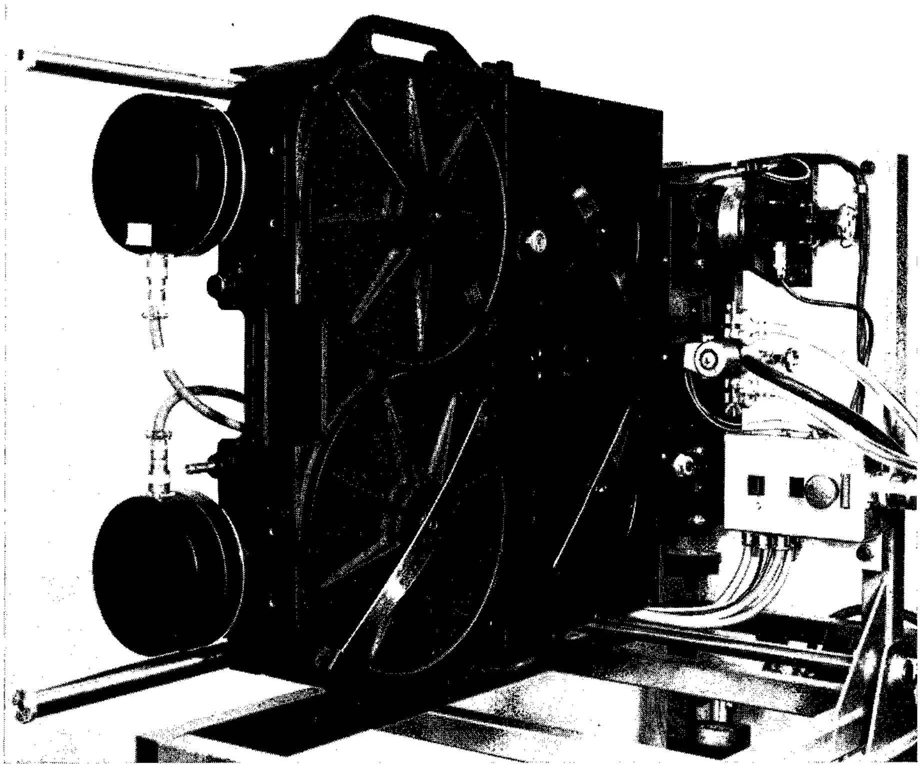
Tests on a coil of hollow superconductor begin on 1 March. The decision on the magnet coil will then be taken in April and manufacture of the coil will be put out to tender.

Work is going into the development of appropriate wire chamber systems and of optical chamber systems, which are likely to be used for the first experiments. A half-size optical spark chamber assembly has been built and successfully tested. It has several unusual features. The aluminium foil planes are only 10 μ thick compared with the usual 25 μ so that the amount of matter the particles cross in

*Two of the special developments for the Omega project. The top photograph is of a half-scale frame for an optical spark chamber. It will carry very thin aluminium foil (10 μ rather than the usual 25 μ) and one side of the frame (on the left) is only 1 mm of aluminium so that low energy particles can escape from Omega and be detected outside the magnetic field. The bottom photograph is of the stereo camera which can take pictures at the rate of one every 50 ms so that a quite high data-taking rate is possible with optical chambers. The camera places two stereo views side by side on 70 mm film.*



*CERN/PI 199.11.68*



*CERN/PI 5.12.68*

such an assembly is much less. The radiation length is increased (to 86 m) and multiple scattering reduced. To allow low energy particles to escape from the magnet the frame on one side of the chamber has been reduced to 1 mm of aluminium (see photograph).

As mentioned above, the data-taking rate in an array of optical chambers is likely to be determined by the rate at which the camera system can take pictures. Development has led to the construction of a high-speed camera for 70 mm film which can operate at the rate of one picture per 50 ms. It may prove possible to push this a little lower still.

Work on the analysis problems has already started in a group in the Data Handling Division. HPD capacity will be provided and appropriate computers are being investigated. The computer programs for the geometric reconstruction of the events and their analysis are being developed.

The Omega will increase the capacity for electronics experiments at CERN and make it possible for a greater number of scientists from European universities to take part in such experiments. By far the larger part of the data will be analysed outside CERN itself.

Several experiments such as the study of baryon exchange processes, missing-mass search at low momentum transfer, and investigation of leptonic hyperon decays have already been considered in some detail.

The total cost of the project (at 1967 prices) is estimated at 13.9 million Swiss Francs for the experimental equipment (magnet, optical spark chambers, etc.) plus 8.4 million Swiss Francs for the data-handling system (computers, HPD, etc...). The construction time is estimated at 3 ½ years and Omega is therefore scheduled to come into operation towards the end of 1971.

# The Weak Interaction

*A few topics from the 'Topical Conference on Weak Interactions' held at CERN on 14-17 January.*

## *New results*

There was little that was really new since the Vienna Conference last September. A CERN group presented the first experimental value of the phase of the amplitude of the decay of the long-lived kaon into two neutral pions. This is another piece of information which is needed to have a complete picture of the decay of the kaon which violates charge-parity (CP) symmetry.

An earlier CERN experiment had seen the CP violating decay into two neutral pions for the first time and had measured the rate of the decay (the measurement has since been disputed by several other teams — see the report of the Vienna Conference vol. 8, page 242). Knowing the phase and the rate for both the decay into two neutral pions and the decay into two charged pions, the theory indicates they can be combined in a certain way. The result of this combination could indicate that charge-parity time (CPT) symmetry remains valid or that time (T) symmetry remains valid.

Since CP is violated in these decays, T symmetry must also be violated if the product CPT is to be conserved. CPT conservation is deeply rooted in modern theoretical physics, and it is therefore assumed that T is not conserved, although so far all experiments to look for T violation have not found it. The present results give support to CPT.

These experiments on the neutral pion decays are looking for very rare events which are very difficult to measure. The results are often controversial. In particular, the conflict on the rate of the neutral pion decay is still open. The CERN team which presented the measurement of the phase, reaffirmed the disputed result on the rate of the decay giving a value several times higher than that measured by some other teams.

## *Astrophysics*

One of the paradoxes of modern physics is that the knowledge gained in the study of the smallest particles of matter is proving essential to the understanding of the largest scale phenomena in the universe. An aspect of this was discussed at the Conference.

A problem in understanding the behaviour of stars is to find mechanisms whereby energy can come out from the centre of the stars where temperatures are higher than at the surface. For some time now it has been assumed that one mechanism is via the production of neutrinos from electrons — the neutrinos can then carry energy away almost oblivious of the volume of matter they pass through in escaping from the star. Deductions from large-scale phenomena have here contributed to particle physics.

Calculations on this process of neutrino production have assumed that it occurs with the same weak interaction coupling constant as the familiar decay of the muon. More recently, however, theorists have been extending weak interaction theory beyond the lowest approximations and this has resulted in suggestions that the two processes may not be related.

## *Avoiding infinities*

These attempts to take weak interaction theory beyond the lowest approximations are very much in the centre of attention. One of the difficulties is that taking the theory further results in infinities appearing in the equations. An interesting observation on this topic has been made by R. Gatto, G. Sartori and M. Tonin, that a limited class of these difficulties can be removed by selecting a particular value of the Cabibbo angle (a value close to the experimentally observed value). Thus theorists have, for the first time, some reason for preferring the observed value to any other.

This choice of the Cabibbo angle removes only a very limited class of difficulties. A far more radical proposal from T.D. Lee and G.C. Wick sweeps away other infinities by changing certain signs in the equations. These signs are associated with causality and changing them means that causality is violated... that things can happen before they are caused (loosely speaking).

Lee and Wick remain cool, while putting forward this revolution in thought, by contending that it is wrong to be ruled by prejudices about causality which we have gained from large scale experience when we are considering events occurring in very short times (say less than $10^{-23}$s). Their theory involves violations of causality only in association with some hypothetical highly unstable particles (of mass say 10 GeV or above) and thus with unobservably short times. (There are conceivable experiments which could say that the theory is right but they would not necessarily say that the theory is wrong ! It could just be that the experiment has not reached high enough mass for the unstable particles.)

The imaginative work of Lee and Wick is an example of a major effort to deal with the problem of infinities and to construct theories rather than phenomenologies. This has been stimulated by two developments. One is purely theoretical — the technique of 'current algebra' has provided a new way of looking at these questions. The other is the increasing accuracy of experiments.

For example, it has been accepted for some time that weak interactions, which do not conserve isospin, violate it in a rather regular way. Now, as experiments look at this with increasing accuracy, irregularities seem to be emerging. It is not possible to assign these irregularities directly to the underlying weak interactions, because of the ever-present electromagnetic interactions which are expected to introduce small corrections. The electromagnetic interaction also violates isospin, and can be expected to lead to irregularities of a few percent even in primarily weak interaction phenomena. So to get at the weak interactions, we would like to switch off the electromagnetism. This can only be done theoretically and naive calculations of electromagnetic corrections usually result in infinities. Hence the effort to reformulate the theory.

# CERN News

## Gargamelle Construction delay

Delivery of the chamber body for the huge heavy liquid bubble chamber, Gargamelle, is now scheduled for the end of June 1969. This has moved back the date foreseen for the start of physics with the chamber at CERN. (A description of the chamber appeared in CERN COURIER vol. 8, page 95.)

At a meeting on 18 February between representatives of CERN and of the Commissariat à l'Energie Atomique, who are financing construction of the chamber at the Saclay Laboratory in France, the possibility of bringing components directly to CERN for testing from now on was investigated.

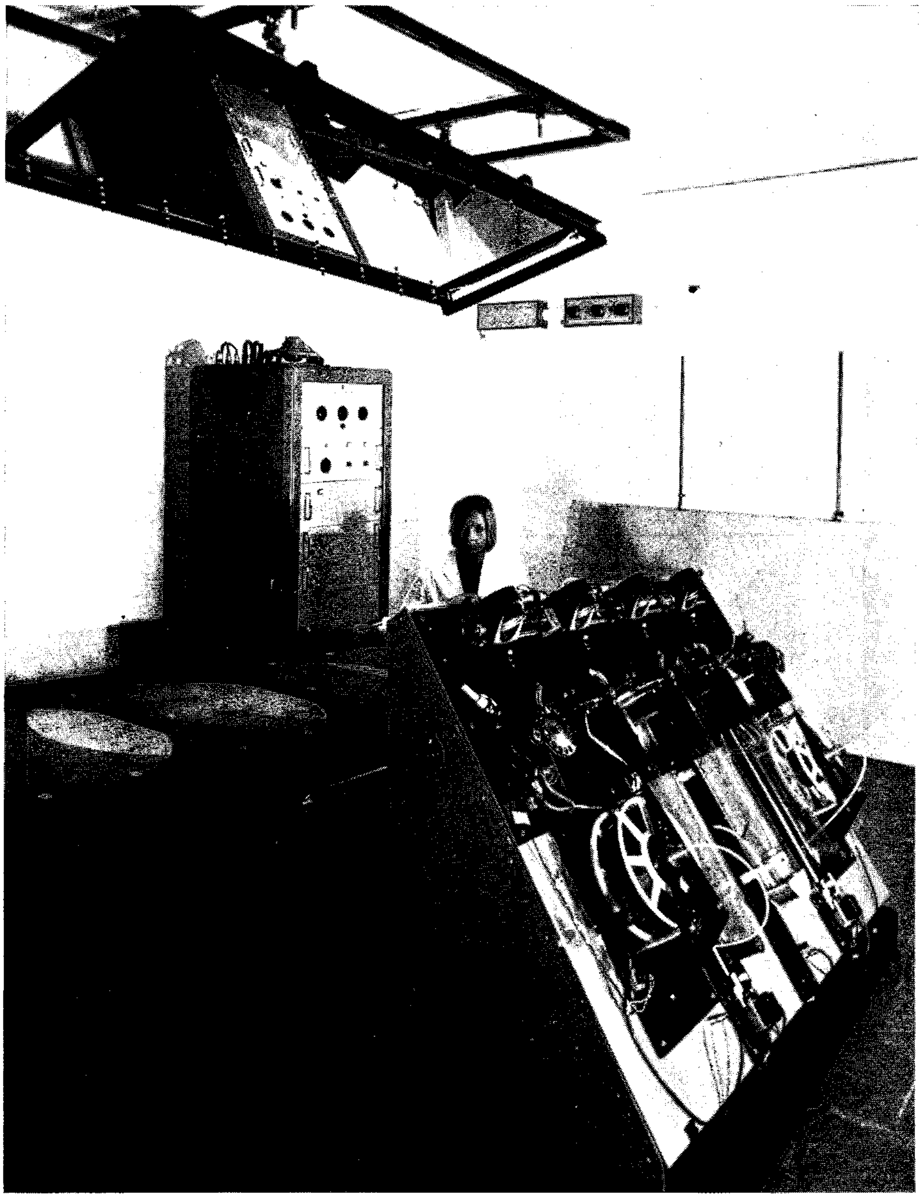
Tests have been successfully completed on the chamber magnet (already installed at CERN), the optics, the heating and regulation system, the system for transfer and distillation of liquids, and on some of the control electronics. Other tests on components such as the camera and data box, and the compressor are under way. Several 'Gargamelle Users Meetings' have been held and discussion of the initial physics programme is well advanced.

### *Gargamelle photo analysis*

A scanning and measuring table for the analysis of photographs taken in Gargamelle has been developed by the Nuclear Physics Apparatus Division at CERN (who financed its construction) in collaboration with University College, London.

The photograph shows a 'pilot model' which will help determine the specification for the final version (called 'Gemini') of which a number will be produced by outside industry. The construction of the tables was put out to tender at the end of January and replies have been requested for 10 March. This should make it possible to have the first machines delivered at the end of 1969.

The table is 'combined-function', being used not only for scanning the photographs, but also for measuring them. The measurements will be done on-line with a CDC 3100 computer, using the experience gained with the present NPA on-line system.



