CERN

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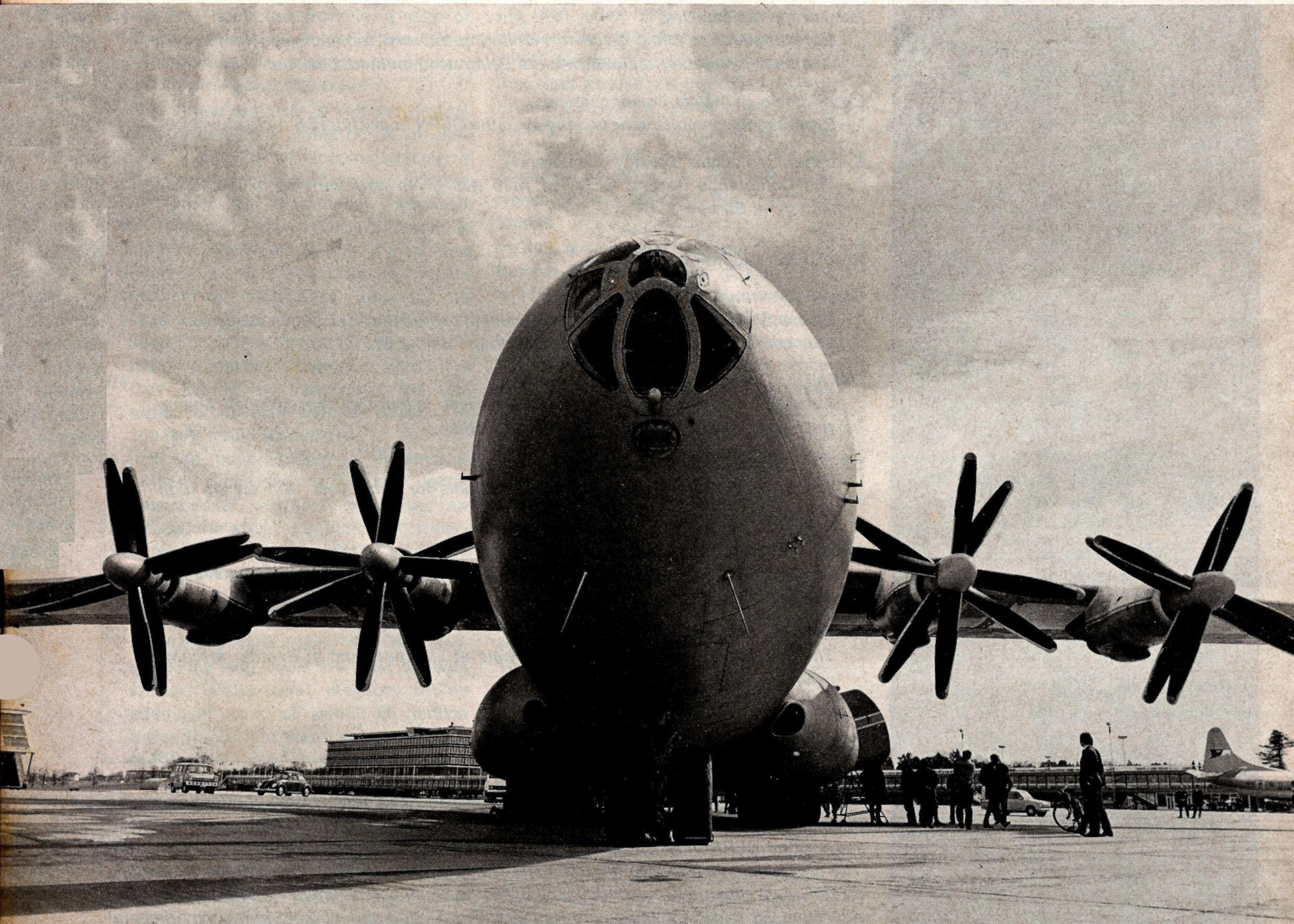

CERN, the European Organization for Nuclear Research, was established in 1954 to '... provide for collaboration among European States in nuclear research of a pure scientific and fundamental character, and in research essentially related thereto'. It acts as a European centre and co-ordinator of research, 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 on the use of two proton accelerators — a 600 MeV synchro-cyclotron (SC) and a 28 GeV synchrotron (PS). At the latter machine, large intersecting storage rings (ISR), for experiments with colliding proton beams, are under construction. Scientists from many European Universities, as well as from CERN itself, take part in the experiments and it is estimated that some 1200 physicists draw their research material from CERN.

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

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

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Cover photograph: The Antonov 22 cargo plane attracted a great deal of attention when it landed at Geneva airport on 1 April. It returned to Moscow loaded with equipment for the second CERN/Serpukhov experiment described in the last issue of CERN COURIER. The removal, including also the transport of heavy items (especially a 110 ton magnet) by rail, went remarkably smoothly which was no small achievement for such a complex operation. By mid-April equipment was already installed and working in the experimental hall of the 76 GeV proton synchrotron at Serpukhov. (CERN/PI 88.4.70)

300 GeV Project Latest design thinking

The article on the 300 GeV project was composed before the news broke on 18 April that a new proposal was being presented for discussion to European governments and to European scientists. The following paragraphs bring out some features of the new proposal and can best be understood having read the article.

The initial proposal was for an accelerator of 300 GeV with conventional combined-function magnets in a ring of diameter 2.4 km. Using separated-function magnets an accelerator of 300 GeV could be built in a ring of 1.8 km diameter which could later accommodate a superconducting accelerator of about 800 GeV.

The new proposal is that the project be started with a tunnel of 1.8 km diameter capable of accommodating a 300 GeV accelerator using existing techniques but that initially only half the magnets be installed. Such a magnet ring would permit a maximum energy of 150 GeV. Should superconducting technology develop as hoped, the spaces could be filled with superconducting magnets which would permit a maximum energy of about 400 GeV. During the installation, the disturbance to experimental physics at 150 GeV would be minimal.

If the superconducting accelerator proved successful then the original conventional magnets could be removed, the whole ring filled with superconducting magnets and the maximum energy taken to 800 GeV or perhaps more.

On the other hand, should superconducting techniques not be mastered, the ring could be filled up with further conventional magnets at an additional cost of about 60 million Swiss francs and the accelerator taken to 300 GeV.

In this way, physics at high energy could start as early as is now possible with the future possibilities of completing the project as a conventional accelerator of 300 GeV or of conversion to an accelerator with energy higher than any currently under construction in the world and based on the most modern technology.

The present impasse in the 300 GeV project is due to the difficulty of selecting a site. At the same time it is disturbing to the traditional unity of CERN that only half the Member States (Austria, Belgium, Federal Republic of Germany, France, Italy, Switzerland) have so far adopted a positive attitude towards the project. The new proposal could possibly resolve these difficulties. With a diameter of 1.8 km, the accelerator could be built not only on one of the five sites previously under discussion, but also on a site adjacent to CERN-Meyrin. There is sufficient uninhabited ground on the opposite side of the Geneva-St. Genis road to take such a ring and a long ejected beam line. The ground is not ideal but experience in tunnelling the ISR beam transport lines indicates that it is practicable.

Such a possibility has been discussed before. The construction of a machine in the range of 300 GeV across the road from the existing Laboratory was first proposed by C.A. Ramm on 13 April 1961. An extension to higher energies using superconducting techniques was referred to in a paper of G. Plass on 27 April 1961. The new potential of the missing magnet design and the growing likelihood that pulsed superconducting magnets will be mastered, open up again the discussion of a site at CERN-Meyrin.

Significant economies would then be possible in the project by sharing development effort, overhead costs and services with the existing Laboratory. The conventional accelerator plus experimental facilities would cost approximately 1100 MSF instead of 1431 MSF and there could be similar savings in the cost of running the existing Laboratory. The personnel complement, for example, could stabilize at 5000 people instead of 7400 in two separate Laboratories. In subsequent exploitation of the research facilities, the plateau budget could be 450 MSF instead of 600 MSF for two separate Laboratories.

This article covers some of the studies carried out by the '300 GeV Machine Committee' in connection with the design of the accelerator. These studies have produced exciting ideas about construction of the machine in such a way as to give maximum flexibility for its future development while being at every stage a viable project in itself. Underlying this new thinking is the realization that the proposed Laboratory is likely to be the corner-stone of high energy physics research in Europe through to the end of the century. Potential for development could prove vital to keeping the Laboratory at the forefront, throughout all this time, in the research possibilities it offers.

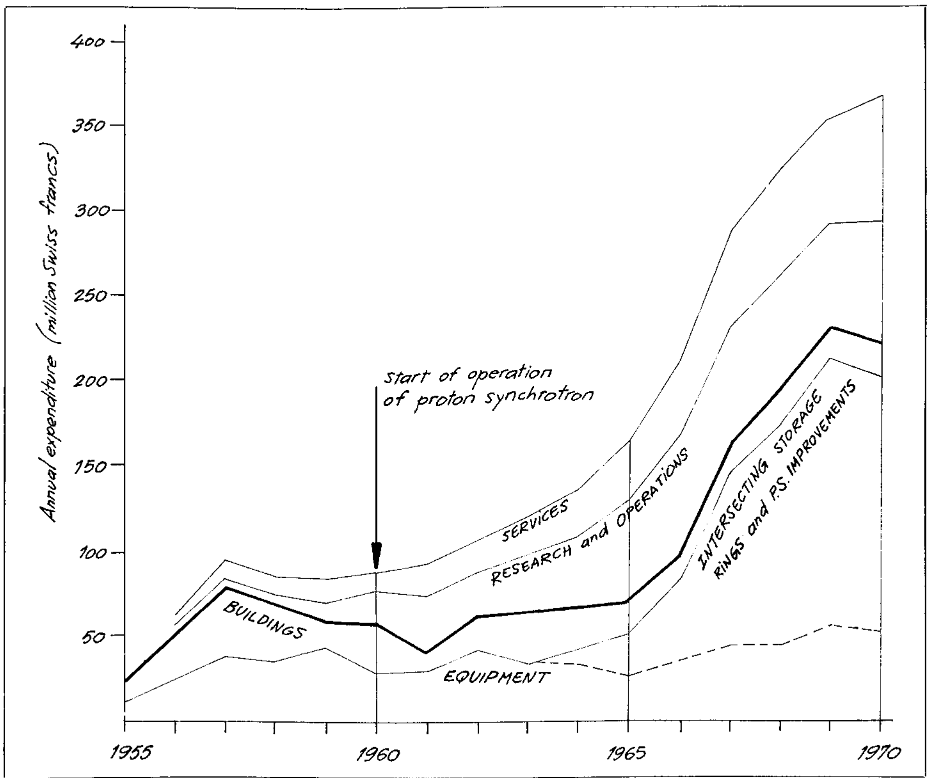
Only a tiny handful of people at CERN remain fully involved in the 300 GeV project but the Committee benefits from the collaboration of all the major accelerator centres in Europe. Membership includes representatives from DESY and Karlsruhe (Federal Republic of Germany), Orsay and Saclay (France), Frascati (Italy), Daresbury and Rutherford (UK) as well as from CERN-Meyrin.

A fuller presentation of much of what will be covered in this article can be found in a recently published 'yellow report', CERN 70-6, entitled 'Design Studies for a Large Proton Synchrotron Laboratory' by J.B. Adams and E.J.N. Wilson.

In particular we will describe the idea of constructing the main synchrotron ring based on a 'missing magnet' design. Let us hope that it won't be very long before we move from the present extreme position where all the magnets are missing !

When the 300 GeV Machine Committee put its head down in the second half of 1969 to take a fresh look at the machine design it had many things to take into consideration. The design which had been previously put before the CERN Council was the result of a study carried out in 1963, 64 under the direction of K. Johnsen. This design had been further endorsed by ECFA in 1967 and there is no doubt that such a machine will fulfil the specification (in particular with regard to the three key requirements of high energy, high intensity and high capacity for exploitation) and that its construction could be confronted with confidence at the price estimates put forward.