*The scanning and measuring table preparing for the analysis of photographs from Gargamelle. This 'pilot model' has been built to finalize details of design before tables are manufactured in industry for several European Universities and for CERN.*

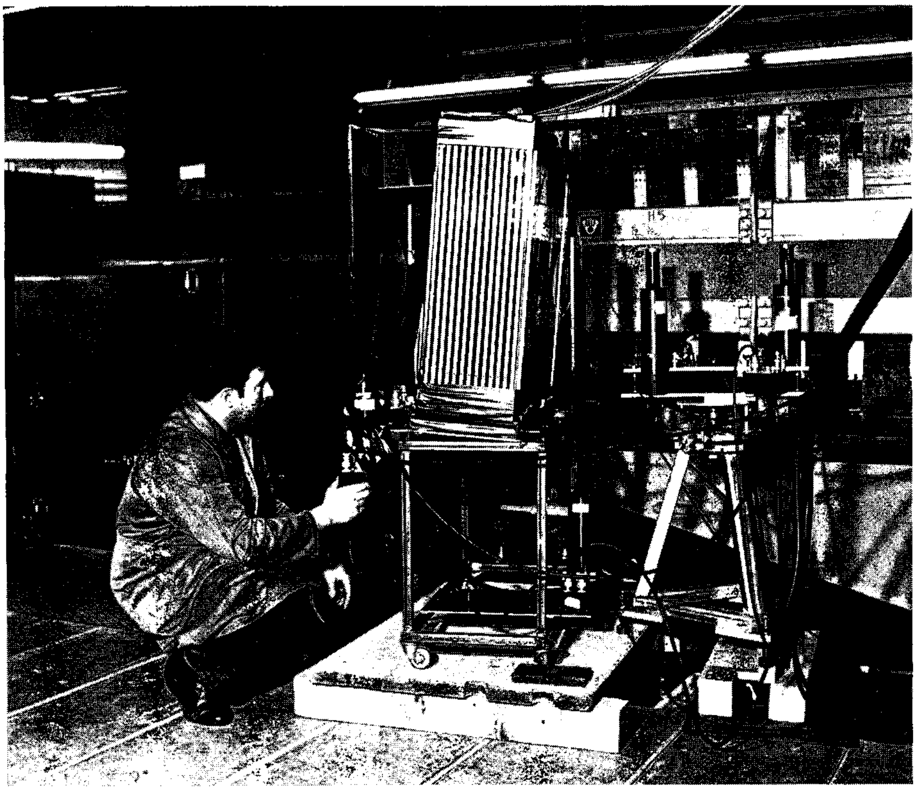
*CERN/PI 298.1.69*

The design of the table is governed by the unique optical system of Gargamelle, which has two parallel rows of four wide-angle lenses (110°) as described in CERN COURIER, vol. 8, page 96.

Two films are used, one for each row of four lenses. Each film passes in succession the four lenses in one row, and a special film-feed mechanism allows the whole area of the film to be used. The eight views can then be projected simultaneously onto the table. Each film is 70 mm x 300 m and can record about 800 photographs.

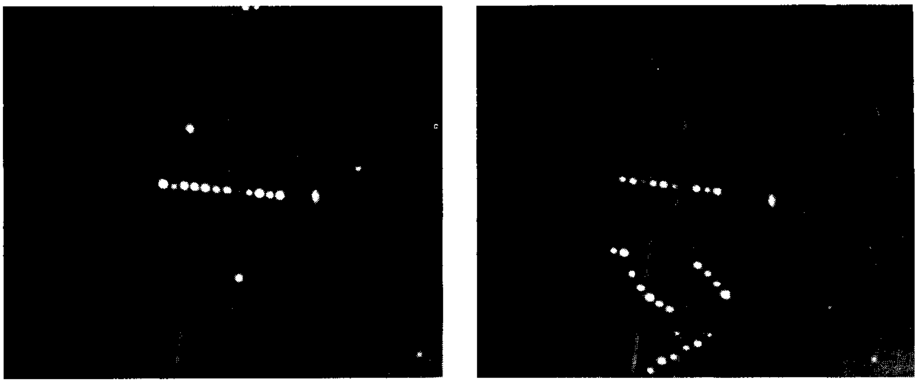
On the scanning and measuring table, eight objectives (one for each view) are connected together, by a system of rods which serves two purposes : 1) the eight views can be moved together while keeping the distances between them constant (each view can, therefore, be brought directly in front of the operator) ; 2) the views can be partially or completely superimposed in such a way that the centre-to-centre distances between adjacent views

*The spark chamber positioned next to the proton synchrotron to look at the 'background' radiation. A high energy beam is allowed to coast in the machine and the spark chamber records particles produced by interactions between the beam and residual gas in the vacuum chamber. From this, the background to be expected at the ISR can be deduced — an important piece of information before the detectors for ISR experiments are built.*



*CERN/PI 86.2.69*

*Below are two photographs taken of the spark chamber. On the left : a high energy particle from beam-gas interactions. On the right: one high energy particle and a low energy particle (easily scattered by the foils in the chamber) probably from induced radio-activity in the accelerator components.*



remain equal. The images can be moved only in the longitudinal direction with an accuracy which allows the images of the same point on several views to be superimposed to within 1 mm.

There are two assemblies of four projectors juxtaposed in the Gemini, so that the two films (from the two rows of four cameras) can be projected onto the table.

Measurement will be made directly in the image plane and not, as with the IEP, by moving the film. This means that a high-quality optical system is required.

Two possible measuring systems have been considered : in the first, measurement is made in bipolar coordinates ; in the second (already marketed under the name of 'D-Mac Pencil Follower') measurement is made in Cartesian coordinates.

Orders for the Gemini will be placed by CERN (four), University College, London (three) and Aachen (two). Further orders will probably come from Bergen and Brussels. There are three other projects to develop scanning and measurement tables for Gargamelle now on hand, at Orsay, at the Ecole Polytechnique de Paris and the Institute of Physics of the University of Milan.

It will be possible to use most of the components of Gemini for the scanning and measuring tables of Mirabelle, the hydrogen bubble chamber which is being built at Saclay for Serpukhov. Some modifications will be needed because Mirabelle has three rows of three cameras and has inverted images.

## Looking at the background

A short experiment on the proton synchrotron, in a series by B.D. Hyams, V. Agoritsas and M. Bott-Bodenhausen, was concluded in the first week of February. It used the PS to investigate what might be expected from 'background' radiation in the intersecting storage rings. Such radiation is expected to come predominantly from collisions between the beam particles and residual gas molecules. For some experiments this will simulate beam-beam collisions and in general it will give strong signals or tracks, complicating the analysis of beam-beam interactions.

Knowing the design figures for the ISR beam intensities and for the pressure in the vacuum chamber, it is possible to calculate the background that can be expected. However, before large amounts of money are invested in detection systems for the ISR, it is important to check these figures in a practical test under as near realistic conditions as possible.

An optical spark chamber was set up close to the beam pipe of the PS. Protons were accelerated to 22 GeV, and the beam was then allowed to coast at constant energy (at the magnet pulse flat-top) simulating a stored beam in the ISR. During 100 ms of the flat-top the spark chambers could be triggered by particles produced in collisions with residual gas molecules in the pipe (no targets or extraction systems were being used).

The pressure in the PS was $2 \times 10^{-6}$ torr and the beam intensity was $2 \times 10^{11}$ circulating protons. Taking the design conditions in the ISR as a pressure of $10^{-11}$ torr and an intensity of $4 \times 10^{14}$ particles in each beam, the results of the experiment can be translated into figures

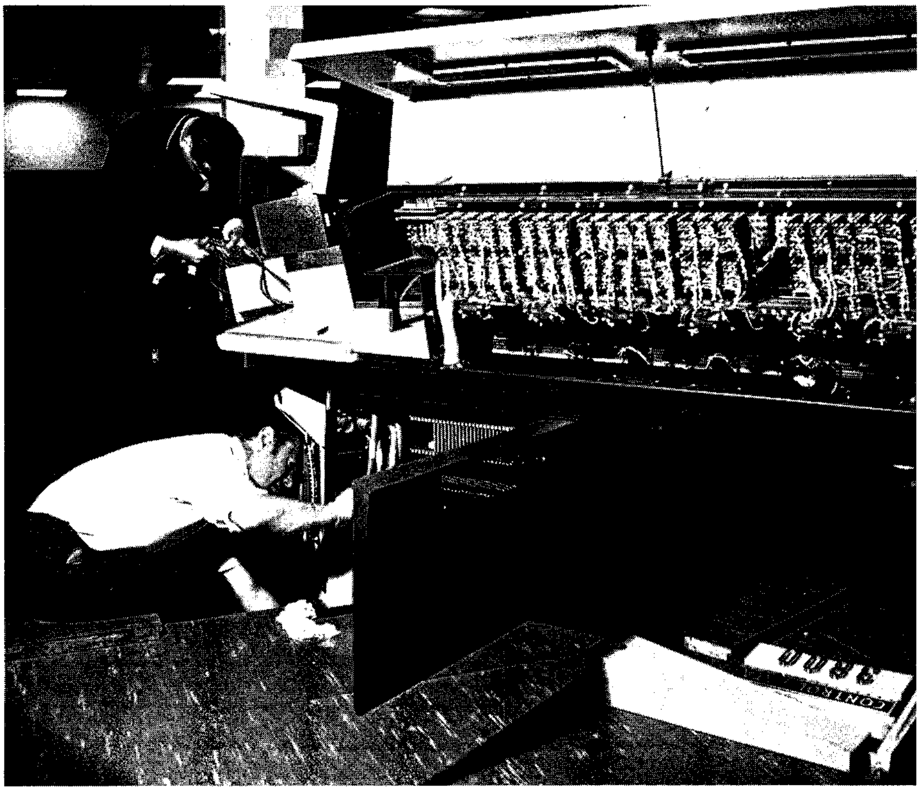
*1. Mr. Willy Spühler, head of the Federal Political Department signing the Agreement establishing the European Molecular Biology Conference on behalf of the Swiss government. Switzerland played an important part in bringing this Agreement to the point of signature at CERN on 13 February.*

*2. The CDC 3800 computer being dismantled for transport to Geneva University.*

*3. The elegant new control room, built by Sprecher and Schuh (Switzerland), of the enlarged power house. From this room, the distribution of general services such as electricity, compressed air, cooling water, etc. throughout the CERN site is controlled. The map of the site on the left is a general alarm panel which can show the location and nature of faults (from a clock which has stopped to an outbreak of fire). The units of the power house itself are also monitored here. The control room came into service in January.*

1.

*CERN/PI 127.2.69*



2.

*CERN/PI 321.1.69*

for the ISR. Calculating the mass of gas traversed and the difference in intensity, the operating conditions for the experiment were about 50 times worse than can be expected at the ISR. Otherwise conditions were comparable — the energy, beam size and magnet structure were similar to the ISR.

The results were close to the calculated figures and one brief way of expressing them is as follows :
If the ISR operating conditions are as mentioned above, then, taking the sensitive time of the spark chambers as 2 $\mu s$ each time they are triggered, a 1 $m^2$ spark chamber placed next to the beam pipe can expect to record one particle track due to background from the ISR about once in every three pictures.

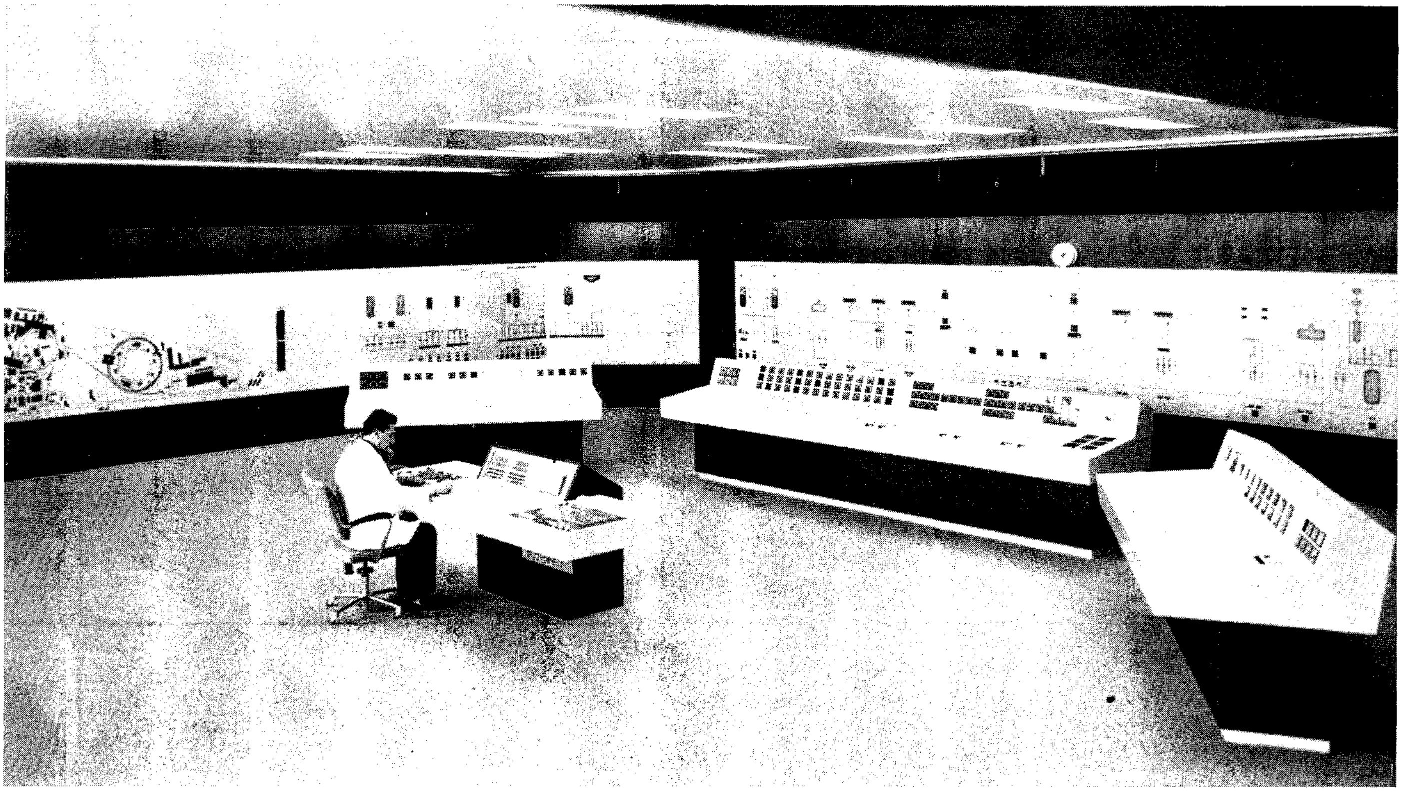
A similar investigation using only counters was carried out in 1965. It showed that, as expected, the background is strongly directional — that the particles from beam-gas collisions emerge predominantly tangential to the circulating beam direction. The recent experiment with spark chambers was able to detect particles of a much wider range of energies. It was possible to see very low energy particles almost certainly coming from induced radio-activity in the accelerator components.

None of this looks unduly troublesome for the ISR experiments. It may however prove necessary to install some shielding far upstream of the interaction regions on both rings to shield the detectors. This is because the directional background will come predominantly from upstream and there the pressure will not be as low as in the interaction regions.

## European Molecular Biology Conference

On 13 February, an agreement was signed at CERN by twelve European countries establishing the European Molecular Biology Conference. This is an important development in European co-operation in the growing field of molecular biology.

The field does not at present call for very large and expensive items of equipment and some countries feel that it is not yet appropriate to set up a central



3. CERN/PI 71.2.69

Laboratory on the model of CERN. There is however a need to bring together scientists with expertise in the variety of disciplines which are involved in molecular biology. Until such a time as a central Laboratory receives sufficient support the 'Conference', formally established at the February meeting (subject to ratification), goes a good way towards achieving the necessary co-operation.

The Agreement states in Article II : 'The General programme to be carried out under the responsibility of the Conference shall comprise in the first instance :

(a) provision for training, teaching and research scholarships ;

(b) assistance to universities and other institutions of higher learning that wish to receive visiting professors ;

(c) the establishment of study meetings, coordinated with the programmes of universities and other institutions of higher learning and research.

The execution of the General Programme is entrusted by the Conference to EMBO.'

EMBO, the European Molecular Biology Organization, is a private organization centred in Geneva which was set up in 1963 by many leading molecular biologists in Europe. It has already initiated a programme along the lines of Article II of the Agreement and it is now assured of State financial support to sustain and intensify this work. The finance will be provided by participating countries in proportion to their national income.

The countries who signed the Agreement are : Austria, Denmark, Federal Republic of Germany, France, Greece, Italy, Netherlands, Norway, Spain, Sweden, Switzerland, United Kingdom.

## Computer to Geneva

A CDC 3800 computer left CERN in February to be re-installed at the University of Geneva. The machine came to CERN in September 1966 as part of the temporary manoeuvres to sustain the computing capacity on the site during the teething-troubles of the CDC 6600. The need for the computer was removed when the CDC 6400 arrived.

At the same time, the Canton of Geneva was interested in acquiring a large computer for use by the University of Geneva and by the cantonal administration. (The computer had a trial run for the administration when it was used in October 1967 to count the votes recorded in the federal elections.)

CERN was able to offer the CDC 3800 on very favourable terms (4.9 million Swiss francs) and an agreement to purchase the computer was signed by the Geneva authorities in April 1968.

A few technical details : The CDC 3800 has a memory of 65 356 words of 48 bits, a capacity of approximately 1 100 000 operations per second and a reading speed of 1 200 punched cards per minute. It has 8 tape decks with a transfer speed of 120 000 characters per second.

CERN will continue to have a small amount of time (120 hours per month) on the computer until the end of 1970.

## Concerts at CERN

Following a long-established tradition, CERN is organizing in 1969 a series of concerts to be held in the large auditorium. The concerts are open not only to CERN staff and their families but to anyone in Geneva. As in previous years, they will involve close collaboration with the Radio Suisse Romande who will record the concerts to be broadcast on the radio.

The concerts will be given by a variety of chamber music groups presenting a variety of compositions. The programme is as follows :

| | |
|---|---|
| 31 March | The Lasalle String Quartet — works by Purcell, Rosenberg, Haydn and Schubert |
| 15 April | The Geneva Wind Octet — works by Rosetti, Telemann. Haydn, Fash and Beethoven |
| 6 May | Lionel Rogg on the harpsichord — works by Bach, Handel and Couperin |
| 20 May | The Geneva String Quartet with the pianist Denise Duport Cellich and bass M.J. Staempfli — works by Martinu, Martin and Schönberg |
| 3 June | The Charles Ravier ORTF polyphonic ensemble — programme to be arranged. |

Seats may be reserved at a price of 5 francs each concert or 20 francs a season ticket for 5 concerts.

For single tickets, contact the Personnel Association (tel. 41 98 11, extension 2819) and for season tickets, contact Mr. Adam (tel. 41 98 11, extension 2317).

# Around the Laboratories

## BERKELEY
### New ERA

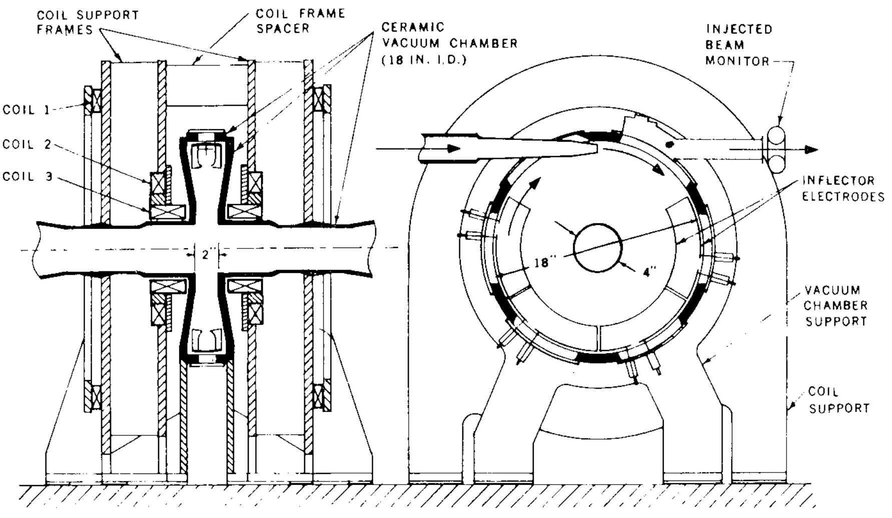
The most exciting work in accelerator physics research at present is being done at the Joint Institute for Nuclear Research, Dubna, and at the Lawrence Radiation Laboratory, Berkeley. Both these centres have now mastered the first stage of the Electron Ring Accelerator (ERA) — the production and compression of electron rings. This report on the progress at Berkeley is based on a talk given at CERN on 21 January by A.M. Sessler.

*How it works*

The basic ideas involved in the ERA were described in CERN COURIER, vol. 8, page 28 and will be reviewed only briefly here. First, an addition to the previous article should be made — in the roll-call of people who had contributed to the ideas, the name of R.B.R-S-Harvie was missed. At the Atomic Energy Research Establishment, Harwell, in March 1951, Harvie produced a brief paper, AERE G/M87 'A proposed proton linear accelerator', in which he pointed out for the first time the possibility and the advantage of pulling protons along in electron bunches or electron rings. He did not take into account, however, the neutralizing effect of the protons helping to hold the rings stable. The idea was not pursued until it was re-invented a few years ago by the late V.I. Veksler at Dubna.

The aim is to achieve a high energy proton beam by accelerating a cluster of electrons in which protons have been persuaded to sit. The practical method is to create a ring of electrons (say 30 cm in diameter) by injecting an intense electron beam into a strong magnetic field. The magnetic field is increased and the ring shrinks in size (to say 7 cm diameter), the electrons increasing correspondingly in energy (they will travel around the tiny ring with an energy of say 19 MeV). The box in which this process occurs is called the 'compressor'.

Hydrogen is then fed in and the fast moving electrons ionize the hydrogen molecules. The positive ions are attracted by the deep negative potential well created by the intense electron ring and stay in the ring. (Both electrons and ions are in the ring itself — the ions are not inside the circle of electrons. If the ring were a wedding-ring both electrons and ions would make up the gold.)



1.

A ring of electrons and protons will be stable provided

$$N_e > N_p > N_e/\gamma^2$$

where $N_e$ is the number of electrons in the ring (typically $10^{14}$), $N_p$ the number of protons in the ring (typically $10^{12}$) and $\gamma$ a measure of the energy of the electrons flying round the ring. It should then be possible to accelerate the ring down a linear machine pointing along the axis of the ring. Several methods have been proposed to accelerate a ring to high energies without pulling it apart.

The great advantage is that the energy the protons gain as the ring is accelerated is greater than that of the electrons in the ratio of the proton mass to the electron mass. In the ERA this is not the ratio of the rest masses (1836 : 1) because the electrons moving round the rings are relativistic — their mass is about 40 times their rest mass. This still leaves a gain of about 45 for the proton.

*Berkeley Compressors I and II*

Following the announcement at the Cambridge Accelerator Conference in September 1967, that Dubna had produced and compressed rings, an intense effort was turned on at Berkeley. There is no doubt that the challenge of the ERA has breathed the breath of life back into the strong LRL team of accelerator physicists who had lost the 200 GeV machine to the mid-West. The ERA has had the powerful backing of the Laboratory management and the support (including financial support — which really means something !) of the Laboratory high energy physicists. During the past year the number of people involved in the project rose as high as 120 at peak times and a total of about $1 M was spent.

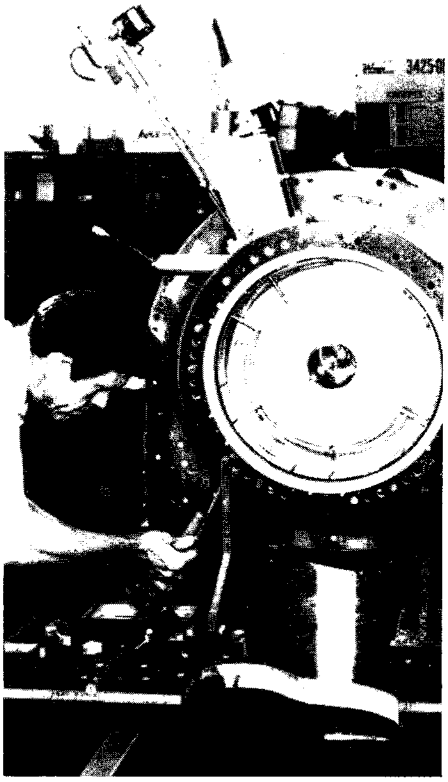
Construction of the first compressor started in February 1968. It was a simple, 'off-the-shelf' device whose purpose was to give some first experience in playing with the new techniques, to help establish

*1. A diagram of Compressor II : on the left, looking along the plane of the rings ; on the right, looking down the axis of the rings.*

*The photographs show Compressor II being assembled.*

*2. Looking inside the Compressor — the inflector structure can be seen around the circumference and coming in from top left is a probe.*

*3. The complexity of the near completed assembly.*



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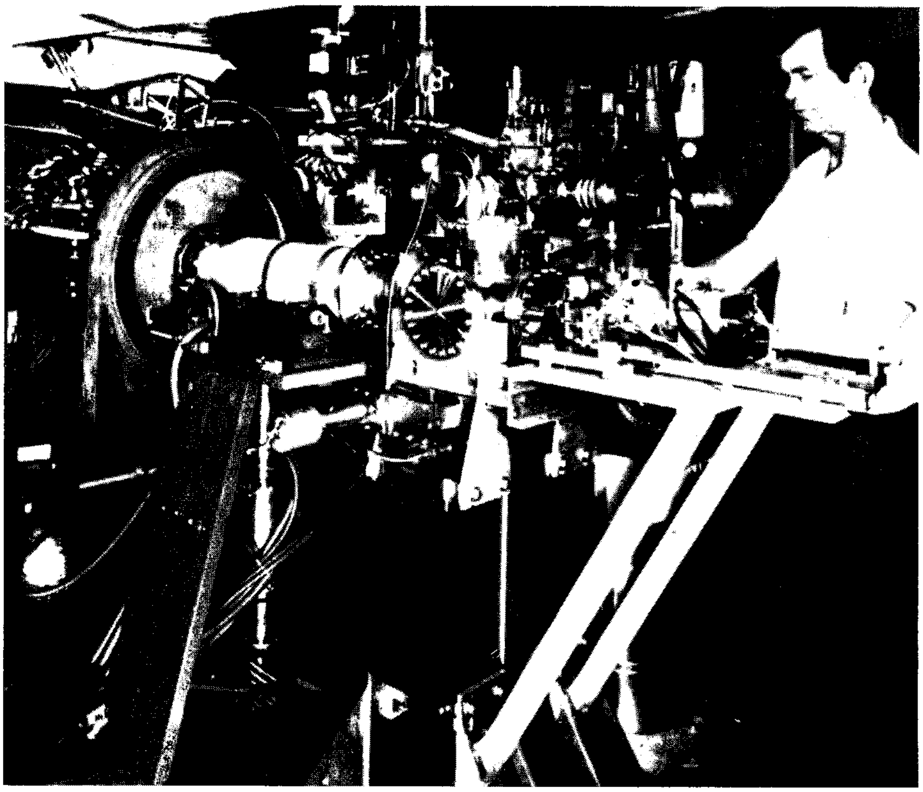


3.

parameters for the first serious compressor and to learn about single particle effects. In June, construction was completed and electrons were fed in from the LRL 4 MeV linac. Rings were soon formed and compressed.

This was very encouraging, but, because of the lack of sophistication of Compressor I and its diagnostic equipment, it was not known how good the rings were and only hard experience with Compressor II showed that little was learned about single particle effects.

Compressor II was a thoroughly engineered device. It was assembled at the Livermore Laboratory where the Astron injector, normally used for thermonuclear fusion research, supplied electrons through a beam transport line about 10 m long. The injector was operated at 3.3 MeV and a pulse rate of 1 per 2 s. A chopper selected 20 ns bursts to feed the compressor with injection over several turns, eventually giving rings of 150 A (4 x $10^{12}$ electrons) and an initial radius of 19 cm. (An inflector structure was built into the compressor but it was found that more efficient self-injection took place with the inflector voltage switched off — an effect which is not yet understood.)

The vacuum vessel was built of alumina and pressures of $10^{-7}$ to $10^{-8}$ torr could be achieved. Foils were used to isolate the compressor from the Astron vacuum. Controlled amounts of hydrogen could be fed in at any time in the cycle by means of a 'puff-valve'.

The magnetic field was provided by three coil pairs (positioned as shown in the diagram). The first coil was powered as the beam was injected giving a field of 600 G. Coils 2 and 3 came on successively to increase the field to 20 kG in about 0.5 ms, equivalent to a ring compressed to 3.5 cm radius and a 19 MeV energy of the electrons. Each coil took thousands of amps at several kV ; typically, coil 3 would take 25 000 A at 5.5 kV and would crash like a sledge-hammer as it was powered.

Compressor II was alloted two periods of three weeks operation. The first run was spent in persuading all the equipment to operate together, in tuning the beam transport system, in synchronizing the injector and the compressor and in testing the diagnostics (probes, X-ray and microwave monitors, synchrotron light). A problem which prevented any major progress was that the foils between Astron and the compressor caused so much beam blow-up that only 40 A could be injected. After injection, the ring was lost in about 10 μs.

During a three week break before the second run there was frantic activity, theoretical and practical, to try to understand and put right the problems. In particular, the inflector structure was redesigned to avoid a possible coherent beam loss when the beam passed through the inflector bars after 10 μs. The situation reached at the end of the first run was recovered almost immediately after switching on again but without the catastrophic loss after 10 μs. It was soon learned that rings could not be held because of single particle effects. Right through to within a few nights of the final shutdown a nerve-racking game of 'dodge that resonance' took place.