Nevertheless, accelerator technology has obviously not stood still since 1964 and it was necessary to look at some of the developments and to assess their implications for the 300 GeV design — examining, for example, whether any of them could result in lower costs or in greater potential in one direction or another. The major developments have been — the novel design of the 200-400 GeV accelerator nearing its final year of construction at Batavia under R.R. Wilson (see



Annual expenditures during the lifetime of CERN-Meyrin and their breakdown into component parts. The feature which is relevant to the present thinking about the 300 GeV Laboratory is that the expenditure on the construction of the 28 GeV proton synchrotron up to 1960 represents only about 10 % of the total expenditure. Improvements to and around the synchrotron have nevertheless meant that the expenditure on equipment and buildings represents about 60 % of the total expenditure. Experience therefore indicates that the design of an accelerator should keep in mind future developments so as to make them as economic and easy to implement as possible.

CERN COURIER vol. 8, page 31); the first tests on the idea of electron ring accelerators proposed by V.I. Veksler at Dubna (vol. 8, page 28; vol. 9, page 198); the progress of superconducting magnet technology (vol. 8, page 183); the increasing use of computers in accelerator control (vol. 9, page 166).

The Committee also considered the foreseeable life of the Laboratory and the way in which the initial machine design takes its place long-term in this life. This was again examined with a view to operating a Laboratory over many years at the lowest reasonable total cost while sustaining over many years a maximum research potential.

We will now deal briefly with these topics since they lead into the latest design thinking. First, concerning developments in accelerator technology:

The Batavia design has obviously been subjected to very close scrutiny in Europe so as to learn what we can from our American colleagues being the first to confront in reality the problems of building a machine of several hundred GeV. A cost comparison between the Batavia machine and the CERN 1964 proposed machine comes out with figures very close. Apart from this there are, as could be expected, some aspects of the Batavia design which are regarded as having advantages over the CERN proposal and others where the CERN proposal is still regarded as preferable.

There are two aspects which have retained attention and to which we will return later in this article. (1) There are some advantages in building a 'separated function' magnet lattice (where the functions of bending and of focusing of the proton beam are carried out by different magnets, as opposed to the 'combined function' where the same magnet does both jobs); (2) there is great attraction in the philosophy of 'extendible energy' (having a machine initially built for a certain energy which is capable later, with comparatively modest further expenditure, of operating at much higher energy).

The radically new technologies of the electron ring accelerator are unlikely to be mastered to the stage where a very high energy accelerator could be undertaken with confidence for very many years yet. Even its optimistic protagonists hesitate to give a date in the 1970s. Superconductivity does not confront quite so many unknowns and there is great hope that pulsed superconducting magnets suitable for a synchrotron ring could be perfected 'before this decade is out'. No-one building a machine now could go for superconductivity but it is again relevant to what we discuss later to recognize that superconductivity is a good long-term bet. Computers in accelerator control might be described as 'not so much a project more a way of operation'. Computers will without doubt be used extensively in the control of any new accelerator but this will not have radical repercussions on the basic design of a machine.

Turning now to the life of the Laboratory and the relevance of the initial machine design to this life: It is obvious that the machine design is crucial to the quality and quantity of the physics which will be done at the Laboratory but let us first look, using CERN Meyrin experience as an example, at how the initial investment on the machine figures in the long-term life of a Laboratory (such an analysis is carried out in much more detail in the Adams/Wilson paper).

At CERN Meyrin, about 80 % of the total expenditure by 1960 had gone into capital expenditure (including buildings) and construction of the proton synchrotron took a high proportion of this. However, by 1970, fifteen years after the start of the Laboratory, capital expenditure still represents about 60 % of the total and the initial cost of the machine has become quite a small proportion of the total capital invested (about 10 %). This is because the initial investment has been followed by others as improvements have been made to and around the machine to keep the research facilities in step with the changing demands of the physics. Two of the lessons from this experience are that, (1) Economies in the initial cost of the machine become negligeable when considering the cost of operating the Laboratory over many years and should not therefore weigh too heavily if they are going to restrict seriously the performance of the machine on which the success of the Laboratory completely depends; (2) Since 'improvements' can absorb a high proportion of total expenditure, the initial design should have at least half an eye to making it possible, later, to introduce, in an economical way, such improvements as are foreseeable. In this way it may be possible to make major advances in the research facilities without the necessity of building a completely new machine, perhaps involving the expense and complication of a completely new Laboratory. In conclusion, to operate a Laboratory in the most economical way over a long lifetime, the initial design, even at comparatively higher initial cost, should be as flexible with regard to future improvement as possible.

'Improvement' has meant such things as increasing the intensity of the accelerated beam, increasing the use of the beam by more sophisticated beam-sharing and beam-transport techniques, using better detection systems (somewhat divorced, but not completely divorced, from the machine design), addition of storage rings... All these are relevant to the discussion above but, since 1967, there is a new possibility to be added to the list — that of increasing the energy of the machine.

In the past, moving to higher energy has always meant building a new machine and the big jumps in energy have come from moving from one generation of machine to another — from cyclotrons to synchrocyclotrons to synchrotrons. At each stage machines have been built to squeeze the maximum out of them in terms of energy given a certain amount of money and a certain state of development of the technology. For example, the existing synchrotrons have used their money to achieve the highest diameter possible, have filled the circumference with magnets and have run the magnets to as high a field as possible. This fixes the peak energy and to go higher means to build a new machine.

In 1967 the idea was put forward, by the team which had been working at Berkeley on a design of the USA 200 GeV accelerator, that the initial design could leave space around the machine circumference. The circumference could be something like half-filled with magnets giving a certain initial peak energy. At a later date, given more money, further magnets could be slotted in and the same machine could, for example, double its initial peak energy. It is from this idea that the phrase 'missing magnet' design comes.

When the Batavia team got their teeth into the final design of the USA machine they took over the philosophy of extendible energy but applied it in a different way. They settled for a ring already filled with magnet but, with the initial money, restricted the installed power supply such that the magnets would operate at something less than half their possible peak rating. At a later date it will be possible to add more power supply and operate at a peak energy of over 400 GeV at high repetition rate. The Batavia machine has been called a 'missing power' design.

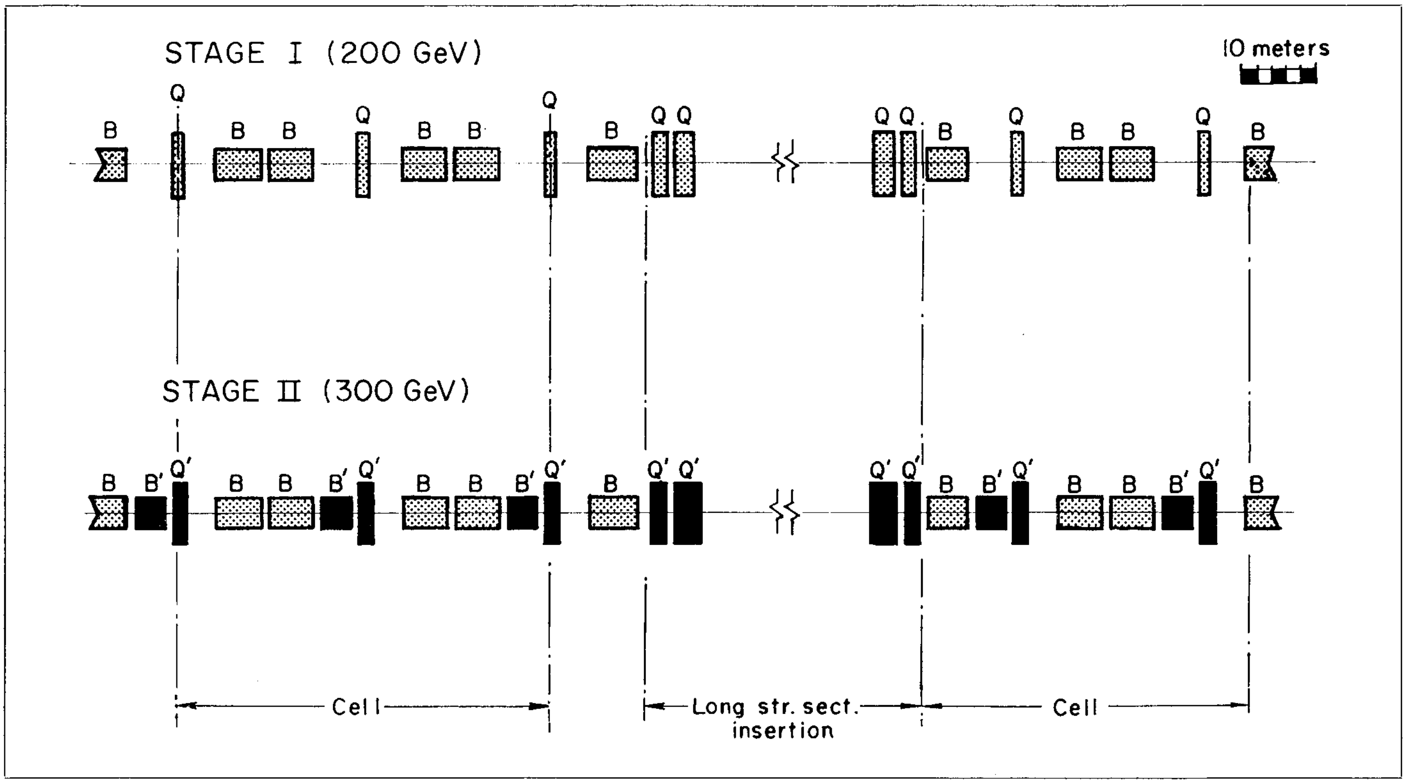
Thus the '300 GeV Machine Committee' had three distinct possibilities to examine against the background of the general considerations above:

(1) A fixed energy machine such as that put forward in the CERN 1964 design study

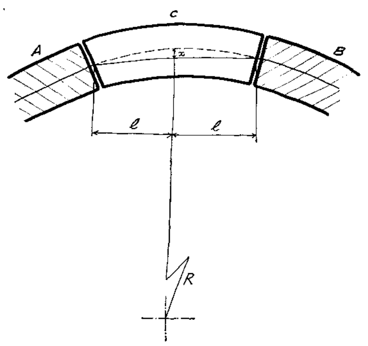
(2) An extendible energy 'missing power' machine such as is being built at Batavia

(3) An extendible energy 'missing magnet' machine such as initially proposed at Berkeley.

Each has particular advantages and disadvantages to which, for lack of space, we can make only cursory reference here. (1) is the best buy for the initial investment since the design is optimized throughout for the peak energy, but this peak energy is fixed and to climb higher means building a new machine. (2) can be converted to higher energy with little disruption to the research programme since the additional equipment is mainly external to the magnet ring, but it builds in from the start some potential which is initially unused and it has rather fewer options open for future development than (3). (3) can also go to higher energy and at each stage has very little unused potential built in, but conversion from one stage to another



An example of a 'missing magnet' design put forward at Berkeley in 1967. This particular design begins with a separated-function 200 GeV machine as stage one. The units marked B are the bending magnets and the units marked Q the focusing quadrupoles. Later it is possible to move to a 300 GeV machine as stage two. The initial bending magnets are retained and further bending magnets, B^1, are added. The quadrupoles are replaced by more powerful variants Q^1 (the initial quadrupoles could be retained if they are initially designed so that they could be run at higher field strengths).



For those who have not lost all contact with their school geometry this is a highly simplified way of seeing how a doubling of the number of magnets in a synchrotron ring, of the dimensions under consideration, has very little effect on the paths of the protons.

We first consider the ring, of radius R, half-filled with magnets evenly distributed around the circumference. Then a proton emerging from magnet A passes straight across to magnet B. We now move to stage two and fill up the entire circumference giving us n magnets in all. The proton path is now curved through magnet C and the maximum difference in the proton paths between stage one and stage two is x.

From the geometry of a circle we get that, approximately —

$$x \, . \, 2R = l^2$$

l is given, approximately, by the circumference divided by twice the number of magnets

$$l = 2\pi R/2n$$

Then we have

$$x \, . \, 2R = (\pi R/n)^2$$
$$x = \pi^2 R/2 n^2$$

Typical values could be a radius of 1 km and a total of 700 magnets. Then, approximately

$$x = 1 \text{ cm}$$

Obviously the actual magnet lattice involves much more refined calculations than this but at least our crude sums give an idea of how little change in proton orbits can be involved in moving from an initial peak energy to double that energy.

causes more disruption of the research programme since it involves installation in the magnet ring.

A detailed cost analysis of the three possibilities swung the emphasis onto the missing magnet design since it showed that, if we are willing to buy the possibility for future development, the missing magnet is the most economical design.

We now turn to examine the missing magnet idea in a little more detail so as to see how it achieves the energy jump and how it makes available a variety of further developments. The Berkeley proposal came from A. A. Garren, G. R. Lambertson, E. J. Lofgren and L. Smith and was published under the title 'Extendible energy synchrotrons' in Nuclear Instruments and Methods 54 (1967) p. 223. At Berkeley itself the proposal got the nickname 'Extendatron'.

They considered conversions from a 200 GeV machine to a 300, 400 or 500 GeV machine as examples of what could be done and also considered separated function variants and hybrid variants (beginning with a combined function machine and adding separated function bending magnets and quadrupoles). One of the more modest possibilities, 200 to 300 GeV separated function, is shown in the diagram on the previous page.

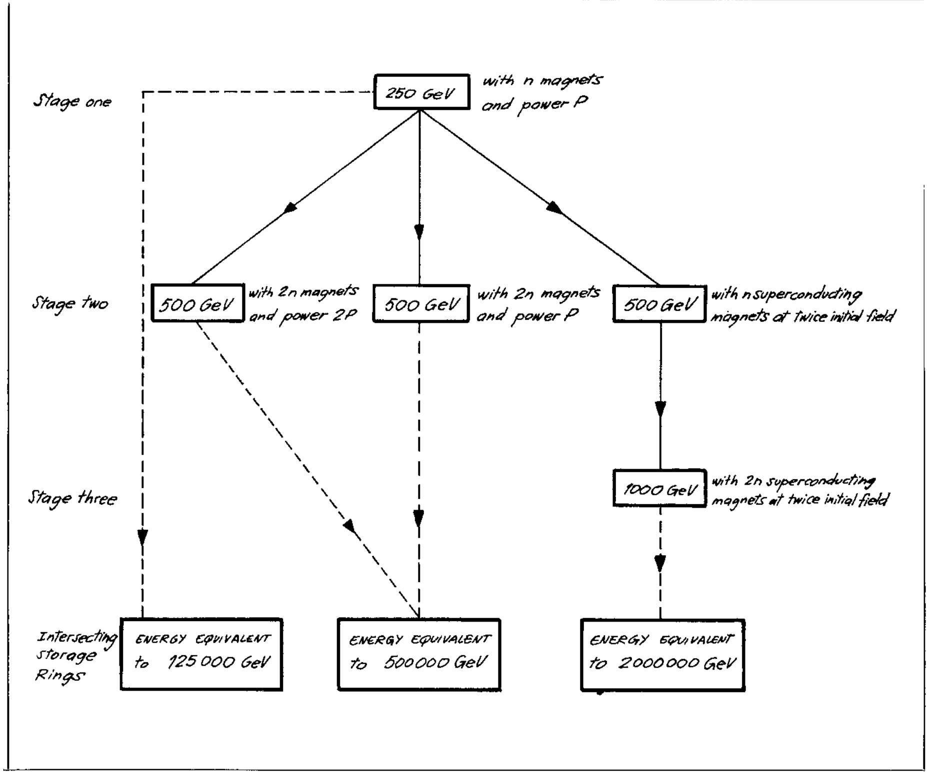
The vital aspect, which is not immediately obvious, is that, with the machine dimensions under consideration, even for a doubling of the energy (by doubling the number of bending magnets and thus doubling the bending radius) the paths of the particles differ by something of the order of centimetres in the radial direction between the two stages. Thus the same ring tunnel and probably the same vacuum system could be used and only very small adjustments would be needed to the positions of the initially installed magnets.

CERN reinvented the idea in a roundabout way. When studying the cost comparisons between separated function and combined function lattices it was realized that the cost of the machine does not climb steeply with radius. For example a 25 % increase in radius gives about a 6 % increase in cost. If we are willing to cut initial magnet costs (accepting a slightly lower initial energy) we can have a much bigger circumference for the same total cost. Then there is lots of room for adding magnets at a later stage.

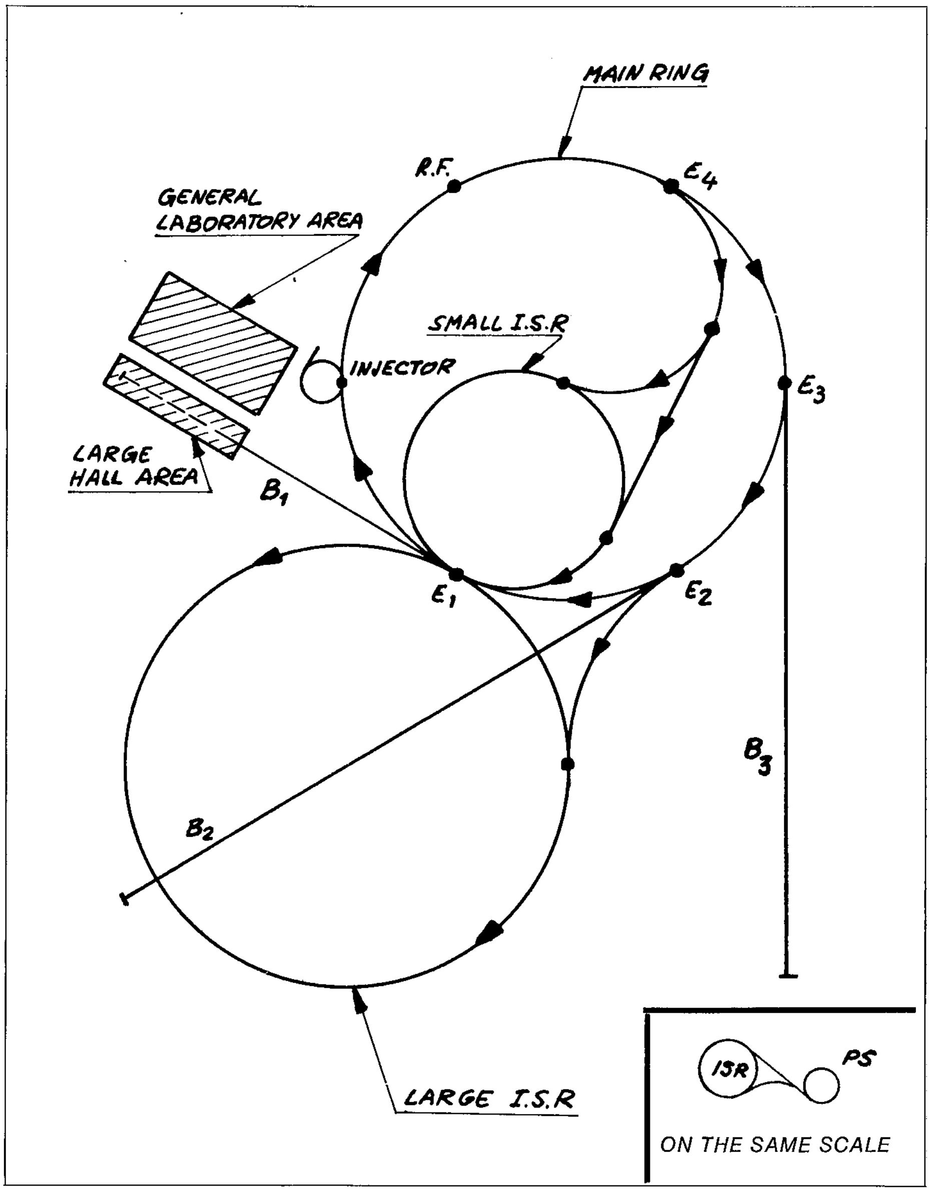
The total sum of money which is likely to be made available in Europe over the construction period of the machine is known. It was 1776 million Swiss francs at 1967 prices at the time of the last ECFA report. This was trimmed to 1335 MSF following the decision of the United Kingdom government not to join the project, most of the savings coming from the planned experimental facilities. At 1969 prices the figure was 1431 MSF and 65 % of this (933 MSF) was scheduled for the machine. About 50 % of the machine money, 470 MSF, is earmarked for the main ring. Obviously, it is possible to manoeuvre these figures while still adhering to the total budget but they give a good idea of costs from which to see the influence of selecting a missing magnet design. Several designs have been made and costed and compared with fixed energy and missing power variants. A typical possibility for a missing magnet design is to build a ring 3 km in diameter (compared with Batavia's 2 km and CERN 64's 2.4 km) installing magnets to give an initial energy of 250 GeV.

Let us take this energy of 250 GeV as an example of what might be stage one and see what are the options for future development through to the end of the century. We should stress however that such developments need not necessarily follow. That will depend on the continuing interest of the physics calling for higher energies and, of course, on the readiness of Europe to support the developments. It is therefore essential that each stage be complete in itself, not depending upon going further, and economic in its use of the capital invested and in operating costs.

There are three options open for stage two. The first is to double the number of magnets and double the available power giving a 500 GeV machine capable of operating at the same repetition rate. The second is to double the number of magnets without adding more power giving a



The most likely options for future development beginning with an accelerator of missing magnet design with an energy of 250 GeV (taken as an example). If the interest of the physics called for it, the machine could subsequently be raised to 500 GeV with the installation of further magnets. If superconducting accelerator magnets become available the ultimate energy could be 1000 GeV. Storage rings could be added at any stage.



A possible site layout showing the addition of intersecting storage rings (either a small version inside the main ring or a large version outside). Beam ejection points, E, are marked as are beam-lines, B, to possible experimental areas. Such a configuration, or modifications of it, will fit onto any of the sites under consideration.

500 GeV machine operating at a lower repetition rate. The third is to install superconducting magnets (if by that time the necessary technology has been mastered) to switch off the conventional magnets and to reach 500 GeV by running the superconducting magnets at twice the magnetic field level of the conventional magnets.

If successful operation was achieved with superconducting magnets a third stage would then open up where the conventional magnets would be removed and replaced by further superconducting magnets giving a machine of 1000 GeV. Another way of reaching this energy (more expensively but with the security of having a conventional machine to fall back on) would be to use the initial ring to feed a separate concentric superconducting ring.

Finally the addition of storage rings at one or other of the stages could give energies equivalent to those available from machines of 125 000 GeV (from stage one) to 2 000 000 GeV (from stage three). These possibilities for development are summarized in the diagram. It is obvious that the missing magnet design gives exceptional flexibility for future improvements.

The final design of the 300 GeV machine will take place only when the site of the new Laboratory is known and the project is authorized to go ahead by CERN Member States. It will take into account the particular features of the site, the prevailing state of the market for accelerator components and the latest developments in technology. No-one can say yet what type of machine will be built. The missing magnet design is currently highly favoured but studies and comparisons are continuing. What this article has tried to bring out is that there are plenty of new and exciting possibilities facing the 300 GeV Laboratory.

CERN News

Polarized targets cooled to 0.5° K

Two polarized proton targets have been in use at CERN since 1965. The first material to be used was lanthanum magnesium nitrate (LMN) cooled to 1° K by an open circuit of helium 4 achieving about 65% polarization. The targets were later improved by the use of solidified alcohols : ethanol in 1966, and butanol in 1968 (both tried for the first time at CERN). This provided targets containing twice as many polarized protons as LMN, for the same volume, and five times less protons bound in complex nuclei, with the result that in certain experiments the background could be considerably reduced. Although polarization was only about 38% at 1° K, the advantage of the lower background was such that, since the beginning of 1969, butanol has been preferred for both CERN targets.

The polarization of these targets can be increased still further, either by lowering the temperature or by increasing the magnetic field. Following studies aimed at reducing the operating temperature, CERN has now produced two butanol targets of the usual size (45 mm long and 15 mm in diameter) cooled to 0.5° K in a bath of helium 3 and polarized to 65-68 %. (An article will appear in Nuclear Instruments and Methods: 'Organic Polarized Proton Targets, using a continuous flow He^3 cryostat' by P. Roubeau, J. Ezratty and H. Glättli from Saclay and J. Vermeulen and M. Borghini from CERN.) Development of the cooling system has been a joint effort by the CERN Polarized Targets Group and the Saclay Physics of Solids and Magnetic Resonance Department.