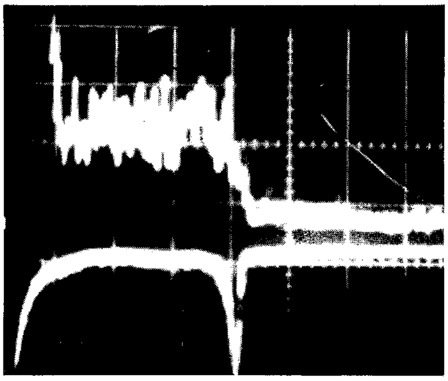
*4. Losing a ring after 40 µs at the $n = 1/2$ resonance. The horizontal scale is 10 µs/cm. The top signal is microwaves (22 GHz) ; the bottom signal X-rays.*

*5. Success. The horizontal scale is now 1 ms. The signals are as in (4) and show that the rings are retained over 5 ms — the full time that coil 3 is adequately powered.*

*6. Synchrotron light from compressed rings. The black marks on the ring are caused by the grid of the camera. These photographs (exposure time 500 ns) show the remarkable stability of the rings and make it possible to measure their cross-section (about 5 mm radially by 4 mm axially).*

*7. Diagram of Compressor III now being built. With this coil arrangement, extraction of the compressed rings, to the right, will be attempted.*

*(Photos LRL)*



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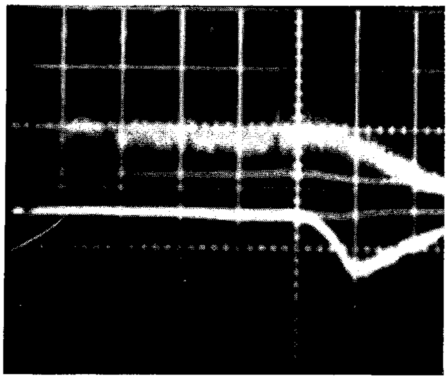

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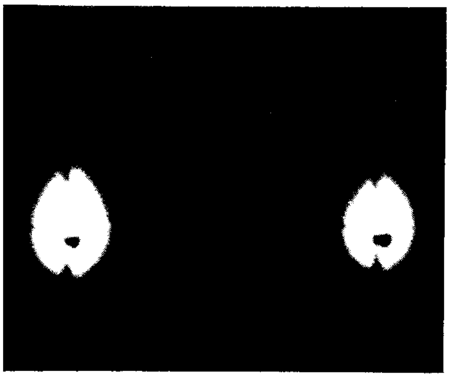
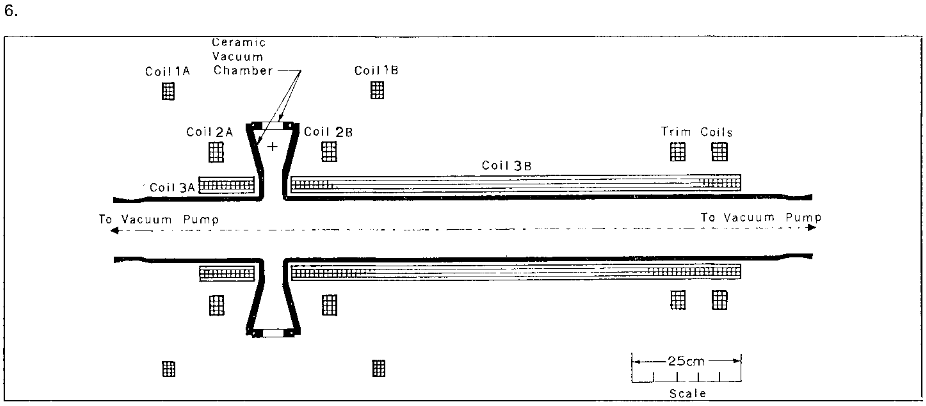


6.

(One way to distinguish between a high energy physicist and an accelerator physicist is to use the word 'resonance'. If his eyes light up he is a high energy physicist — his sub-conscious is thinking of new particles and beautiful symmetries ; if his eyes contract he is an accelerator physicist — his sub-conscious is thinking of enormities committed on his beam.)

A single particle travelling round in the magnetic field follows an oscillatory path and care has to be taken to set up the magnetic field in such a way that the particle is pushed back whenever it deviates from the perfect circle. If this stability is not achieved the particle beam will be lost. The phenomena which cause the loss are called 'resonances' and a beam cannot be allowed to sit too long under magnetic field conditions equivalent to a resonance. The way to express this in accelerator theory is to say that the magnetic field index, n, should not have values of $1/2$, $1/4$...

It was found that serious loss of the rings after about 70 µs was due to the $n = 1/2$ resonance and other resonances caused loss earlier. A long battle began to programme the currents fed to the three coils in order to avoid crossing resonances early in the life of the ring. When the ring had been compressed away from the inflector structure, to where the magnetic field was better, it proved possible to cross resonances without trouble. Typically, coil 2 came on when the ring had a radius of 12.5 cm and coil 3 at 6 cm. The final radius was 3.5 cm and the fully compressed ring could be held remarkably stable for 5 ms before the current in coil 3 died away.



7.

Once this stage had been reached, rings could be produced with near perfect reliability. Only two nights were left for experiments but several important measurements were achieved. The puff-valve was operated and the behaviour of the partially neutralized rings was exactly as expected.

### *Compressor III*

The experiments had to stop for the complete re-building of the Astron injector which, it is hoped, will give four times the current and twice the 'brightness'. This will increase the injection efficiency into Compressor III which is now being built to come into operation about the beginning of July.

With Compressor III it will be possible to tackle the next vital stage — the extraction of the rings. This requires that axial fields of 20 kG are established with less than 3 G of radial field.

If all goes well it is still likely to take several years to gain a thorough understanding and technical mastery of ERAs before construction of a machine for physics is contemplated. Nevertheless an abundance of ideas are beginning to emerge as people grapple with this new acceleration technique.

Within a year, the Berkeley team have achieved compressed rings and the important thing about their work is that they have a pretty thorough understanding of what has happened en route. The problems they could expect to bump into, in terms of known accelerator theory, they did bump into and could get round. More complicated stages lie ahead but, unless some presently unknown phenomenon emerges, there is no reason to believe that the ERA will not work.

## KARLSRUHE/MUNICH
## European ERAs

Research on electron ring accelerators is starting at two centres in the Federal Republic of Germany — Karlsruhe and Munich.

At Karlsruhe a team of ten people has been set up and they hope to finalize the design of a compressor this month. A 'Febatron' has been ordered from Field

Emission Corporation as injector (to be delivered in April). Its parameters are — energy 2.2 MeV, momentum spread about 1 %, inside a pulse length of about 20 ns. It is hoped to inject $10^{13}$ electrons.

It is intended to compress at a slower rate than at LRL with a flexible current programme for the coil to steer away from resonances. To feed in the protons, an atomic hydrogen beam may be fired across the ring rather than flooding the compressor with hydrogen.

Munich have a team of 26 people. They also will use a Febatron as injector and will try faster compression than LRL to cut the growth time of instabilities. The Febatron is installed and the compressor will be completed soon. Protons will be injected from a duoplasmatron ion source.

## ARGONNE 12 foot chamber

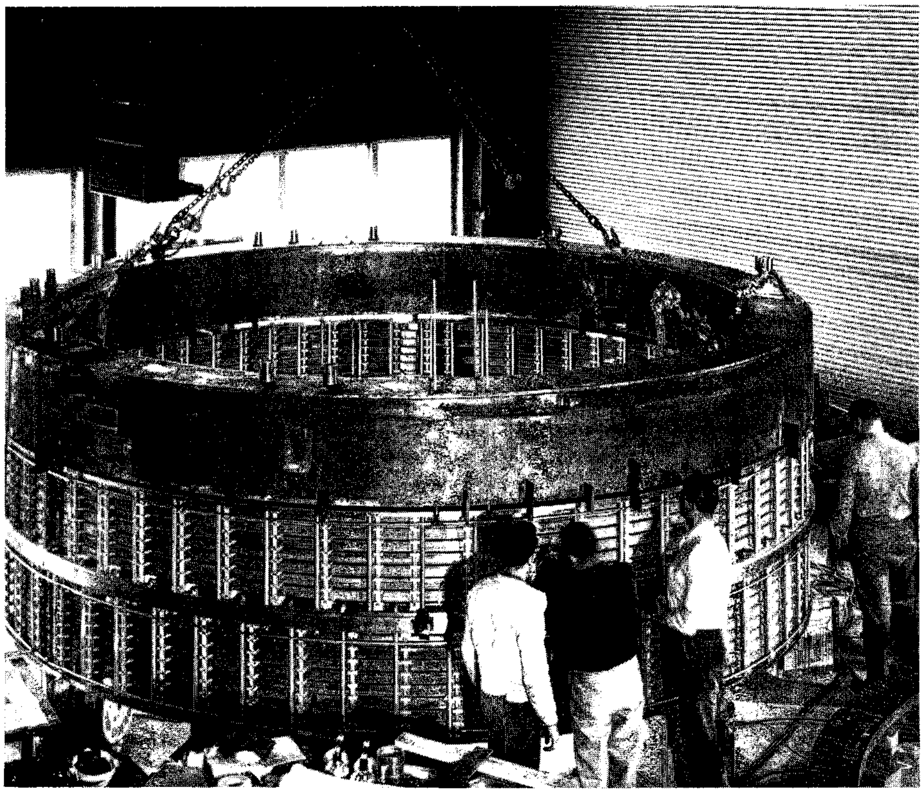
It was announced on 22 January that the world's largest superconducting magnet has been successfully tested at the Argonne National Laboratory. The magnet is designed to provide an 18 kG field for a large hydrogen bubble chamber 12 foot (3.7 m) in diameter.

The chamber and the superconducting magnet were first proposed for use at the 12.5 GeV Zero Gradient Synchrotron (ZGS) in June 1964 and the project was funded in July 1965. Some preliminary experience was gained when Argonne pioneered the use of superconducting magnets on bubble chambers with a 10 inch diameter, 40 kG helium chamber in 1966.

Cost estimates were prepared for both a conventional magnet system and a superconducting magnet system to produce the required field over the chamber volume. The estimates for both systems came out at about $2.4 million (the actual cost was close to this estimate) but the superconducting magnet scored heavily in projected operating cost. Assuming operation for 50 % of the time over ten years, a conventional magnet (which would need about 10 MW) would cost $ 4 million to run and the superconducting magnet $0.4 million.

The main features of the bubble chamber are as follows (no explanation of the design will be given since it has much in common with the large European chamber and the Brookhaven chamber which have been covered previously — vol. 7, page 143 ; vol. 9, page 12) : The chamber volume is 25 $m^3$ (about 20 $m^3$ of 'useful' volume seen by the cameras). The expansion system is mounted at the bottom of the chamber and involves a piston of large diameter connected to the chamber walls by flexible steel toroidal bellows. A resonant hydraulic system powers the piston and the chamber can be operated with a period of 35 ms producing a 1 % volume change. Four cameras with very wide angle lenses (140°) are positioned at the top of the chamber. The cameras look through three-layered fish-eye windows. There are flash tubes around the cameras and scotchlite coating within the chamber gives bright-field illumination.

The huge superconducting magnet is designed to produce a field of 18 kG in the chamber. The magnet differs from those of the other large chambers in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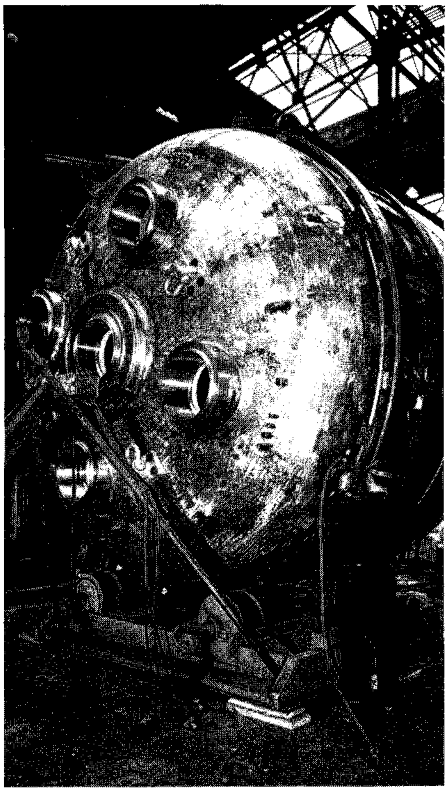
*1. A stainless steel container being lowered over one of the coil sections of the huge superconducting magnet which will establish fields of over 18 kG in the Argonne 12 foot hydrogen bubble chamber.*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*2. The chamber body undergoing its last weld (between the elliptical head and the cylindrical section). The five camera ports, which are on top of the chamber when it is mounted in its final position, can be clearly seen.*

using a steel core (1600 tons). The field is established over a volume of about 5 m diameter and 3 m high, and the stored energy is 80 MJ.

A composite superconductor is used with six ribbons of niobium-titanium embedded in a copper strip 5 cm wide and 0.25 cm thick. This strip is wound into thirty coils in the shape of flat pancakes. The total length of conductor used is 40 km. Two stacks of fifteen coils are mounted one above and one below the position of the beam entrance window separated by a spacing of 60 cm. The coils are cooled by liquid helium produced by a 400 W refrigerator. The current in the conductor is about 2000 A.

The magnet was cooled down for the first time at the end of November and, after some trouble in filling the cryostat had been cleared, the emergency energy dumping system was successfully tested for various currents in the superconductor. Eventually a field of 18.5 kG was achieved and the Argonne team is confident that the field can be taken above 20 kG. The manager of the magnet project is J.R. Purcell and the manager of the bubble chamber project is E.G. Pewitt.

The chamber will be used, filled with deuterium, for neutrino experiments, particularly looking at the elastic interaction at low energies where the ANL neutrino facility can achieve better statistics than elsewhere. It is hoped to take a million pictures with the ZGS intensity pushed a bit higher than it is at present ($2.3 \times 10^{12}$ protons per pulse at one pulse every two seconds). The fast extraction efficiency is between 50 and 70 %.

The chamber will be fully assembled ready for final tests beginning early spring. Cool-down is planned for July and experiments could start in September.

## Conference

An International Conference on Hypernuclear Physics will be held at Argonne on 5-7 May 1969 ; it is intended to be informal and to give a comprehensive coverage of hypernuclear physics with ample time for discussion. The Conference is open to all physicists working in the field and contributed papers are welcomed (abstracts should be in by 15 March).

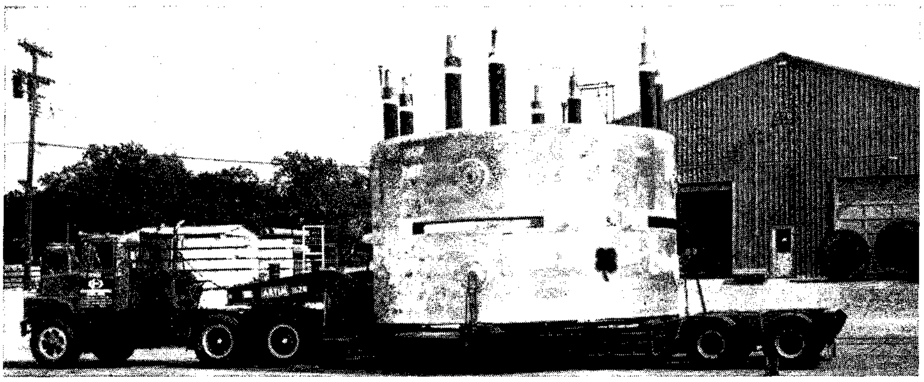
The preliminary programme is —

| | |
|---|---|
| 5 May | Free Hyperon-Nuclear Interactions<br>Meson Theory of Baryon-Baryon Interactions<br>Emulsion Data<br>Exotic Hypernuclei |
| 6 May | Hypernuclear Spectroscopy<br>Helium Bubble Chamber Data<br>Production of Hyperons and Hypernuclei by $K^-$ Capture |
| 7 May | Experimental Techniques<br>Critical Discussion of Experiments<br>Summary |

Anyone interested in the Conference should contact

L.G. Hyman
Argonne National Laboratory
9700 South Cass Avenue
Argonne, Illinois 60439

3. *The encapsulated superconducting magnet being transported to the bubble chamber building.*



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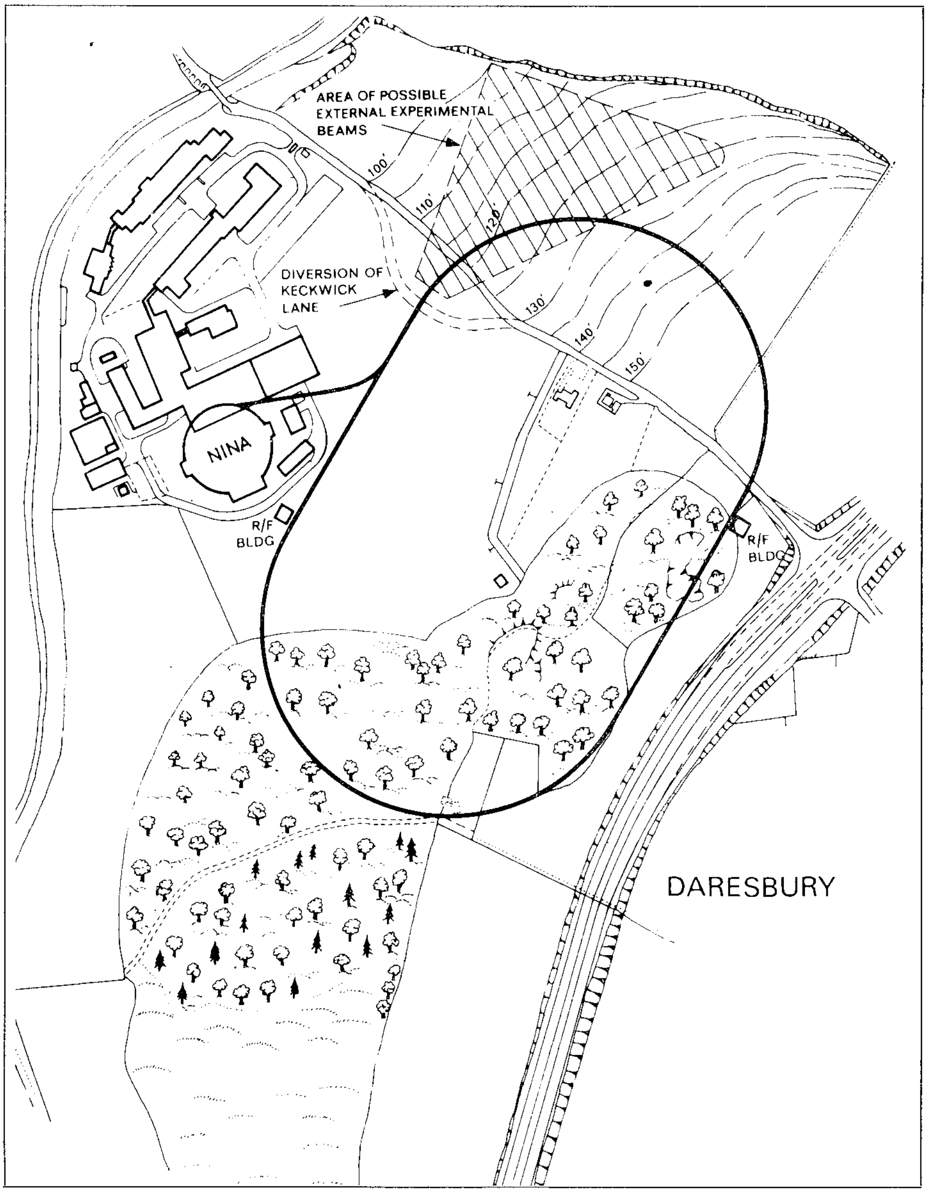
## DARESBURY
## Higher energy electron synchrotron

A preliminary design study for a 15-20 GeV electron synchrotron has been published by the Daresbury Laboratory, UK. The proposed machine has become known as the 'NINA Booster' since it will receive electrons from the existing 5 GeV synchrotron, NINA, and boost their energy to 15-20 GeV. (Not to be confused with the more usual use of the term 'booster' to describe the accelerator stage which boosts the energy at which particles are injected into a synchrotron.)

The proposed machine fits neatly into an overall scheme of European (and world) accelerators. Present competitors in this energy region are the 20 GeV electron linear machine at the Stanford Linear Accelerator Centre, USA, and the 10 GeV electron synchrotron at the Wilson Synchrotron Laboratory, Cornell, USA. (The Cornell machine has been built for extension to 15 GeV.) There is nothing comparable, in existence or planned, in Europe.

Research at Stanford has illustrated the richness of this energy range for electron and photon physics and has indicated the need for a synchrotron to cover the same range with a much better duty-cycle (the percentage of time for which the machine is supplying accelerated particles) than is possible with a linear machine. Cornell will partially meet this need and is likely to skim some of the cream from the energy range, but Cornell is essentially a University machine without the extensive facilities and financial resources of a National Laboratory. It is unlikely to be able to mount many of the experiments it is desirable to do or to accommodate many experimental teams.

The Daresbury design aims for a machine of 15-20 GeV with a current of over 1 μA and a duty-cycle of at least 5 %. The intention is to use NINA (which at present has an average current of 2 μA which could be pushed to 10 μA) to inject electrons into a larger ring. This will result in a considerable saving in the cost of a 15 GeV synchrotron — first, because NINA as injector is already built, and,



*One of the two possible layouts of the 15-20 GeV electron synchrotron proposed at the Daresbury Laboratory. Beams would be injected into the larger 'ring' as indicated from the existing machine, NINA.*

*(Drawing DNPL)*

second, because the quality of the beam from NINA makes the higher energy stage much simpler. Between energies of 2 and 3 GeV the beam in NINA has small emittance and energy spread so that the magnet aperture in the larger ring can be small (giving cheaper magnets and power supplies). Injecting at an energy of a few GeV also means that the field in the larger ring can be comparatively high so that remanent field effects can be neglected and larger eddy-currents can be tolerated, resulting in a simpler and cheaper vacuum chamber.

High energy electron synchrotrons suffer from the awkward requirement that their radius should be as high as possible. This is to keep the energy lost per turn by radiation (which has to be replaced by the r.f. system) down to a reasonable level. For a maximum energy of 20 GeV, to keep this loss down to 120 MeV/turn the bending radius would need to be 120 m. Space for r.f. structure, injection and ejection takes the desirable average radius up to 200 m.

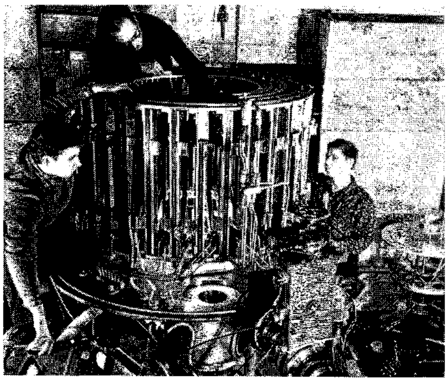
Various changes can be rung on this by having curves of magnets separated by long straight sections. Two such layouts, which can just be squeezed onto the available site, have been considered at Daresbury. The first one uses the existing experimental hall (giving a further saving in the cost of the new facility) but involves the new machine crossing NINA in two places. This would obviously cause major disruption of NINA operation during construction and only seems reasonable if the need to keep the cost down becomes paramount. The second layout (shown in the drawing) does not cut the NINA ring and has two long straight sections. This scheme would require a new experimental area to be built. Preliminary cost estimates for the two schemes are £ 4.9 million and £ 5.4 million.

A few of the parameters of the design are as follows : The circumference of the machine is 1323 m long with a bending radius in the magnets of 120 m. The magnetic field needed at 20 GeV is 5.6 kG, rising from 0.8 kG at injection of beams at 3 GeV. The vacuum vessel dimensions in the bending magnets rise to a maximum of 50 mm in the horizontal plane of a focusing magnet and to a maximum of 25 mm in the vertical plane of a defocusing magnet. In the quadrupoles the dimensions are 85 mm horizontal and 45 mm vertical. The design pressure is $10^{-6}$ torr generally and $10^{-7}$ torr in the r.f. sections. The radio-frequency system has to cope with a maximum radiation loss of 118 MeV per turn. It would operate at twice or three times the NINA r.f. frequency (816 or 1224 MHz). There are two r.f. stations each 80 m long of the travelling wave type.

The major field of interest to be investigated with the 15-20 GeV synchrotron will be electron and photon physics not accessible to electron linear accelerators. This includes the whole field of electroproduction experiments which need a long duty-cycle accelerator for complicated coincidence experiments. In addition, recent experiments, particularly at Stanford, have shown that secondary particle beams of comparable intensities to those available at high energy proton accelerators can be achieved at electron accelerators.


1.

*1. Lenin Prize winners for their research on transuranic elements using the heavy ion cyclotron of the Laboratory of Nuclear Reactions : (left to right) G.N. Flerov, S.M. Polikanov, I. Zvara, V.A. Druin. Zvara, from Czechoslovakia, was the first scientist from outside the Soviet Union to receive this prize.*


2.

*2. Scientists from Poland at work on a beta-spectrometer, called 'Orange', which was built in Poland and brought to the Laboratory of Neutron Physics.*


3.

*3. The Director of JINR, N.N. Bogoliubov (left) and the Director of CERN, B.P. Gregory, photographed at Dubna. There has always been close collaboration between the two international centres including a regular exchange of scientists.*

*(Photos Dubna)*

In the context of an overall European programme it will be a unique facility, complementing the important but limited research which will be possible at the storage rings of DESY and Frascati, and pushing electron synchrotron energies as high as can be reasonably achieved at present. To spread the cost, a period of four years from the time when financial approval is forthcoming is planned for construction. By then it is possible that much more progress will have been made towards opening up 'national' accelerators to scientists from throughout Europe. Daresbury has already welcomed teams from France and Italy to do research on NINA.

# DUBNA Organization and Research Equipment

*This information is taken from an article by M. Lebedenko (Head of the Publishing Department at Dubna) which appeared in the January issue of Europhysics News (Bulletin of the European Physical Society).*

The Joint Institute for Nuclear Research (JINR), more usually known simply as 'Dubna' after the small town 130 km north-west of Moscow where it is situated, came into existence in 1956. An Agreement to set up the Institute was signed on 26 March of that year in Moscow by representatives of eleven countries — Albania, Bulgaria, China, Czechoslovakia, German Democratic Republic, Hungary, Korean Democratic Republic, Mongolia, Poland, Rumania and USSR. The Democratic Republic of Vietnam joined later.

The Institute was seen as performing a similar role to that of CERN, and its aims were stated in the Agreement as :

1. To foster collaboration in nuclear research by scientists in the Member States.
2. To promote nuclear physics research in the Member States by the exchange of information and results of both theoretical and experimental research.
3. To maintain close relations with other national and international scientific research organizations engaged on the development of physics and on the global applications of atomic energy.
4. To promote the most effective use of the intellectual effort available in the Member States.

Finance is provided by the Member States in proportion to their financial resources, contributions ranging from 0.5 % to near 50 % (USSR). Each Member State has a delegate on the Council which meets once a year.

The present Director is N.N. Bogoliubov (USSR) and the Deputy Directors are K. Khristov (Bulgaria) and N. Sodnom (Mongolia). The scientific policy is worked out by a 'Learned Council' comprising leading scientists from the Member States (not more than three from any one country). The Institute is sub-divided into six Laboratories, each with its own Director.

*Laboratory of Nuclear Problems*
*Director, V.P. Dzhelepov*

This Laboratory was in existence before the Institute was founded. It operates the very successful 680 MeV synchro-cyclotron and has made some major contributions to intermediate energy physics. It is also a centre of development for experimental techniques including work on Cherenkov counters, polarized targets and streamer chambers.