These targets are now in use — the first for a positive kaon-proton scattering experiment around 1 GeV/c, and the second for a proton-proton scattering experiment at 17.5 GeV/c and π^- p and K^- p scattering at 14 GeV/c. With these targets the statistical accuracy of the experiments has been improved by a factor of about three. New experiments with low counting rates are now possible, such as, for example the study of the $K^- p \rightarrow \bar{K}^0 n$ charge exchange, or pion backward scattering at high energy. Both of these experiments are being prepared at CERN.

Design of the system

The targets contain beads of frozen butanol enclosed in a metal container, which is located in a 25 kG magnetic field and subjected to microwaves of 70 000 MHz. Cooling is by two separate circuits : an open He^4 system, of the liquid-gas type, which provides cooling to 1° K and cools the heat shields, and a closed He^3 system, of the gas-liquid-gas type, which lowers the target's temperature to 0.5° K. (He^3 is a rare and costly gas and its use in a closed circuit ensures that the losses are negligeable.) The main advantage of He^3 over He^4 is that its vapour pressure is higher at a given temperature ; conversely, its temperature is lower for a given vapour pressure. We thus have, for a pressure of 0.1 torr, a temperature of 0.47° K with He^3 compared with 1° K with He^4.

The He^4 and He^3 circuits form two separate sub-assemblies each of which is housed in its own pumping tube ; this means that they can be easily kept apart and there is therefore no danger of mixing the He^3 with the He^4. The thermal contact between these circuits is by conduction through coaxial cylindrical elements sliding within each other.

Completely separating the systems has made it appreciably easier to solve leakage problems, as well as to overcome difficulties with the heat shields and when filling the container at the temperature of liquid nitrogen with the beads of solidified butanol.

The liquid He^4 passes through an expansion valve, after which it evaporates as a result of a 0.1 torr depression provided by a high-speed pumping system (3600 m^3/h) and its temperature is brought to 1° K. The gaseous He^3 is steadily cooled to 1° K in the heat exchanger, until it liquefies ; in this case too, the gas is subjected to a depression of up to 0.1 torr as a result of being pumped through a calibrated leak by a pumping system with an output of 250 m^3/h, and its temperature falls to 0.5° K.

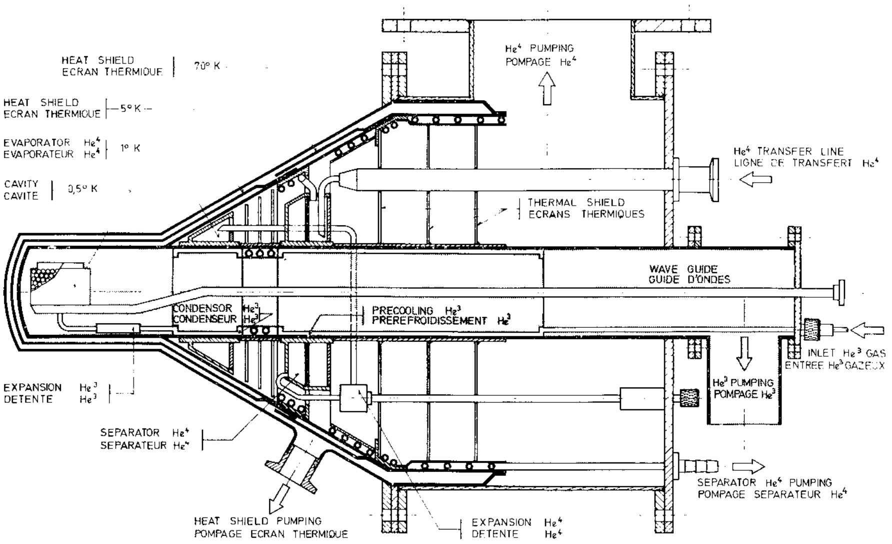


Diagram illustrating the principle of the combined helium 3 and helium 4 cryostats. The separation of the two circuits (helium 3 and helium 4), the co-axial structure and the arrangement of the heat screens can be seen. The centre section, the helium 3 cryostat, can be withdrawn for refilling the target cavity at 77° K.

New accelerating system for the PS

The r.f. accelerating system now in use on the 28 GeV proton synchrotron is that which was installed when the machine was constructed in the 1950s. However it has been possible to change many aspects of its performance over the past ten years and this has contributed considerably to the increase in proton beam intensity and improvement in beam quality available from the PS. The scope for further adaption of the system has now become very small and, to cope particularly with the planned further increase in beam intensity, it has been decided to install new cavities of a different type.

The energy needed to accelerate the proton beam is supplied by radio-frequency amplifiers via cavities in the synchrotron ring. The tuning of the cavities is achieved in the PS by a core of ferrite rings, whose inductance can be influenced by a magnetic bias field. The high losses in this core must be made up by the r.f. amplifier, so that the total r.f. power consists of power given to the beam plus power dissipated in the cavity.

In the present system, almost the whole amplifier output power is dissipated in the cavities. The accelerating voltage of 10.2 kV peak per station represents a limit imposed by both the present amplifiers and the cavities: the amplifiers and associated supplies can just deliver the corresponding ferrite power without reserves for a more intense beam; also, the cavity cooling system cannot handle an increased dissipation.

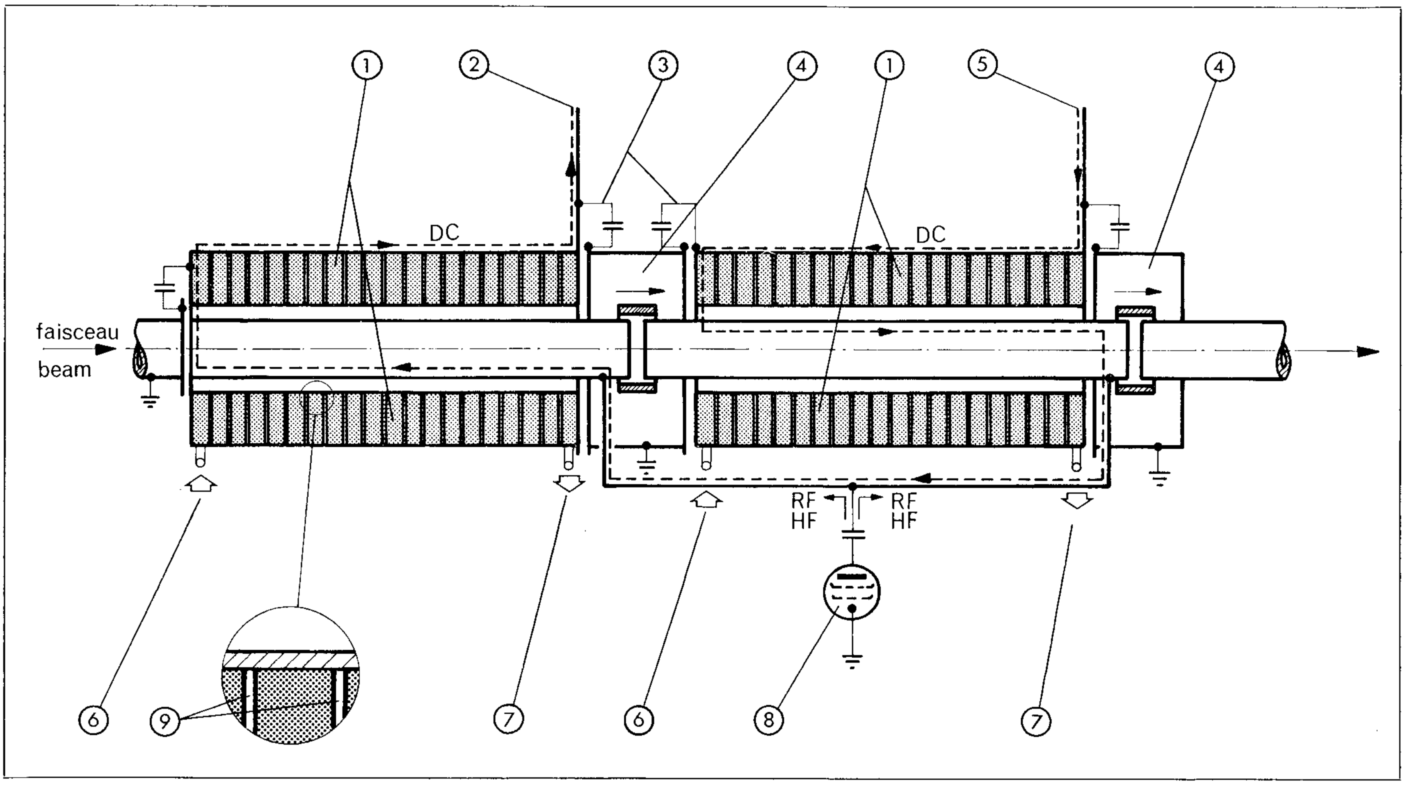
Future PS operation, when the Booster comes into service, will require power to cope with a higher intensity beam. In addition, the accelerating voltage must be raised to shorten the time needed for acceleration as well as to provide higher stored energy (to keep beam-loading effects low).

The major requirements for the new r.f. system (for 2×10^{13} protons per pulse) are as follows — the corresponding figures for the existing system (at 10^{12} protons per pulse) are given in brackets: Accelerating voltage per station of 2 half-cavities — 2 × 10 kV (2 × 5.1 kV); Beam power per station at the stable phase angle of 30° — 15.3 kW (0.382 kW); Cavity losses — 34 kW (4.8 kW); Total amplifier power — 49.3 kW (5.2 kW).

Another aspect of the increased beam intensity will be the increase in radiation, which is expected to go up by about a factor of five. The resulting higher failure rate of components combined with the aggravated problems of servicing requires that a maximum of equipment be positioned outside the ring tunnel. It has been decided to position only the new cavities and associated final power stages in the tunnel and to locate all supplies, controls and preamplifiers in a separate building in the ring centre.

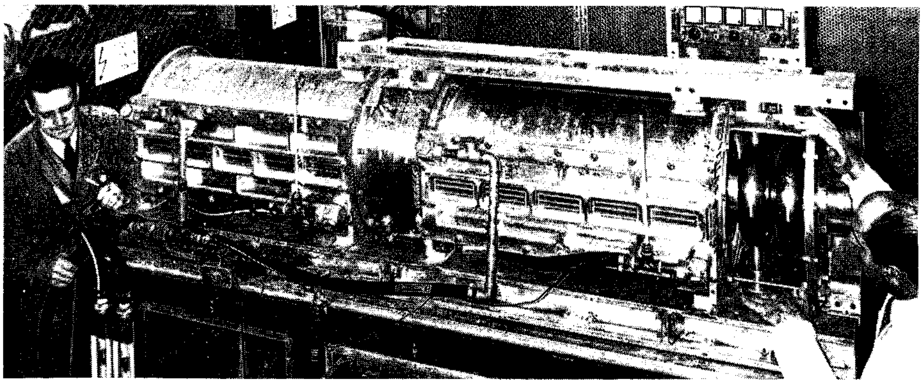
The key parameters of the new system are:

- 13 cavities in the ring, producing a total peak voltage of 260 kV;
- frequency range 2.8-10 MHz with cavities tuned by a centralized servo system;



Simplified diagram of the new r.f. accelerating system for the 28 GeV proton synchrotron. The indications are as follows: (1) ferrite rings (20 per half-cavity), (2) tuning current out, (3) capacitors for the separation d.c. - r.f., (4) accelerating gap (10 kV peak), (5) tuning current in, (6) water cooling input, (7) water cooling out, (8) r.f. amplifier, (9) cooling water.

Prototype of the new type of r.f. accelerating station under test at CERN.



CERN/PI 180.1.70

— maximum rate of change of frequency 500 MHz/s.