*Laboratory of High Energy*
*Director, A.M. Baldin*

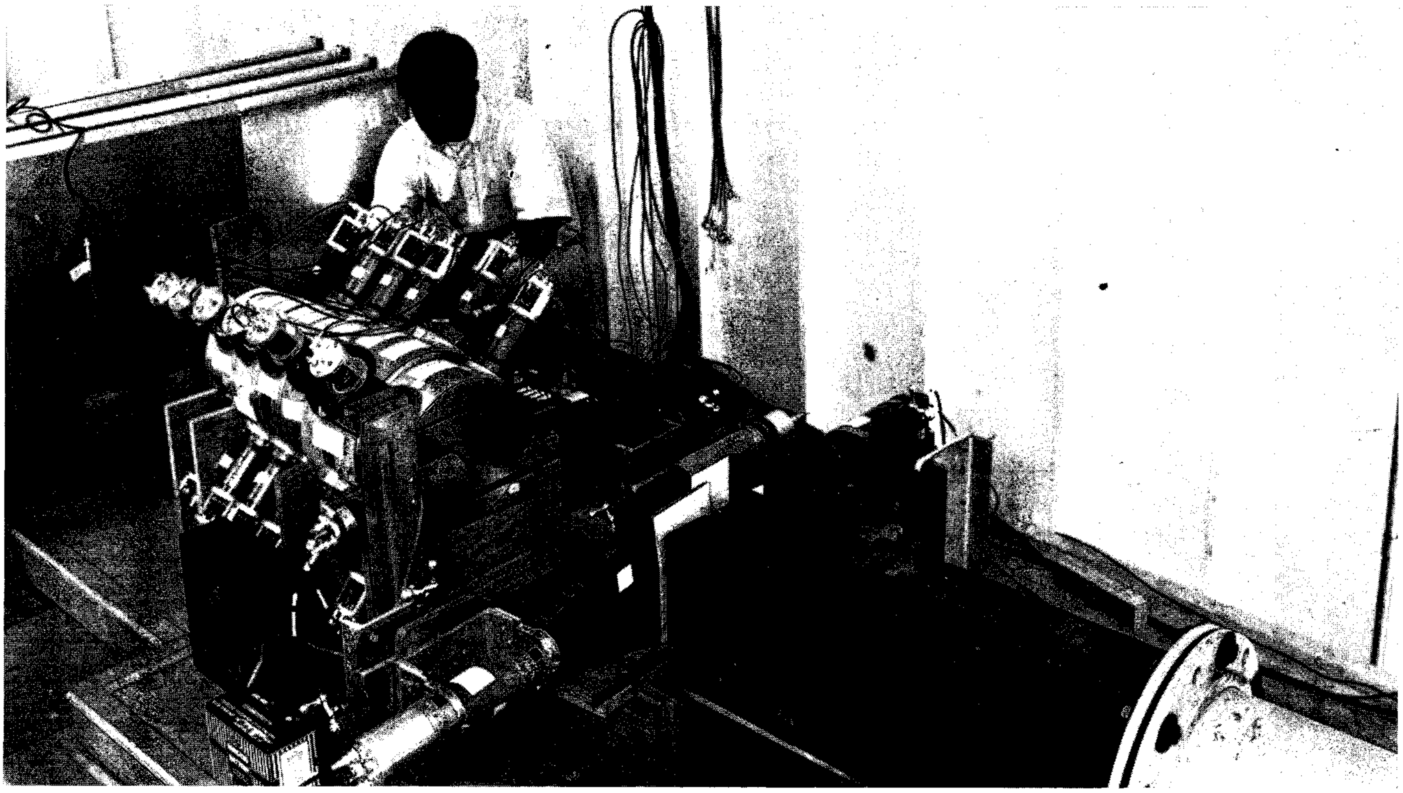
The Laboratory evolved from the Electro-Physical Laboratory and was led for many years by the late V.I. Veksler. High-energy physics is carried out with the 10 GeV synchro-phasotron. It is also the home of the current research on the new technique of Electron Ring Accelerators (see the article on Berkeley).

*Laboratory of Theoretical Physics*
*Director, D.I. Blokhintsev*

Research on theoretical problems is concentrated in this Laboratory. It is one of the largest international centres for theoretical physics with a staff of over 100 physicists. The Laboratory has a high reputation and has done some pioneering work on topics such as the theory of dispersion relations.

*Laboratory of Neutron Physics*
*Director, I.M. Franck*

The main research facility is a fast neutron pulsed reactor involving a stationary core of plutonium 239 and a uranium 235 core mounted on a steel disc rotating at speeds up to 5000 revs/min. Pulses of neutrons are produced when the cores are in coincidence ; the pulse width and repetition rate can be varied.



*The scintillation counter built up from six large sodium iodide crystals used to measure electrons, up to energies of 14 GeV, coming down the pipe on the right from the Stanford electron linear accelerator. Development of scintillation counters for the detection of very high energy particles is being done at the Stanford High Energy Laboratory under R. Hofstadter.*

*(Photo Stanford University)*

*Laboratory of Nuclear Reactions*
*Director, G.N. Flerov*

The Laboratory has a powerful heavy ion cyclotron (giving energies up to 8 MeV per nucleon with beam intensities up to 200 μA). With this machine a number of transuranic elements have been synthesized including element 104 named Khurchatovium after one of the founders of the Institute, I.V. Khurchatov.

*Laboratory of Computing Technique and Automation*
*Director, M.G. Meshcheryakov*

This Laboratory is a large computing centre with a series of computers the largest of which is the BESM 6. There is a programming section and research is carried out on automatic data-processing techniques and on-line systems.

## STANFORD (HEPL) Scintillating Detector

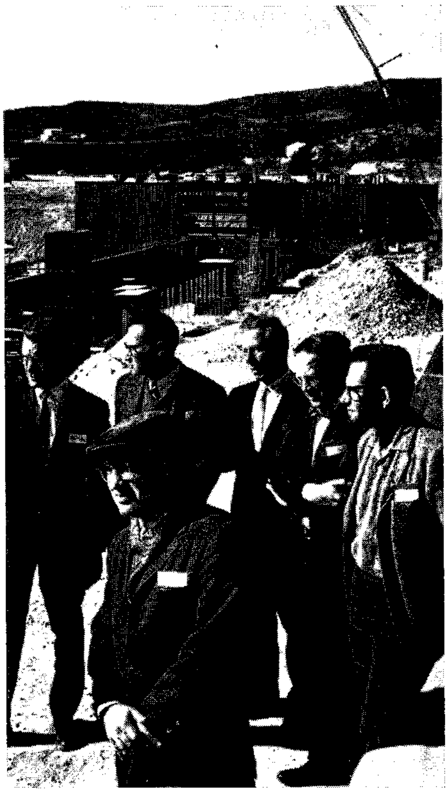
Development of a 'universal' particle detector at Stanford University High Energy Physics Laboratory was reported on 5 February at a meeting of the American Physical Society. The detector is a giant version of the familiar scintillation counters which have been in use since the late 1940s.

The first indication that HEPL was taking a new look at scintillators came in the 18 January issue of *Nature*. There, Nobel Prize winner R. Hofstadter together with three visiting research associates — E.B. Hughes and W.L. Lakin (UK) and I. Sick (Switzerland) — reported their work on total absorption shower detectors for electrons and gammas in the GeV energy range. They had stacked together six separate NaI(Tl) crystals to give a total thickness of scintillator of nearly 70 cm (the crystals were up to 33 cm diameter and up to 18 cm thick).

This assembly was carried to the 20 GeV electron linear accelerator at SLAC and used to look at electrons in the energy range 4-14 GeV. It proved possible to define the energy of an electron to better than 2 % over the whole range (the energy resolution improving as the energy increases so that it is down to 1 % at 14 GeV). This is a much better performance than alternative methods of total absorption such as lead/scintillator sandwiches or lead fluoride Cherenkov counters both of which are above 5 % at 14 GeV.

At a joint meeting of the American Physical Society and the American Association of Physics Teachers on 5 February, Hofstadter made it clear that he sees the reported results as just the beginning of the investigation of the capabilities of a large scintillator detector. He listed a series of advantages — high-speed counting and timing, good energy resolution, applicable to virtually all types of particles (including neutral particles), ability to distinguish between different types of particle, detection capability over a very wide range of energy. This last point is particularly interesting as accelerator energies move into the hundreds of GeV. Given a big enough scintillator there is no limit to the detectable energy (fortunately also scintillator size scales logarithmically with energy).

*Glenn T. Seaborg, Chairman of the U.S. Atomic Energy Commission breaks ground for the Linac at the ceremony held at the National Accelerator Laboratory, Batavia, in December. Design of the units of the 200 GeV accelerator are being progressively finalized and put out to tender. A prototype enclosure for the 10 GeV booster was completed this month and the booster section have given themselves the tight schedule of having a complete machine period installed and operating (with the magnets powered and the vacuum chamber pumped down) by 1 September 1969. The date for 10 GeV operation of the booster is 1 July 1971.*



*The newly elected Executive Committee of the LAMPF Users Group tours construction of the accelerator. In the foreground is the Chairman, H. Palevsky. Behind are (left to right) D.A. Lind, A. Poskanzer, L. Rosen (LAMPF Director), H. Willard, R. Haddock.*

*(Photo Los Alamos)*

The essential requirement in the operation of the detector is that the incoming particle loses all its energy within the scintillator (hence the term 'total absorption'). The light output, detected by photomultipliers, is then proportional to the energy of the particle. NaI(Tl) — a sodium iodide crystal with thalium impurity added to increase the light yield — is a particularly good scintillator which is often used. It has, in addition to its high scintillation yield, a high density which reduces the path length of the particle and results in a small detector for total absorption at high energies.

Nevertheless, this fairly obvious application has not become common at higher energies because of the difficulty of producing crystals of the required size. As is obvious from the electron detection results above, crystals of appropriate size are now becoming available.

The HEPL team have classified the detectors in two types — TASC counters (Total Absorption Shower Cascade) and TANC counters (Total Absorption Nuclear Cascade). TASC counters are for electromagnetically interacting particles such as electrons, positrons and gammas. These particles dissipate their energy in short distances and crystal assemblies such as that used at the linear accelerator are adequate. TANC counters have to catch all the produce of strong interactions produced by neutrons, protons, pions, kaons etc. and need to be much larger. Tests have been carried out with a TANC counter 150 cm long but the crystals were not of sufficient diameter. Given this limitation the counter worked very well.

It is theoretically possible to have energy resolution down to 0.02 % but 0.1 % is likely to be the practical limit. Other materials such as lead fluoride, which is used in Cherenkov counters, would be even better than NaI(Tl) if some way were found to increase their light yield. The HEPL results are likely to bring more attention to bear on problems like this.

## LOS ALAMOS LAMPF Users Group

At a meeting on 16 January, the LAMPF Users Group adopted a Charter and elected an Executive Committee. The 800 MeV proton linear accelerator, LAMPF, will be used as a national accelerator when it comes into operation in 1972, the experimental time being shared about equally between Los Alamos staff, and outside universities and research centres.

The purpose of the Users Group is specified in the newly adopted Charter as :

a) To provide a formal channel for the exchange of information between the LAMPF administration and scientists of other Laboratories who will utilize this facility for their research.

b) To provide a means for involving scientists and engineers from user groups in specific projects at LAMPF and for offering advice and counsel to the LAMPF management on LAMPF operating policy and facilities.

The Executive Committee was elected as : H. Palevsky (BNL) Chairman ; D.A. Lind (Colorado) Chairman-elect ; R. Haddock (UCLA) ; H. Willard (Case) ; A. Poskanzer (LRL). The experimental programme itself will be decided on the basis of scientific merit by a Program and Scheduling Committee appointed by the Director of LAMPF, L. Rosen. Some members of this Committee will be selected from the Users Group.

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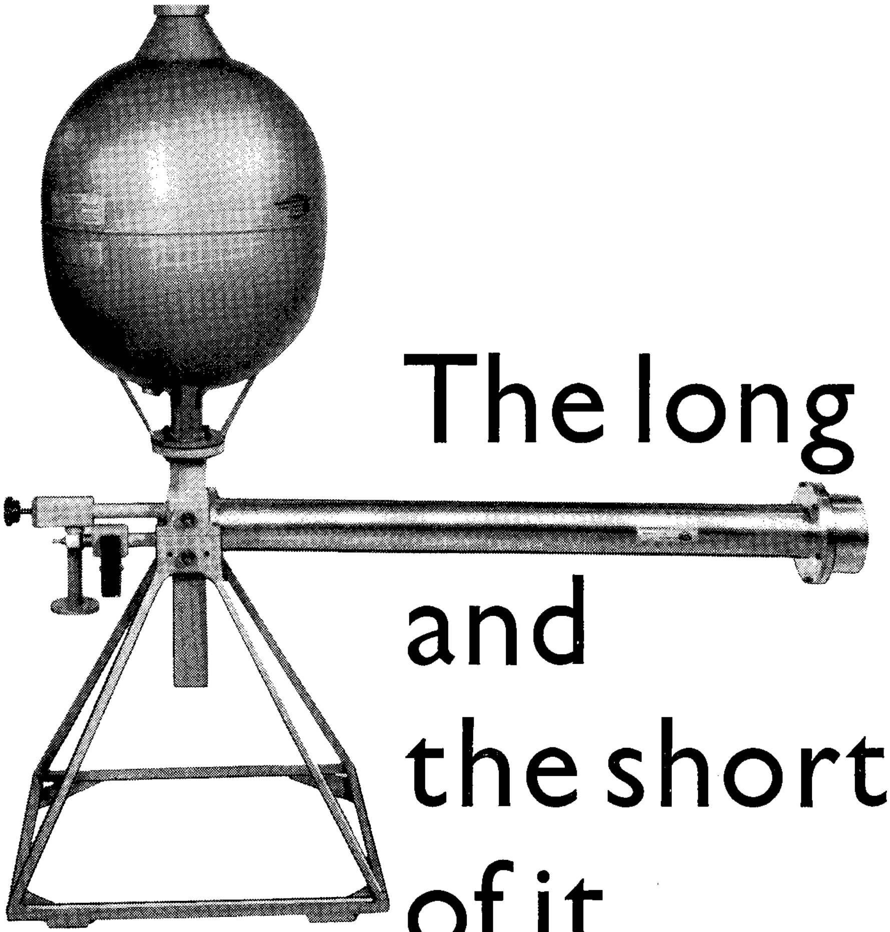

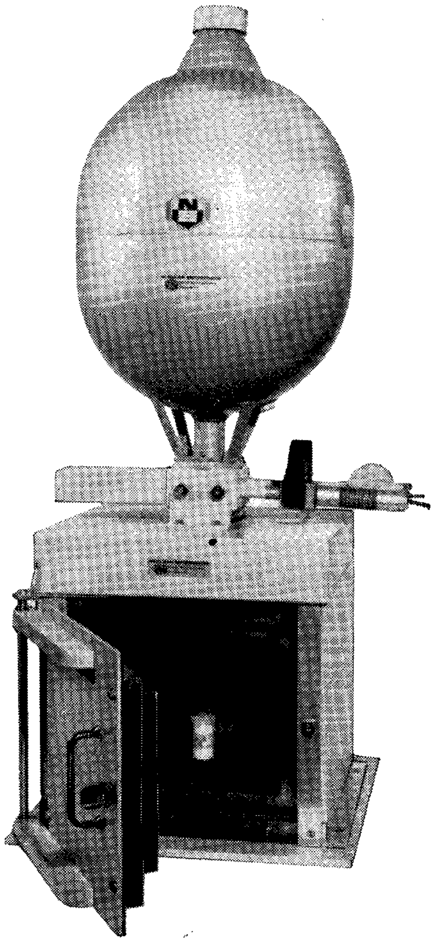

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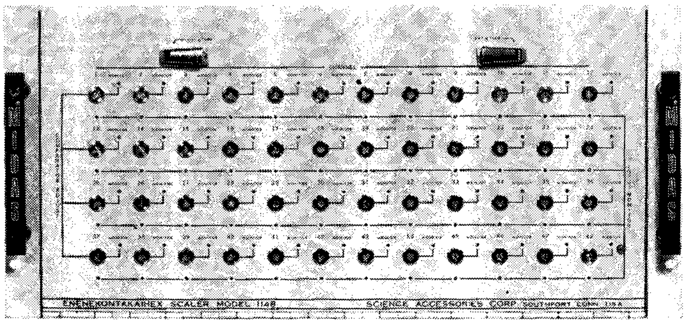