A prototype station has been developed at CERN around these figures. The main problem was to double the station voltage with a fixed cavity length, given by the dimensions of the long straight sections. To reduce the magnetic flux density and consequently the losses, larger ferrite rings have to be used. Their outer diameter of 440 mm is near to the present technological limit of ferrite manufacturing, which coincides approximately in this application with the electrical limit given by the circumferential resonances. Even with the ferrite cross-section thus increased, the high magnetic induction would only have permitted pulsed operation because of excessive losses of the present ferrite material (4H) at the low frequency end; an improved material (4L), which allows continuous operation for test purposes, was therefore adopted. The power density is nevertheless significantly increased and the problems of efficient cooling and of equal power distribution are dominant.

The ferrites are biased by the high current from the tuning system which flows directly through the central conductor of the cavity. This method ensures the best symmetry of the bias and thus optimum power distribution. To be able to inject this tuning current at 'cold' (r.f. free) points of the cavity, two half-cavities are grouped together, connected in parallel for the r.f. but in series for the bias.

The magnetic stray field of the 3000 A bias current must be small enough not to disturb the beam. A system of two busbars at the top and at the bottom of the cavity is therefore used.

Since the magnetic quality of the ferrites drops considerably with increasing temperature, the cooling water should be at the lowest possible temperature. No secondary distilled water circuit has therefore been designed; the whole cavity can be considered as a heat exchanger using the normal water supply with the additional benefit that pumps etc. are not necessary.

The final amplifier is housed in the cavity base and consists essentially of a single power tetrode and associated components. All other equipment is concentrated in the central building and connected via cables of approximately 180 m length.

The whole system is of modular design for rapid exchange of defective subgroups. To increase the reliability, semiconductors instead of vacuum tubes are used wherever possible. Since in addition most of the equipment will be accessible during operation, down-time of the improved system should be much lower despite the almost tenfold increase in output power.

The contract for the delivery of most of the hardware has been placed: Siemens AG will furnish the cavities and amplifiers; 8 cavities will be installed during the shutdown early in 1972, giving roughly the same energy gain per turn as the present equipment. A further five stations are scheduled to be installed by October 1972 during the machine servicing periods.

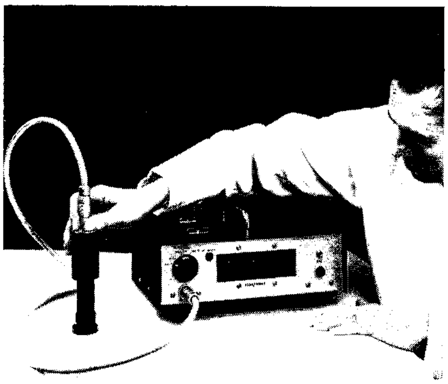
Monitoring radioactivity

A large number of detectors set up around the CERN site give a continuous reading of the 'direct' radiation (produced by the emission of particles from the accelerators). They have shown that the dose level outside the restricted areas is virtually negligible. More attention is now being given to the observation of induced radioactivity, from materials which have been irradiated by direct radiation.

Induced radioactivity can spread via dust from these irradiated materials in suspension in air or water, or via mud, metal filings, factory waste, etc. Dusts are the most troublesome since some of them can be inhaled or ingested. They can come to rest permanently in tissue or bone, where they constitute radiation emitters capable of affecting the body cells. This is particularly true of substances such as iodine or strontium.

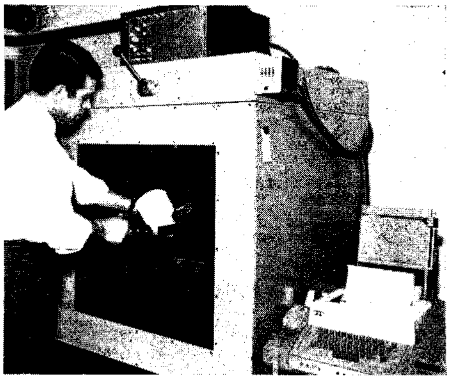
Although most materials become radioactive under the action of direct radiation, not all forms of radioactivity are equally dangerous. The hazard varies depending on the chemical nature of the material, on the type of emission (alpha, beta or gamma) and on the radioactive half-life. Alpha radiation, consisting of heavy, low-energy particles, can be stopped by a small quantity of matter (a few centimetres of air). It is not therefore dangerous as an external source of radiation, but, once absorbed by the organism if the chemical nature of the substance is appropriate, its destructive power over a small area is tremendous. The materials subject to primary radiation at CERN are not alpha emitters, which need a very heavy nucleus like uranium.

The only isotopes likely to form a hazard, therefore, are those emitting beta and gamma rays. The half-life of many isotopes formed from substances which are abundant in nature, such as nitrogen, oxygen, hydrogen, and carbon, is so short that their radioactivity becomes negligible a very brief time after their formation. Other substances have a long half-life, but following the law that the radioactivity is weaker the longer the half-life, their radiation is weak in their usual concentrations.



Prototype of a surface dose meter designed by the Health Physics group. A small (1 cm²) scintillator is placed on a probe and can measure radioactivity from small surface areas. It can detect beta and gamma rays and its sensitivity can be set between 30 mrad/h and 100 mrad/h.

CERN/PI 552.1.70



The new detector for high energy (over 20 MeV) radiation developed by the Health Physics group. Cylinders of a plastic material with a high carbon 12 content are introduced. The carbon 12 under the effect of previous exposure to high energy radiation can be converted into the radioactive isotope carbon 11 which gives off gamma rays. In the detector the cylinder acts as a scintillator revealing its own radiation. This is observed by a photomultiplier tube and recorded on punched tape. Thick walls shield against background radiation.

CERN/PI 46.2.70

The most important substances, taking account of their concentrations, are those with a medium half-life, ranging from a few hours to a few months; for example beryllium 7 (a spallation product of oxygen and nitrogen in the atmosphere) with a half-life of 54 days.

Since the CERN accelerators were first commissioned, periodic measurements of the induced radioactivity of substances in suspension in air and in water have been made. These measurements have invariably confirmed that such radiation has remained very low — of the order of 1 % of the maximum concentrations permitted by the Swiss safety standards. The level is, in fact, so low that more sensitive equipment than that usually marketed has to be used. Recently, however, firstly to increase our knowledge of the mechanisms for the production of radiation from induced radioactivity and secondly to ensure that the radiation will never exceed the specified limits even when the intensity of the machines is considerably increased, it was decided to set up continuous detection stations on the site. They are intended on the one hand to check the dust suspended in the air and on the other to test all the water used on the site before it is allowed to flow away as waste.

A first continuous air detector has been installed on the roof of Building 28. Two stations to monitor the waste water will start operating shortly. High-capacity filters are used to collect specimens of air-suspended dust and the specimens are analysed after a period long enough to allow short-lived isotopes to decay. In the case of the waste water, samples will be taken and tested after evaporation. The samples are set before beta and gamma counters, either of the scintillator or semiconductor type.

The air monitor has already provided its first results.

With regard to overall beta and gamma activity it had been impossible previously to discover any correlation between radioactivity in the air and accelerator operation. However, a definite reduction in activity can now be observed during official holidays even when the accelerators continue to operate, and this indicates that natural radioactivity in dust from the ground, swept up by civil engineering work and by traffic, plays a bigger part in this respect than the CERN machines.

Beryllium 7 is the only substance present in the air which can be regarded as being due to machine operation. The level detected is, however, so low that the results are difficult to interpret. Studies have nonetheless encouraged the improvement of the equipment ready for the machine intensity increases.

Three new instruments

For some months, the Health Physics group has been using a simple method for monitoring direct high energy radiation in the vicinity of the two CERN accelerators. The method involves placing, in the area where measurements are needed, a transparent plastic block (polyvinyl toluene) which is rich in carbon. Carbon 12 can be transformed by radiation (neutrons, protons or pions) into the radioactive isotope carbon 11. The polyvinyl toluene then acts as a scintillator detecting its own radiation. Using a photomultiplier and counting the number of emissions per second, the induced radioactivity, which itself depends on the direct radiation, can be deduced.

As the production threshold for carbon 11 is 20 MeV, only high energy radiation is registered. A disadvantage is that the plastic blocks have to be transferred from their exposure point to the counter but the half-life of carbon 11 is 20.4 minutes and this is not a great problem. The counter itself comprises a thick-walled chamber (to stop background radiation) which is completely light-proof and inside which a photomultiplier is placed. The block is brought into close optical contact with the photomultiplier.

When measurements are taken, the corrections usually made with activation detectors (radiation time and time elapsed between completion of radiation and measuring) have to be taken into account. An automatic tape punching machine and a typewriter are linked to the detector, so that the data can be recorded and subsequently processed by computer.

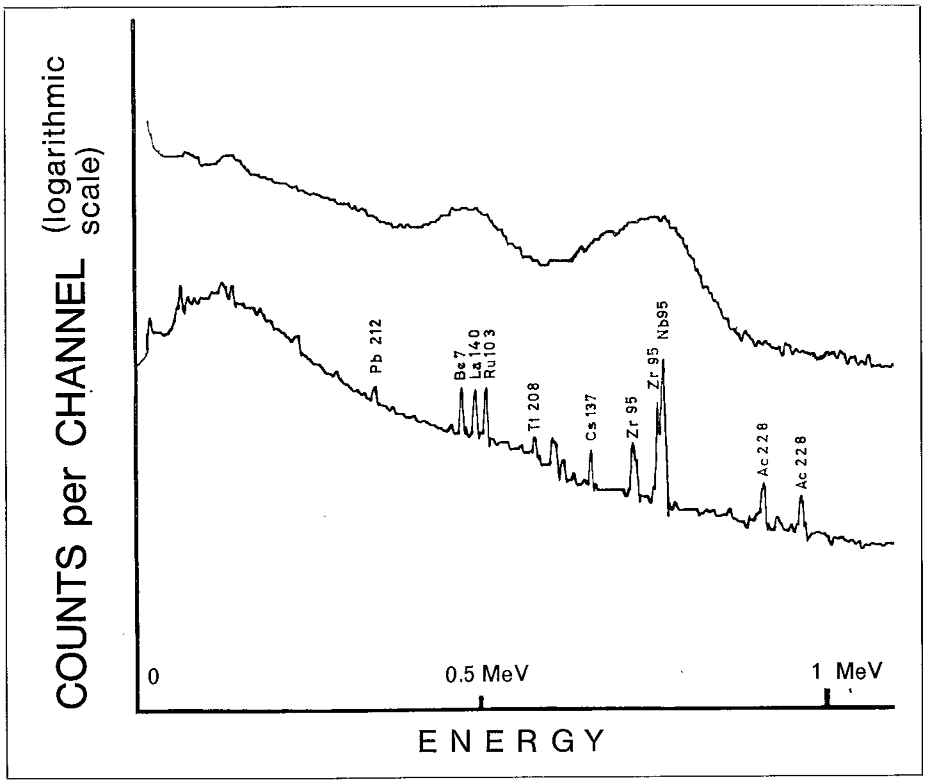
Another instrument developed in the group is a dosimeter which is able to measure doses at very short distances. It checks that doses absorbed by the hands when handling radioactive components do not exceed the doses received by the whole body (checked by film badges). This instrument is proving very useful as the age of the accelerator components increases. Accelerator parts were once machined from new metal, but machining is now increasingly being done on old machine parts which are fairly radioactive.

The detector element is a thin scintillator (0.4 mm) which is sensitive to both beta and gamma radiation. It is small in area (1 cm²) so that it can be placed in contact with the irradiated components, even when these are of small dimensions.

Another new instrument is a gamma radiation detector whose element is a semi-conductor of unusually large volume; it therefore possesses the very high resolving power common to this type of detector (2.5 keV) but, because of its volume, it is in addition extremely sensitive. The semiconductor is composed of lithium doped germanium.

Graphs from a sample of dust collected late March from 5200 m³ of air on the CERN site. Above is the curve from a conventional detector; below is the curve from a new gamma detector using lithium doped germanium. The new detector combines sensitivity with very good energy resolution — about a dozen isotopes can be identified from the curve without the need for prior chemical separation.

Almost all the detected isotopes come from fall-out, natural radioactivity, or are produced by cosmic radiation. Only a small percentage of beryllium 7 (from spallation of nitrogen and oxygen in the air) is caused by the accelerators.