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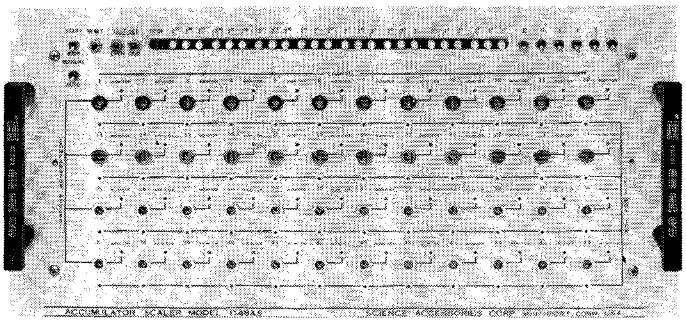

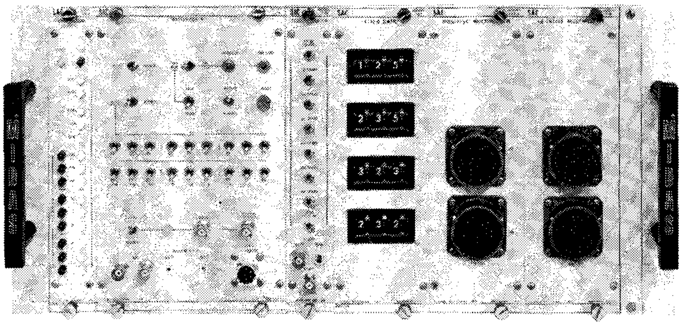

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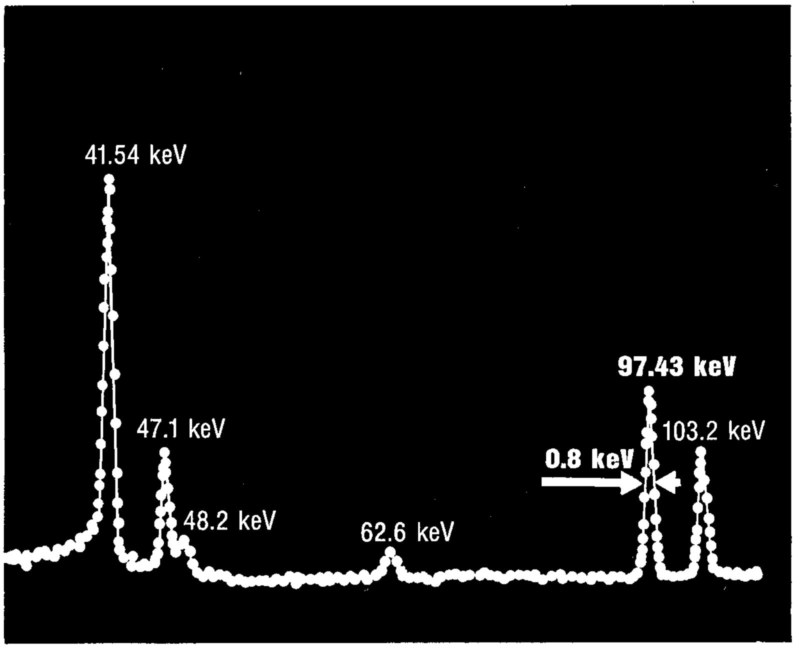

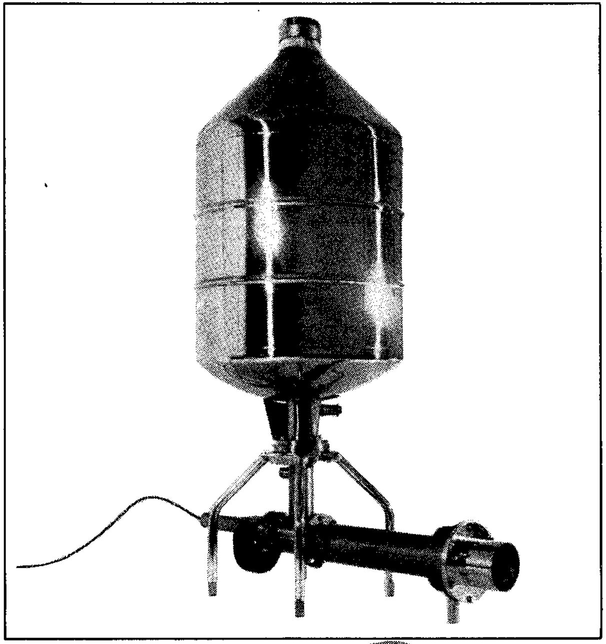

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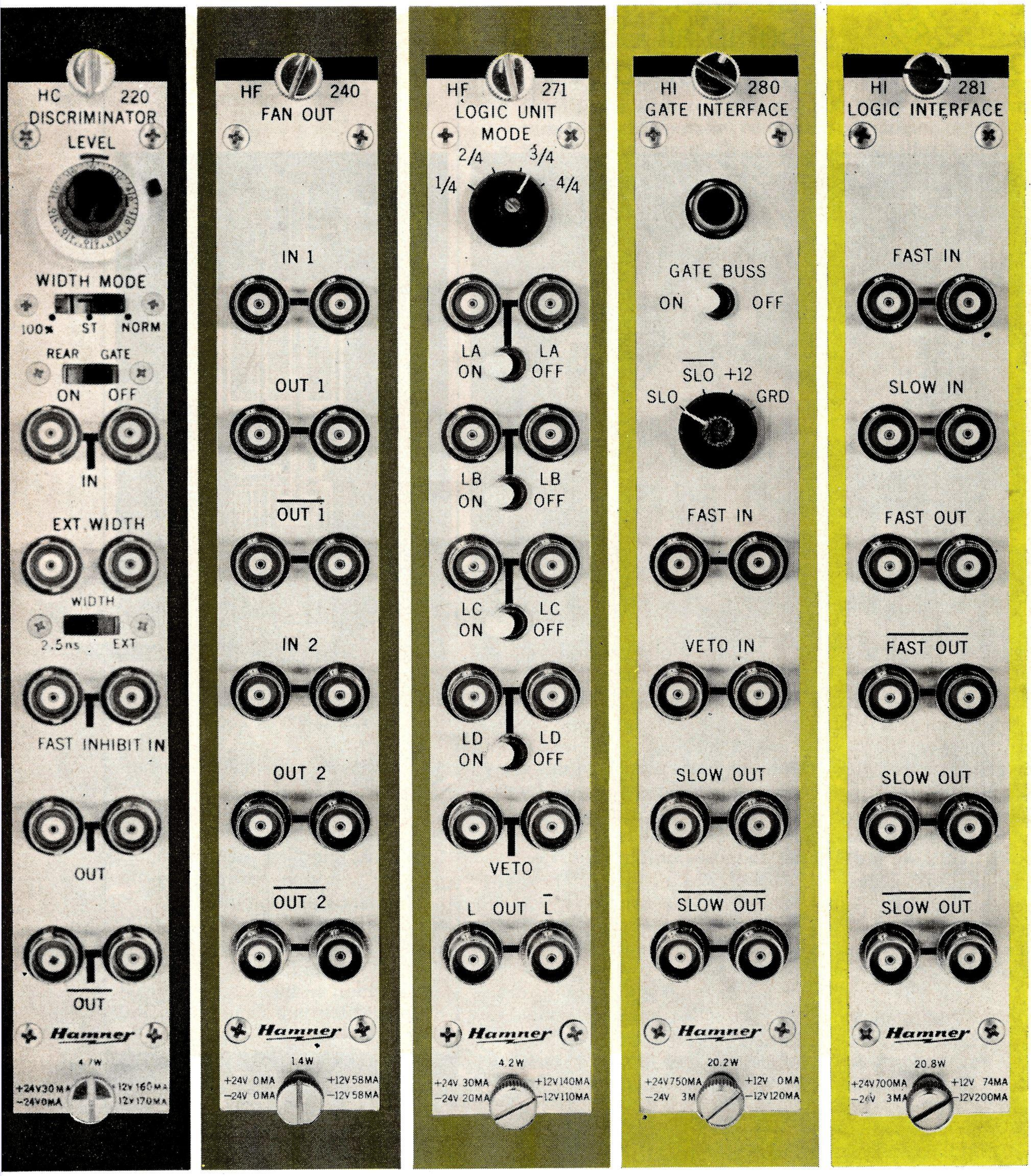

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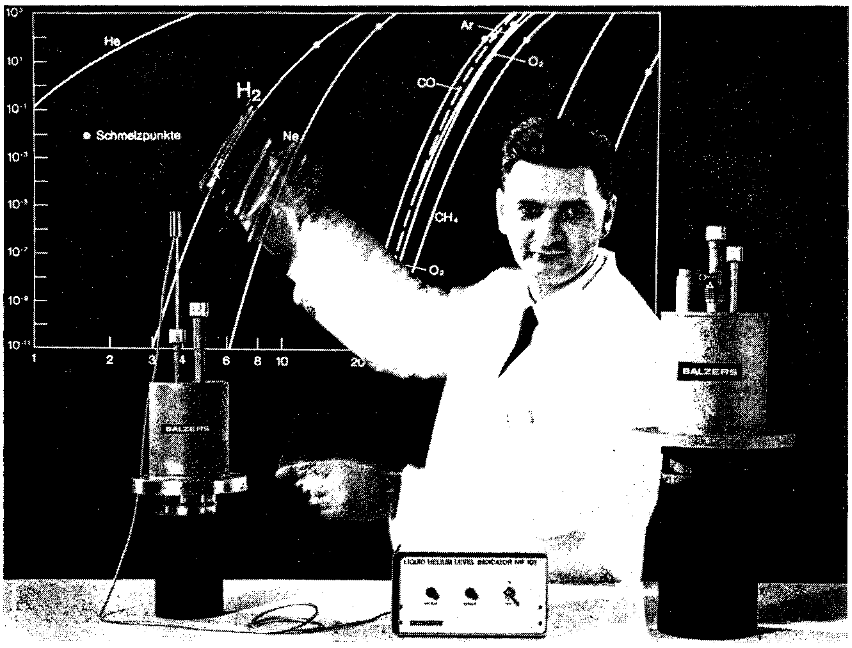

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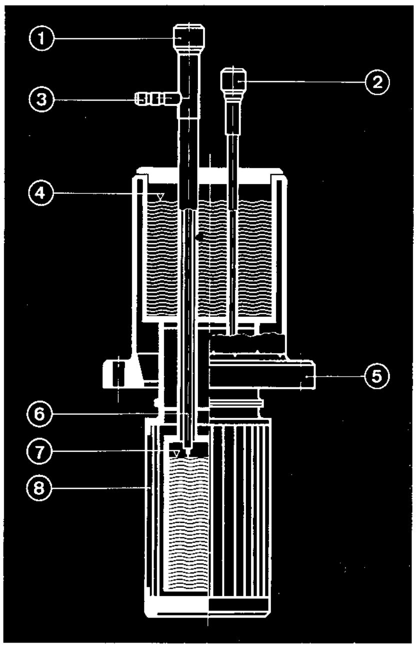

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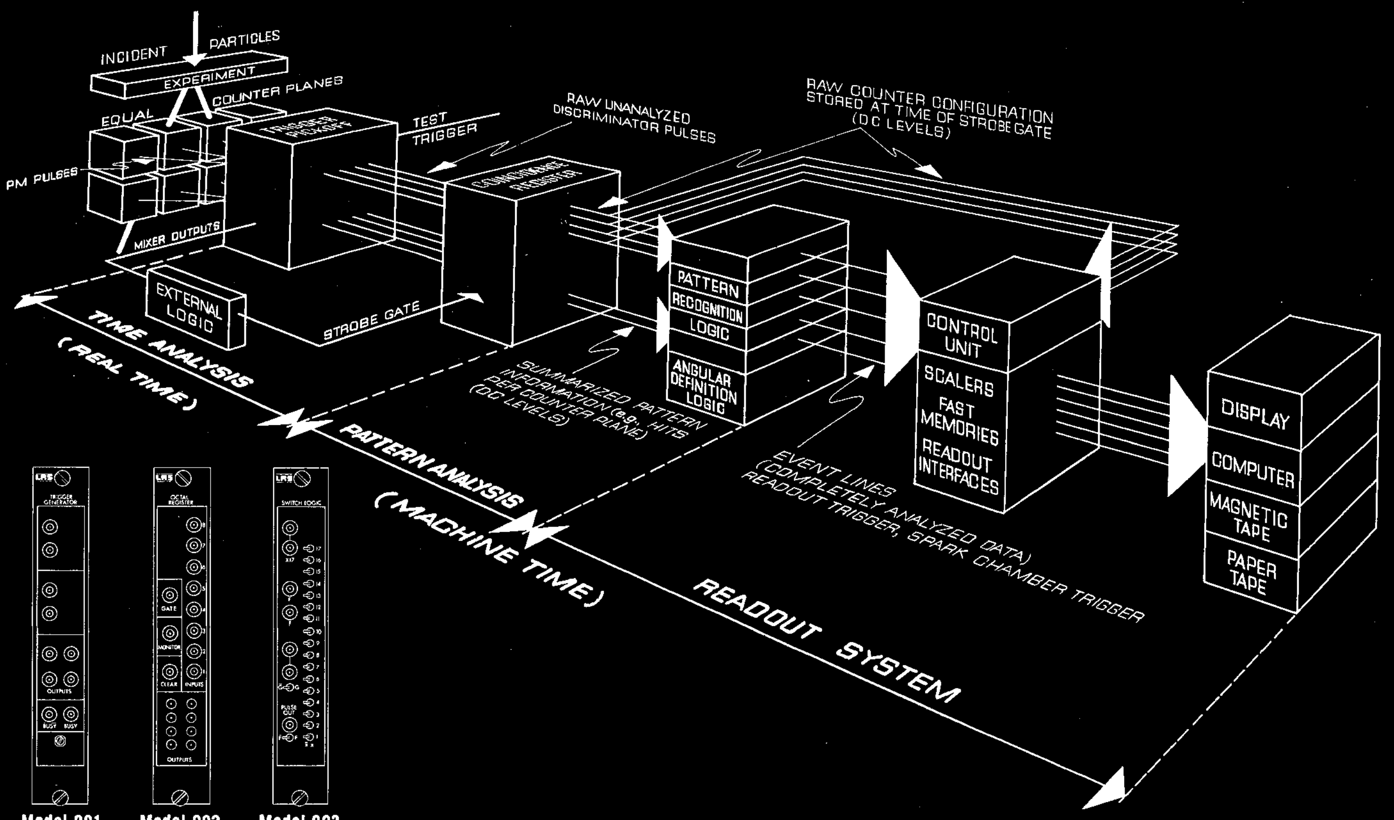

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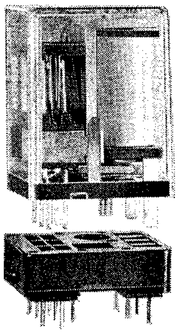

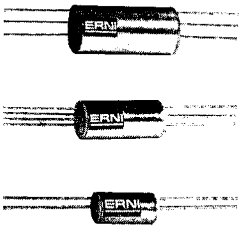

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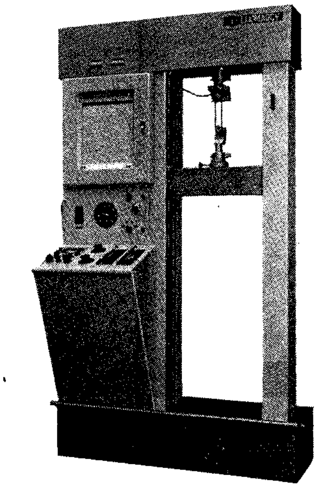

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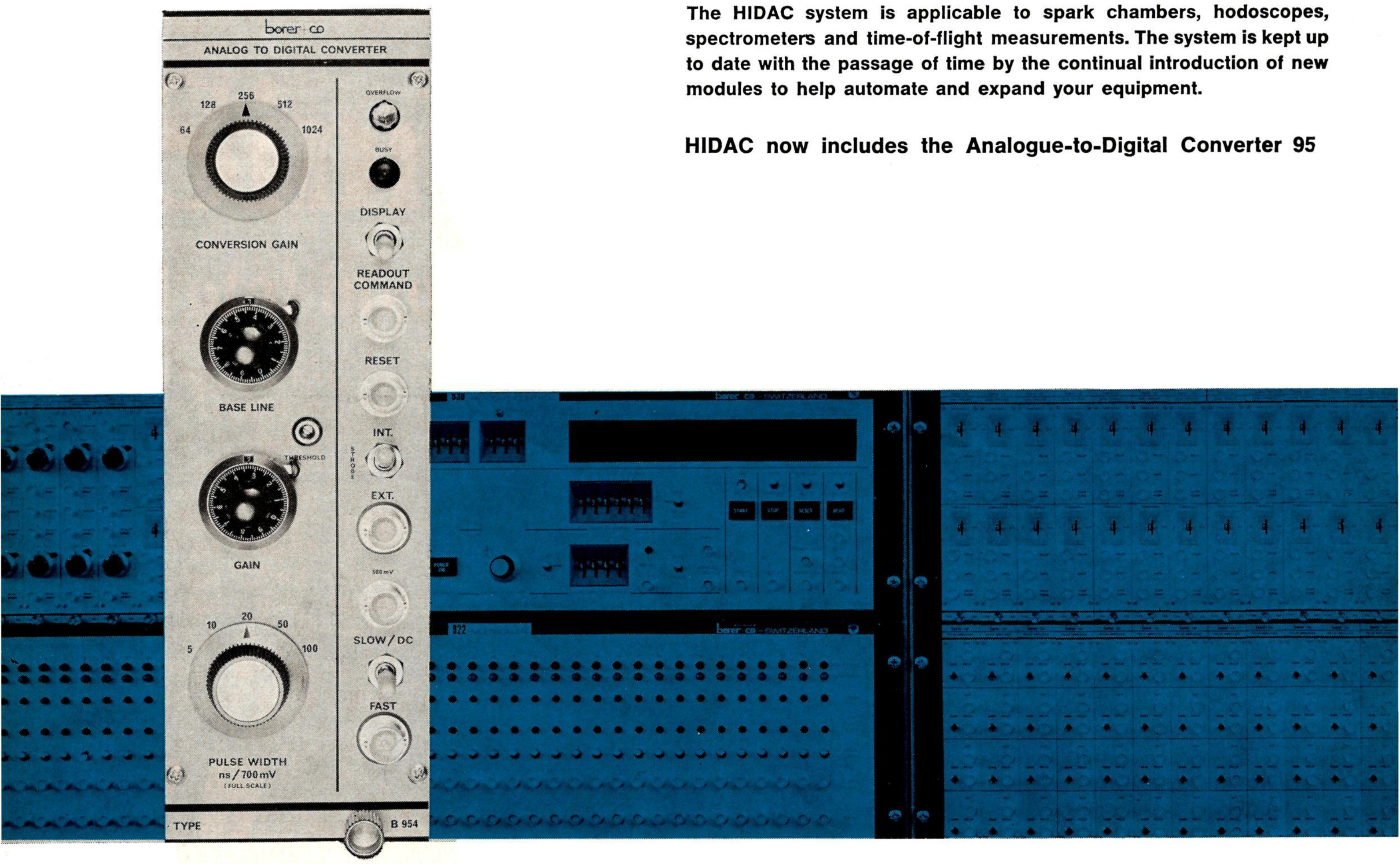

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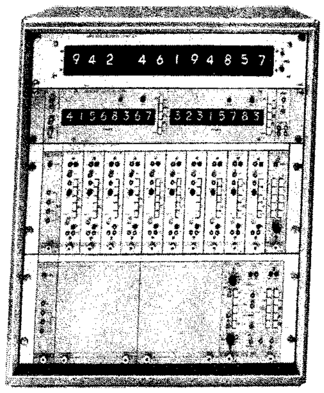

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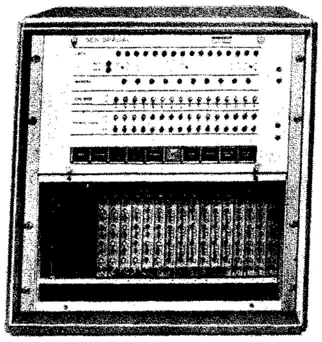

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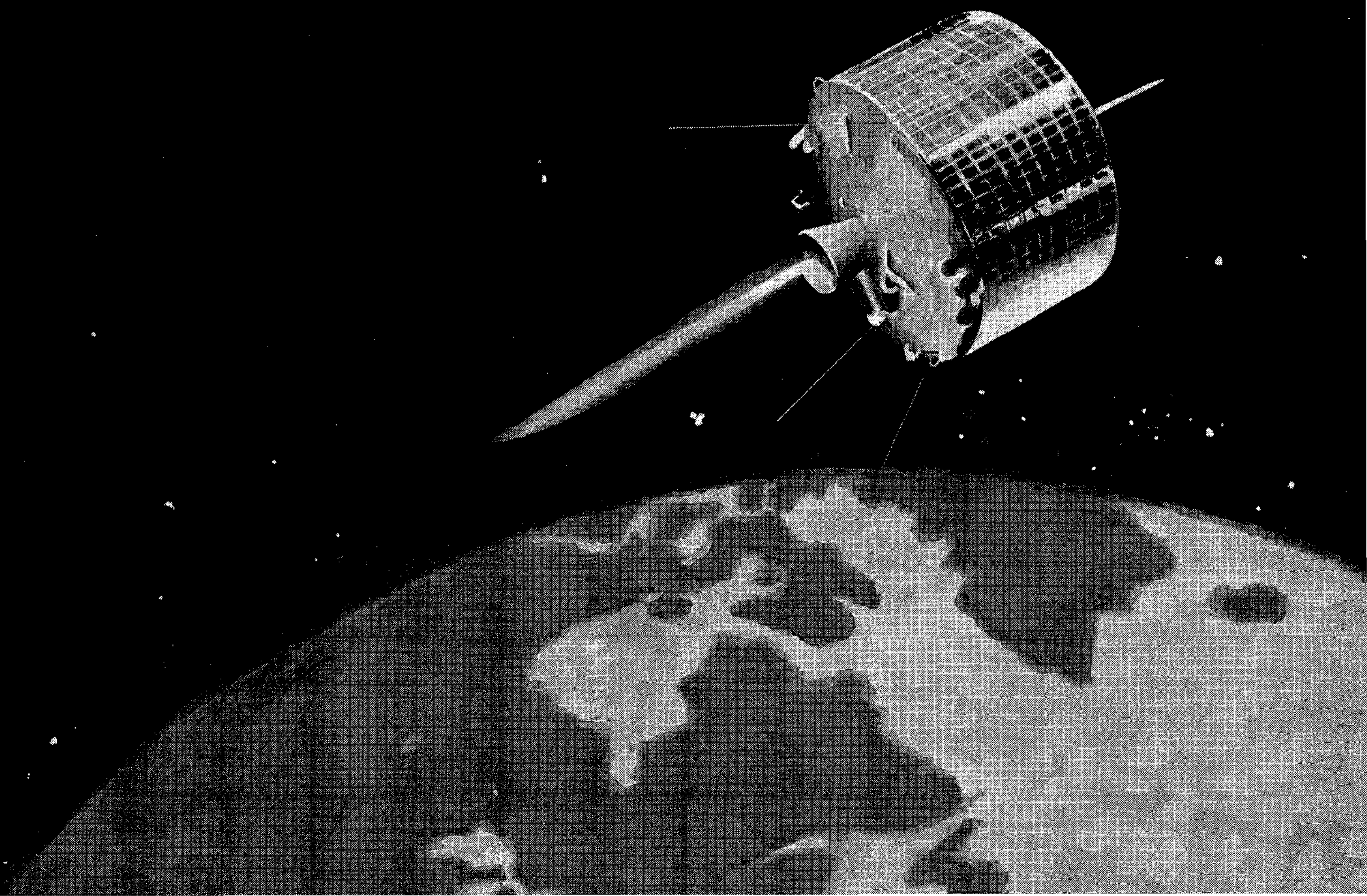
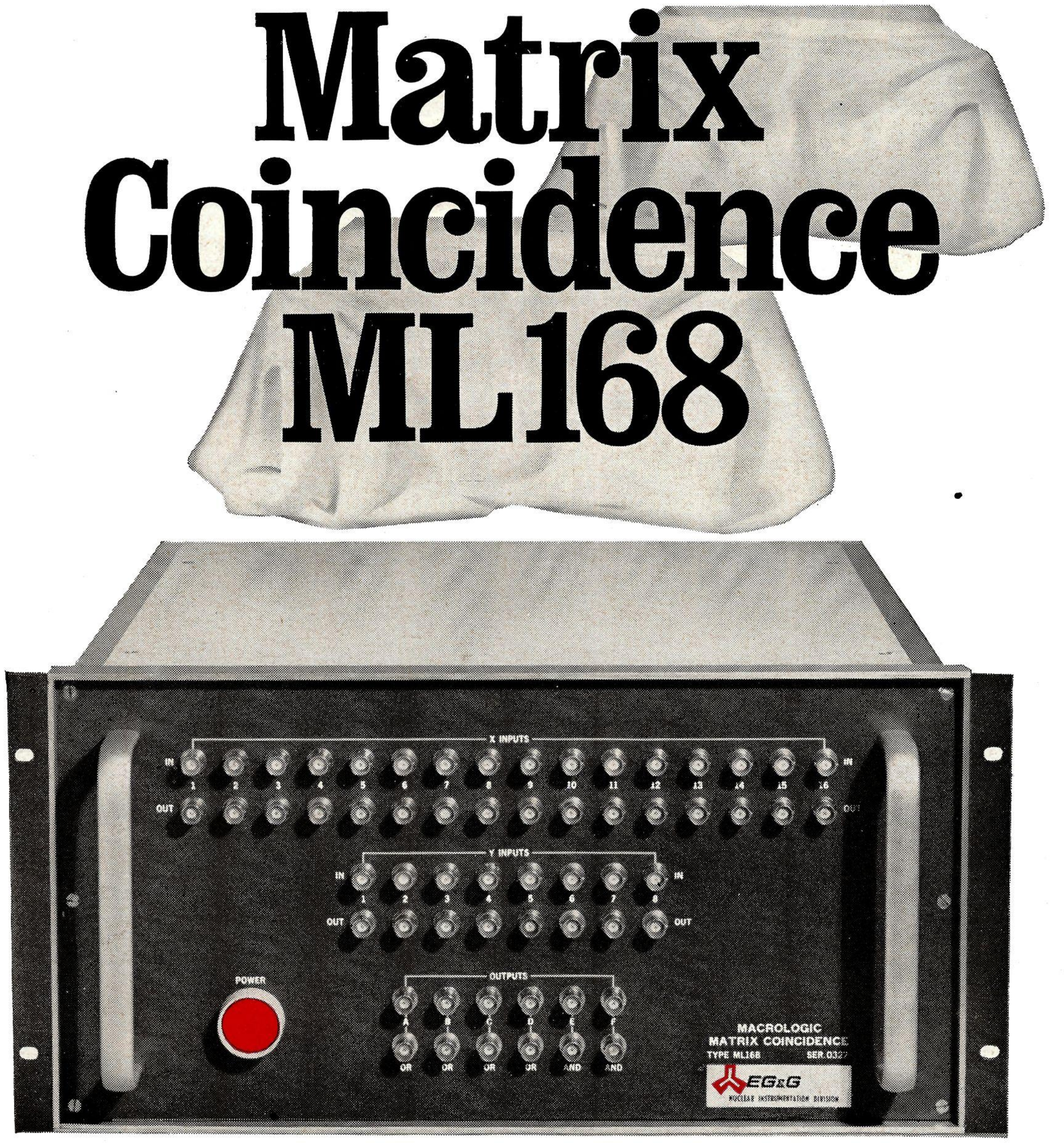


# MACROLOGIC Matrix Coincidence ML168



First of the new MACROLOGIC™ family of nuclear instruments that put more in a package by using Integrated Circuits. ML168 contains an 8x16 rectangular array of 128 two-fold coincidence circuits. Each coincidence output may be individually connected to any of four 36-input OR circuits or two 8-input AND circuits.

When used with a hodoscope array, the ML168 performs fast, real time "topological filtering" decision making, to determine if an event satisfies programmed spatial constraints. You can tighten triggering requirements and filter invalid data before recording. Therefore, it is an especially appropriate adjunct to wire or optical spark chambers, spectrometers or bubble chambers.

The ML168 is complete and self-contained, rack mounting, totally enclosed and shielded and made with standard, unselected IC's.

The ML168 accepts NIM-standard fast logic signals at each of 24 bridging inputs. The four OR outputs and two AND outputs are Dual NIM-standard fast logic outputs. It is conservatively rated at 50 MHz.

For more on ML168 MATRIX COINCIDENCE™ and other MACROLOGIC instruments, soon to be unveiled, write or call: EG&G Inc., 40 Congress Street, Salem, Massachusetts 01970. Phone: 617-745-3200. TWX: 710-347-6741.

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