The advantage which the semiconductor has over scintillation detectors is that the electrons liberated by ionization during the passage of the ionizing particles are picked up directly, giving rise to an electric current which can be amplified. Thus the semiconductor by-passes the 'light' stage of the scintillator and a very high resolving power is obtained. On the other hand, semiconductor detectors are usually small in volume owing to the high cost of the Ge (Li) and are consequently less sensitive than detectors such as scintillators of the sodium iodide type. The equipment recently acquired by CERN has a detector element whose useful volume is 44 cm³ and which provides a high degree of sensitivity.

Experiments in heavy liquid chamber

Since the spring of 1969, the CERN 1.2 m heavy liquid bubble chamber has been used for two experiments supplied by the k11 beam.

The first (T134) used 1.1 GeV/c positive kaons, and took 700 000 photographs to study their decay by the mode $K^+ \to \pi^0 e^+ \nu$ in propane. The second (T133) used negative kaons of energies from 800 to 1050 MeV and took 1 300 000 photographs to investigate the $K^-p \to Y^*$ interaction in a 50 % propane/50 % freon mixture.

The first experiment, carried out by Aachen, Bari, Brussels and CERN, is essentially a continuation of the study of the K^+ decays giving three particles including leptons which was started in 1965 by the 'X2 collaboration'. The behaviour of the decays:

$$K^+ \to \pi^0 \mu^+ \nu$$
$$K^+ \to \pi^0 e^+ \nu$$

is determined by two so-called form-factors, f+ and f-, which are unique functions of the neutral pion energy.

The old X2 experiment was carried out in C_2F_5Cl (radiation length about 25 cm) and was designed to study the K^+ decay and especially T invariance conservation in this decay. This decay mode, though very interesting, restricts one to an accurate determination of the ratio of the form-factors f^-/f^+ only. In order to determine f+ directly it is necessary to study the exact form of the neutral pion spectrum in the K^+ decay. Such a study is very difficult from the X2 photographs due to the fact that the gamma rays from the instantaneously decaying π^0 can only be measured to an accuracy of 25 %. In using propane (radiation length 100 cm), this error is reduced by a factor of 3 and hence allows a much more accurate determination of the π^0 spectrum. This experiment should yield the most accurate determination of f+ to date.

The second experiment, carried out in 1969 by a CERN, Brookhaven, Ecole Polytechnique, Orsay, Turin group, also used a negative kaon beam with the chamber filled with a 50/50 mixture of propane and freon.

The aim was to investigate the formation reaction $K^-p \to Y^*$ at an incident particle energy varying between 0.8 and 1.05 GeV/c, giving masses between 1.6 and 1.8 GeV for the resonances Y^*.

It was not a production but a formation experiment in the sense that the energy of the incident particles was used entirely for the formation of the resonance. Such is not the case in production experiments, where the energy of the incident particles produces both the resonances Y^* and other particles.

The neutral decay of a Y^* gives the following two types of reaction:

$$Y^* \to \Sigma^0 \pi^0 \quad (\Sigma^0 \to \Lambda^0 \gamma \text{ and } \pi^0 \to \gamma\gamma)$$
$$Y^* \to \Lambda^0 \pi^0 \pi^0 \quad (\pi^0 \to \gamma\gamma)$$

Y^* resonances with this type of decay have zero isotopic spin.

Because of the short radiation length (30 cm) in the propane-freon mixture, the many gammas resulting from the neutral particles can materialize inside the chamber as electron-positron pairs, which would not be seen in a hydrogen chamber, where the radiation length is much longer. The experiment was completed in February 1970 and scanning is now in hand.

During the period before the large heavy liquid bubble chamber, Gargamelle, begins operation (this chamber will be using part of the beam line supplying the 1.2 m chamber), there is time for a further experiment. It uses the beam m10 (positive pions at 3.5 GeV/c) into a propane/freon mixture (giving a radiation length of 30 cm). The purpose of this experiment, which is being carried out by a Bergen, Ecole Polytechnique, Orsay, Strasbourg collaboration, is to examine $\pi\pi$ interactions (which cannot be studied directly) by an indirect method using the $\pi^+p \rightarrow N^{*++}\pi^0\pi^0$ reaction.

It may be assumed that when the π^+p collision occurs and the N* resonance is formed, a virtual negative pion is produced which combines with a positive incident pion to produce either a π^+ and π^- or π^0.

The question is to look deeply into the interaction and the existence of $\pi\pi$ resonances to find out whether there is a resonance associated with the charge-exchange reaction. This is, indeed, indicated by theoretical studies. It would involve very short-lived resonances of zero isotopic spin, presumed to have a mass of about 750 MeV.

The basic measurement in this experiment is the direction of the momentum of the gammas (seen when they produce electron-positron pairs) resulting from the decay of the two neutral pions. If the existence of a resonance associated with the charge exchange reaction is confirmed by this experiment, it will be possible to pursue the study at higher energies in Gargamelle.

European Molecular Biology Conference

A very successful session of the European Conference on Molecular Biology was held at CERN on 6-8 April. For the first time the Conference was meeting 'formally'; as from 2 April 1970 sufficient European governments had ratified the agreement setting up the Conference for it to move from provisional to formal status. The Member States are now Austria, Denmark, France, Federal Republic of Germany, Netherlands, Norway, Sweden, Switzerland, and UK. Ratification procedures are underway in Greece, Italy and Spain. In addition it was agreed, in the course of the meeting, to admit Israel as full member of the Conference. Israel's support, both financial and scientific, has been considerable from the beginning. Close relations are being established also with the Belgian Fonds National de Recherche Scientifique which will assume the financial obligations which would otherwise have been taken up by the Belgian government. To complete the membership roll-call, Finland has been invited to send an observer to the Conference.

Taking administrative matters first: the following officers were elected for one year — H. Voirier, President (Switzerland); A. Alline, Vice President and Chairman of the provisional Finance Committee (France); C. Zelle, Vice President (Federal Republic of Germany). J. C. Kendrew (UK) was elected Secretary General of the Conference for three years. A budget of $ 632 000 was agreed for 1970 (expenditure for 1970 is foreseen as $ 714 000 using, in addition, some funds already accumulated). A provisional sum for 1971 was accepted as just under $ 1 million with a growth rate of about 20 % for the two following years. Contributions from the Member States will be assessed, as are those at CERN, on the basis of UN statistics of net national revenue.

Scientific activities, both those already implemented in 1969 and those foreseen for 1970-1971 were covered by M. Eigen the President of the European Molecular Biology Organization (EMBO) which is effectively the executive arm of the Conference. EMBO has concentrated on implementing high level study and training in molecular biology in Europe. For example the major items in the budget for 1970 are — Fellowships ($ 524 000), Courses and workshops ($ 76 000), Management ($ 55 000). The Conference itself absorbs only about 5 % of the budget.

Even before the creation of the Conference, EMBO and individual scientists had been urging that a European Laboratory for Molecular Biology should be established. The purpose of such a Laboratory would be to bring together in one centre the many disciplines which are involved in the pursuit of molecular biology. This is extremely difficult to achieve on the scale of University research departments. Another major task of the Laboratory has received more emphasis in recent discussions — this is the development of sophisticated instrumentation such as an advanced electron microscope and an intense source of X-radiation for diffraction studies of molecular structure. In a similar way to the way in which CERN operates, the Laboratory is seen as a research centre with limited 'permanent' scientific staff, to which visiting scientists would come to carry out short-term or medium term experiments, in a multi-disciplinary environment with first class equipment, and then return to their home countries. The long-term evolution of the Laboratory is not being defined too precisely at the outset to enable the Laboratory to adjust to the rapid developments in molecular biology.

A new detailed proposal concerning the establishment of such a Laboratory was presented to the Conference and was warmly welcomed by many delegations of the Member States. It has not yet been examined by the governments but there is a strong conviction in the scientific community that such a Laboratory is of vital importance for the future of molecular biology in Europe. The Conference set up a Working Group to pursue the study of the proposed Laboratory and to make recommendations at the session of the Conference to be held on 26, 27 November 1970.

Around the Laboratories

SACLAY

Mirabelle ready to move

Mirabelle, the large hydrogen bubble chamber built by the Elementary Particle Physics Department of the CEA is being dismantled for removal to the Serpukhov 76 GeV accelerator where experiments with the chamber are due to start from the middle of 1971. The chamber was officially inaugurated on 18 March at a ceremony held in the presence of the Soviet Ambassador to France, V. A. Zorin.

From 1965, when various laboratories were considering plans for giant bubble chambers, there were discussions between the Institute for High Energy Physics (Serpukhov) and Saclay on joint physics experiments at the Soviet accelerator (then due to come into operation in 1967), and, in 1966, a Franco-Soviet agreement was signed. The agreement specified that a large bubble chamber would be built at Saclay and installed at Serpukhov to be used for collaborative experiments. It gave French physicists the possibility of working with the highest energy accelerator in the world while allowing Soviet scientists to profit from Saclay's considerable experience in the field of bubble chamber construction.

The extent of this experience can be seen from the Table. The largest chamber built by Saclay prior to Mirabelle had been the 180 litre chamber operated from 1964 to 1967 on the 7 GeV Nimrod accelerator at the Rutherford Laboratory under a similar exchange agreement with the UK, and later at Saturne.

Due to the efforts and enthusiasm of the team, lead by P. Prugne, chief engineer, it was possible to complete the programme for the construction of Mirabelle ahead of the schedule laid down in 1966.

The project ran into difficulties in 1967 when an explosion occurred in part of the full-scale model. Two months later, the model was operating again. Final studies and manufacture began at the end of 1967. Two months were lost during the troubles of May 1968; nevertheless testing of the chamber in its final form began in July, 1969, a month ahead of schedule.

The agreement laid down that the chamber, which costs 37 million French francs, would be operated at Serpukhov for at least five years by French staff, while, in return, teams of French physicists would take part in the experiments in mixed teams. Serpukhov is providing the buildings and water, electricity and hydrogen supplies. Saclay is supplying the film and the two Laboratories are providing film scanning facilities. CERN, which is supplying most of the components for the beam-line to the chamber (see CERN COURIER vol. 10, page 31) may also take part in the experiments.

Dismantling of the chamber began at Saclay in April. Reassembly at Serpukhov is scheduled for the first half of 1971; it should then be possible to carry out the first experiments after the accelerator's summer shutdown. However, the actual programme is only in draft form and it will take on its final form after the Franco-Soviet Scientific Commission, which meets twice a year, has taken its decisions.

First Operation	*Useful Volume*	*Operated at*
1957	1 litre (a model known as ME3 in which tracks were first photographed)	Saclay
1959	3 litre (20 cm long)	Saclay
1959	25 litre (35 cm long)	Saclay
1960	70 litre (50 cm long)	Saclay
1961	70 litre (81 cm long)	CERN
1962	300 cm^3 (Known as ME5, it was installed as a target inside a heavy liquid chamber)	Saclay
1964	130 litre (81 cm long)	DESY
1964	180 litre (81 cm long)	Rutherford
1966	7000 litre (The Mirabelle prototype known as ME6)	Saclay
1969	7000 litre (Mirabelle)	Saclay Serpukhov

Scanning and measuring

The problems of scanning are being examined. The main difficulty is due to the fact that each of the eight cameras sees only part of the chamber. The best solution will be found empirically, using several tens of thousands of photographs taken at Saclay before dismantling of the chamber began. They will be analysed on a prototype scanning table, 2.7 m long and 1.2 m wide, built by a group led by J. B. Baton. The scanner can project either three views from the upper bank or three from the lower bank of cameras simultaneously, with a magnification of ten in relation to the film in each case. It is also possible to project two views from the central bank of cameras, in which case the magnification is times twenty. This procedure is envisaged only where it is considered necessary to examine some complex event in detail. Experience with the prototype will enable the final version, several of which will be built, to be specified. Final measurement will be possible on HPD, Spiral Reader or IEP machines.

Installation at Serpukhov

Mirabelle weighs 2000 tons, and the total weight, including all the auxiliary equipment, is 3600 tons. Dismantling, transporting and reassembling such a huge assembly is obviously a labour of Herculean proportions and will take a year to complete.

The equipment will be taken from Paris to Le Havre by road, from there to Leningrad by boat, and then by train from Leningrad to the experimental hall at Serpukhov. Mirabelle was designed with this move in view, and no single component exceeds 55 tons in weight. A. Patoux will be responsible for coordinating the different aspects of the removal.

Once Mirabelle is operating, a small colony of fifty families from Saclay will be housed in the village of Protvino, near Serpukhov. Together with the families of the scientists taking part in the joint experiments there will be a total of almost 250 French people. Saclay have given particular attention to this problem of

A little bit of France in the Soviet Union. The photograph shows some of the first French families to move to the Serpukhov Laboratory for the operation of the Mirabelle bubble chamber enjoying their Sunday dinner in a flat in Protvino village.

'transplantation'. There are many similarities with the experience already gained in the operation of the 180 litre chamber at the Rutherford Laboratory. This was successful and should therefore be all the easier to repeat.

An advance party of ten Saclay technicians and engineers has been at Serpukhov for some months to assist in problems such as the setting up of a workshop, stores, etc. It is likely that the families who will be going over later will adapt themselves fairly easily, especially in view of the way in which Soviet technicians who have been working at Saclay have become integrated.

The families will be distributed in blocks of flats in which local people also live, so that they will not tend to feel like an 'isolated colony'.

Children's education will concern many families, and here too, the experience gained in the UK will be useful. An infant school (open also to the children of visiting CERN families) has been set up, integrated into a local Russian school, with its operating costs shared between the French Ministry of Education and the CEA (the French Atomic Energy Commission). Two French teachers are to be employed initially. In order to make it easier for the children to become adapted to their new surroundings, they will receive lessons in Russian from a Russian teacher.

BATAVIA

Operation at 500 GeV

At the Users Meeting on 10 April, the Director, Professor R. Wilson, made a statement to the following effect:

'Construction of the synchrotron at the National Accelerator Laboratory is on, and in some cases ahead of, schedule. It now appears possible to have an accelerated proton beam by mid-1971, a year earlier than the originally scheduled date, and considerably before the experimental areas and the rest of the Laboratory are completed. It also appears possible that the protons can be accelerated to an energy close to 500 GeV at reduced intensity not long after the synchrotron is brought into operation. This advance in the schedule and in available energy has been achieved inspite of the fact that finance has become available more slowly than the optimum rate projected in our design report.

In fact, it has been in response to the reduced rate of funding that internal schedules have been rearranged by postponing construction of some parts of the Laboratory. We have also been able to move rapidly because actual bids for many components and structures have been low, which is a measure of the simplification that has been made in the design. Almost all the accelerator components and structures have been purchased but the experimental areas and laboratories have not.

Our main accelerator design has included from the start the capability of extending the proton energy from 200 to 400 or, perhaps, to 500 GeV.

Recent checks on production magnets have made it clear that they will be good up to field levels corresponding to 500 GeV. Furthermore the technology of thyristors, which are used as rectifiers in the power supply, has been advanced considerably. This and other technical developments have made it possible to install from the beginning a power supply, adequate for 500 GeV operation at smaller cost than originally estimated for 200 GeV.

The cooling capability that is being installed corresponds to year-round operation at 200 GeV with the design intensity of 1.5×10^{13} protons per second. Operation at higher energies will mean choosing cooler days or lowering the repetition rate. The average intensity at 500 GeV will probably be down by one or two orders of magnitude. Nevertheless there are exploratory experiments that can be carried out and it is expected that some experiments will begin as soon as possible making use of whatever facilities are available. It is expected that at a later date greater capacity for cooling, coping with radiation, and correction for loading of the electrical services will be added.

The first area for electronics detector experiments is presently expected to come into operation in July 1972. It will be limited to 200 GeV in order not to delay it. The second area is expected for completion by January 1973 and will provide a neutrino beam for weak interaction experiments. A bubble chamber will be designed for incident protons of energies up to 500 GeV.

Any attempt to predict an exact date for the initial operation is hazardous. As better information is forthcoming, the expected date will be corrected. Great effort and continued good luck will be required to meet the advanced schedule.'

USA Laboratories

Budget situation

In this article we pull together as much information as we have concerning the budget estimates for fiscal year 1971 (beginning 1 July 1970) and their impact on the USA high energy physics Laboratories.

In President Nixon's budget the Atomic Energy Commission, which is the channel of most high energy physics money, moves from $ 2189 M for 1970 to $ 2194 for 1971. Within the AEC budget, the money for 'Physical Research' goes down from $ 278 M to $ 274 M. Within Physical Research the high energy physics budget also goes down from $ 120·5 M to

$ 119.5 M. It should be added that the presidential budget is often revised (downwards) by Congress.

It is obvious that at a time when major construction programmes are underway, the money for experimental physics is taking a severe cut. The AEC, in consultation with the High Energy Physics Advisory Panel, had the difficult decision to take on where to apply the cut — for example to distribute it evenly round the Laboratories or to chop some programmes very hard in order to sustain others at a high level. The results are given in the following information from the Laboratories:

Argonne

The budget for the Argonne National Laboratory moves from $ 36.9 M to $ 36.4. Within this budget is the money for the operation and research at the 12 GeV Zero Gradient Synchrotron (the Laboratory has many other activities — reactors, chemistry, solid-state physics, metallurgy). The Director, R.B. Duffield, announced at the end of March that 230 staff would have to go by the beginning of the next fiscal year. The precise impact on the high energy physics programme is not known at this time.

Batavia

Construction of the 200-500 GeV accelerator at Batavia continues to be strongly supported. The budget for the next fiscal year is $ 65 M for construction with $ 17 M for operation. As is clear from the article above, this will see the completion of machine construction through. However budget restrictions over the past years have meant the preparations for the experimental programme have not moved in parallel and initially, utilization of the machine will be limited.

Berkeley

The budget allocation for the high energy physics programme at the Lawrence Radiation Laboratory involves a 5 % cut. Adding the effect of inflation the total cut is somewhere near 10 %. The effect on personnel will be a reduction of about 75 people.

Inspite of this it is hoped to continue operation of the 6 GeV proton synchrotron (Bevatron) on the same schedule as in the current year. Also the Electron Ring Accelerator development programme (see CERN COURIER vol. 10, page 51) which has been strongly supported at the Laboratory will continue at about the present level.

Clearly this means that cuts will have to be imposed on other areas of the high energy physics programme. One known casualty is the 25 inch hydrogen bubble chamber which will be shut down by the end of the present fiscal year. Other areas of reduction are still under discussion.

Brookhaven

The budget for high energy physics at the Brookhaven National Laboratory, centred on the 33 GeV Alternating Gradient Synchrotron, has increased by a few percent. However taking inflation into account the actual buying power of the available dollars goes down by something over 5 %. The impact on the experimental programme has not yet been detailed but there is no doubt that fewer experiments than planned will be done or experiments will take longer to do. Overall, the Laboratory (which like Argonne is multidisciplinary) will lay off about 250 staff.

Cambridge

The Cambridge Electron Accelerator Laboratory where research is centred on the 6 GeV electron synchrotron is perhaps the worst hit, for though the blow is hardest at Princeton, the Princeton Laboratory had some prior warning.

The cut in the budget is over 30 % (from $ 3.475 million to $ 2.4 million) and makes it impossible to both sustain the present research programme (mainly electroproduction and photoproduction experiments) and to pursue the colliding beam project (Project Bypass, see CERN COURIER vol. 8, page 289).

After considerable heart-searching it has been decided to phase out all conventional physics before 1 June 1970, in the belief that the most interesting physics open to the Laboratory is likely to result from colliding beam experiments. All the effort will then turn to Project Bypass. The time allocated to experiments already approved is considerably greater than can be provided and a difficult pruning operation has been needed.

In terms of personnel, 68 people out of a total Laboratory staff of 185 have been given termination of appointment notices.

Cornell

The Wilson Synchrotron Laboratory at Cornell University which operates a 10 GeV electron synchrotron stands somewhat aside from the rest of the Laboratories in the present situation since it draws its money from the National Science Foundation (whose budget is significantly increased) and not from the AEC.

Approval has just been received for the Laboratory budget effective from 1 March 1970 giving $ 1.4 M for operation, $ 1.2 M for research and $ 300 000 (appropriated earlier) for a modest improvement programme. The combined funds will allow the Laboratory to operate at a level near that of last year. Curtailment of the research at Cambridge in particular is however leading to an increased interest in using the Cornell machine.

Los Alamos

The 800 MeV proton linear accelerator project LAMPF, at Los Alamos Scientific Laboratory is another favoured child being allocated $ 10.5 M for construction and $ 6.2 M for operation. These figures are very close to the amounts requested.

Due to the fact that the funds requested for the present (1970) fiscal year were held back to $ 5 M for construction, the total construction cost of the project has moved from $ 55 M to $ 56 M. (The new figure has been accepted by the AEC.) A delay of six to nine months is likely for completion of the facility so that physics research will probably start in 1973. Nevertheless it is intended to hold to the scheduled full energy beam date of 4 July 1972. This is presuming that the final funds for completion of construction (approximately $ 7 M) will be allocated for fiscal year 1972.

Princeton

The writing appeared on the wall of the Princeton-Pennsylvania Accelerator Laboratory some months ago (see CERN COURIER vol. 10, page 16). The budget for the next fiscal year is $ 2 M to allow an 'orderly shutdown' of the 3 GeV rapid cycling proton synchrotron. No AEC funds are projected for the fiscal year 1972.

An additional 100 people have to be dismissed leaving only 90 for next year. It is intended to try to finish the committed experiments (5000 hours) but it may prove difficult as moral is obviously very low.

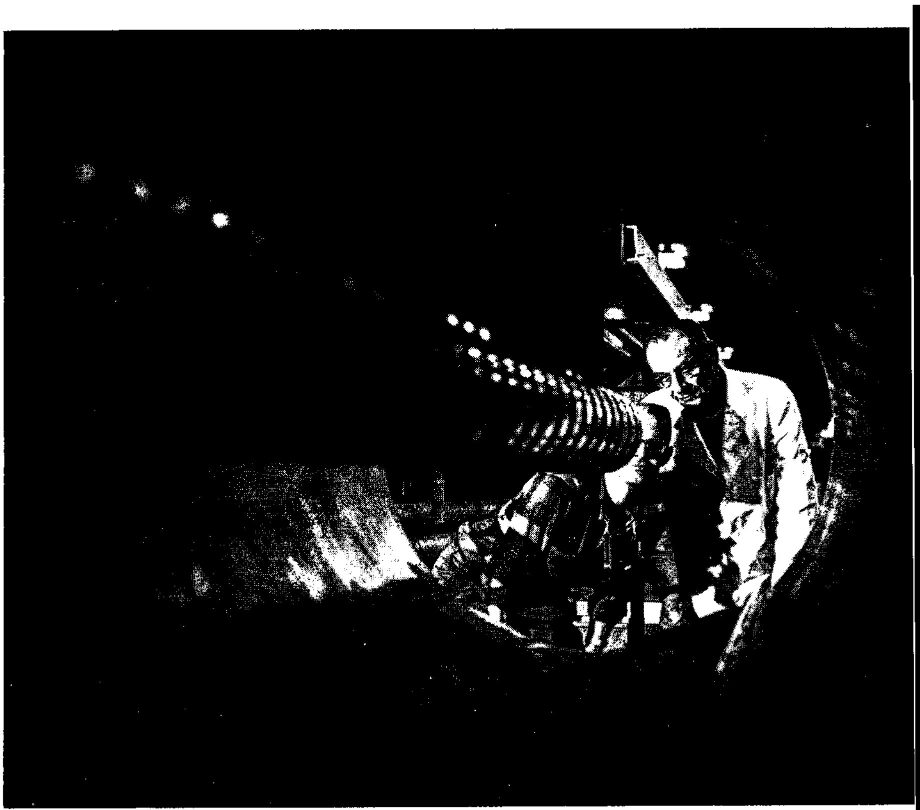
Users groups, the University, and the Director, M.G. White, are searching hard for other sources of money to keep the Laboratory alive — for example, the National Science Foundation, NASA (who could be interested in the heavy ion conversion of the accelerator), and other Foundations. Hopes however are not high.

Stanford

The Stanford Linear Accelerator Laboratory is being held to the same budget as in the present fiscal year which means an effective reduction of about 5 % in buying power. About 40 people are being cut from the staff of 1300 by the end of June. The effect on the physics programme will be that the 20 GeV electron linear accelerator will be used to somewhat less than 75 % of its potential.

In the 1971 fiscal year, some experiments will not receive the machine time requested and some requiring new detection equipment will have to be postponed or dropped altogether. Though there are two bubble chambers at the Laboratory (40 inch and 82 inch hydrogen chambers) and experiments could be run with both simultaneously, the funding is only sufficient to provide crew to operate one at a time.

At the time of writing, the Laboratory budget office has not completed its analysis of the implications for the storage ring project, SPEAR (see CERN COURIER



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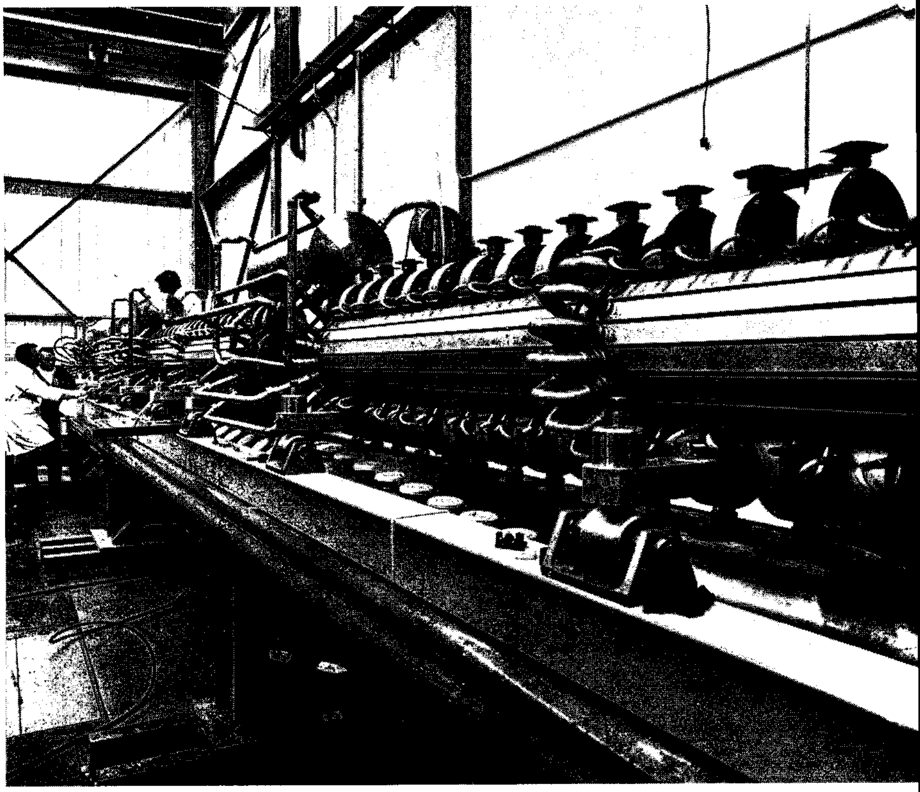

2.

LAMPF taking shape. The photographs show the first units of two sections of the 800 MeV proton linear accelerator:

1. The first of the four Alvarez type tanks, which will accelerate the protons to 100 MeV, has been installed in the beam channel and is being coupled to the proton preinjector.

2. The first of the 45 modules of the side coupled cavity type, which will complete the acceleration to 800 MeV, is being tested.

(Photos Los Alamos)

vol. 9, page 271). It had been proposed to proceed with the design and construction of this cut-price project taking money from existing funds without requesting a special additional budget. This would now mean however that other desirable detection devices could not be built and that there would be further reduction in the experimental programme.

LAMPF
Project progress

The Los Alamos Meson Physics Facility was described in CERN COURIER vol. 8, p. 132. To recall briefly its major features: LAMPF is an 800 MeV proton linear accelerator consisting of three acceleration stages — a 750 KeV preinjector feeding a 100 MeV conventional (Alvarez type) linac followed by a wave-guide type linac with side coupled cavities. The total length is 850 m. The design average beam current is 1 mA with a duty factor of 6 %, possibly eventually rising to 12 %. Thus LAMPF will be capable of higher energy (sufficient for the copious production of mesons), intensity and duty cycle than any proton linear accelerator yet constructed.

The preinjector has three injection systems each consisting of a Cockcroft-Walton high voltage set, an ion source, an accelerating column and beam transport system. One provides a high intensity proton beam, a second provides a polarized proton beam and a third provides a negative hydrogen ion beam. Using the H^- source in addition to the proton source it will be possible to accelerate two beams simultaneously — the conventional proton beam with the r.f. fields in one direction and the H^- beam with the r.f. fields reversed. At the end of the accelerator the two beams can be separated by a magnetic field and directed to different experimental areas. The H^- beam can then be fired through a 'stripper' foil where some of the particles will convert to protons or neutral hydrogen atoms. A magnetic field can separate the positive, neutral and negatively charged particles for use in different experiments.

The Cockcroft-Walton set for the proton beam has been installed and tested to 1 MeV, the ion source has been tested, and other components of the high intensity injection system are coming together and are scheduled for operation by the end of April. The negative hydrogen ion system is being manufactured and is expected to begin to come together late this year.

The first of the Alvarez type linac tanks has been installed in the beam channel and is being coupled to the proton injection system. The other three tanks are being manufactured. One of the 45 modules of the side coupled cavity system has also been completed and is being rigorously tested. Manufacture of these modules is no picnic. They are machined to critical tolerances and each cel involves several brazings. There will be 15 000 copper forgings in the complete accelerator unit, sequentially brazed into sections which are then assembled in modules.

Contracts have been placed for about 80 % of the r.f. power systems. For the tanks there will be four amplifiers, based on a conventional electron tube, operating at a peak power of 3 MW; for the modules

there will be 45 amplifiers, based on a large klystron, operating at a peak power of 1.25 MW (LAMPF will use about 40 MW of power when in operation). The power systems are being tested to give a 12 % duty factor.

LAMPF will incorporate computer control into machine operation to an exceptionally high degree (see CERN COURIER vol. 9, page 169) and a great deal of development work on the computer program and the maze of interface units has been necessary. By now about 80 % of the hardware has been ordered and the computer itself has arrived.

LAMPF will be a nationally available facility, and a Users Group, involving about 300 scientists from over 100 universities and other research centres, is already participating in the project particularly concerning the planning of experimental areas and the experimental programme. The first of three areas, Area A, is under construction and is intended for physics with pion and muon beams. Area B is intended for physics with proton and neutron beams and Area C will have a high resolution spectrometer for experiments with protons. Areas B and C will also receive polarized proton beams.

As reported elsewhere in this issue, construction funds in the present fiscal year were held back to $ 5 million and $ 10.5 million has been deferred to fiscal year 1971. This has meant delays in construction and, with rising construction costs, the total cost of LAMPF will climb by $ 1 million to $ 56 million. The completion of the experimental areas and the start of a full experimental programme will be delayed until 1973. Nevertheless the date for the first full energy proton beam remains as 4 July 1972.

A fuller account of the present state of the project can be found in the journal 'The Atom', March 1970, published by Los Alamos.

Conference Proceedings

The Proceedings of the Electron/Photon Symposium held at Liverpool in September 1969 (see CERN COURIER vol. 9 page 389) have been distributed to participants and are now available for sale.

The contents of the Proceedings are as follows: Status of Quantum Electrodynamics — S.J. Brodsky ; Single Pion Photoproduction in the Resonance Region — R.L. Walker ; Pseudoscalar Meson Photoproduction — K. Lübelsmeyer ; Vector-Meson Photoproduction — A. Silvermann ; Vector-Meson Dominance (Present status and future prospects) — J.J. Sakurai ; Photoproduction Mechanisms — H. Harari ; N* Electroproduction (Experimental results) — A.B. Clegg ; Electroproduction of Baryon Resonances (Theory) — F. Gutbrod ; Nucleon Form Factors — J.G. Rutherglen; High Energy Electroproduction — F. Gilman ; Muon Physics — W.T. Toner ; Experiments with the Orsay Storage Ring ACO — J. Perez-y-Jorba ; Storage Rings (Novosibirsk) — V.A. Sidorov ; e^+e^- Annihilation into Hadrons (Sum Rules and Asymptotic Behaviour) — R. Gatto ; Application of Current Algebras to Electroproduction — G. Furlan ; Inelastic Electron Proton Scattering in the Deep Continuum Region — R.E. Taylor ; The Phases of Vector Meson Photoproduction Amplitudes and Rho-Omega Interference — G.R. Allcock.

The proceedings, published by the Daresbury Laboratory, contain all invited talks and full discussions, abstracts of contributions received, author index to abstracts and list of participants. Copies may be obtained (price £6 sterling) from the Librarian, Daresbury Nuclear Physics Laboratory, Daresbury, Nr. Warrington, Lancashire, England.

The Proceedings of the Boulder Conference on High Energy Physics are now available and can be ordered from:

Mrs. Marion Higa, Department of Physics, University of Colorado, Boulder, Colorado 80302 with checks made payable to the University of Colorado. The cost of the Proceedings is $15.00 per copy.

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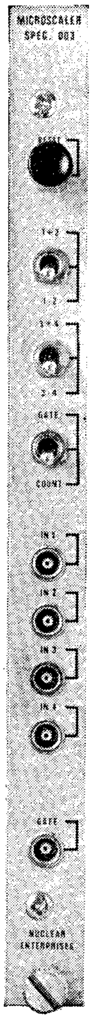

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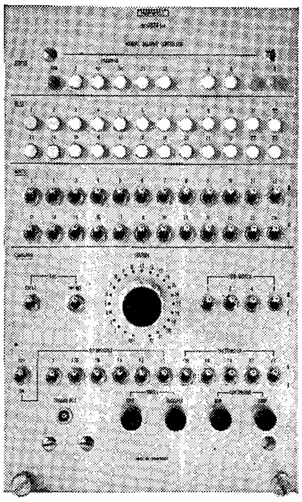

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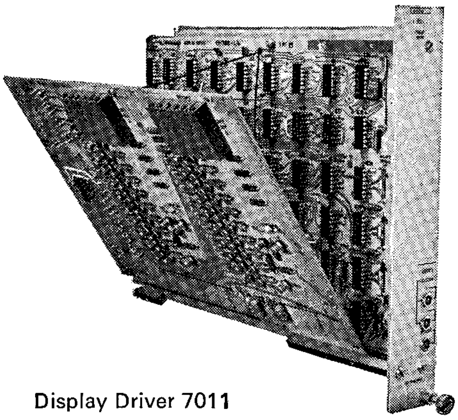

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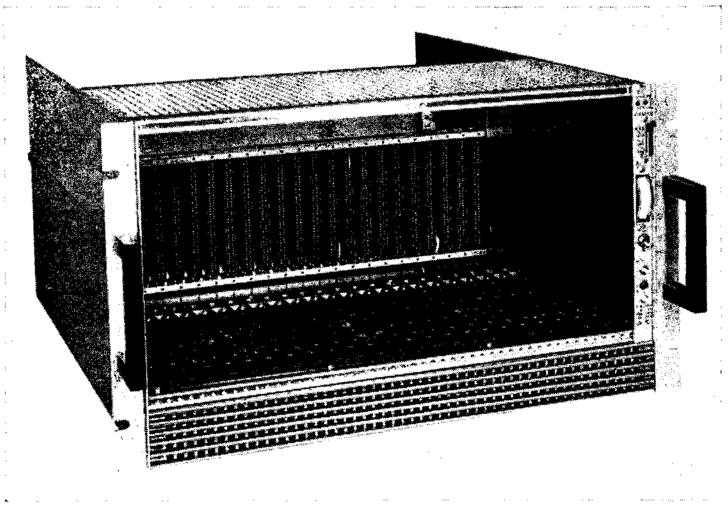

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Taux de régulation en fonction du réseau (+10 % à —12 %)	$\pm 5.10^{-4}$				
Régulation pour 100 % de variation de charge et des variations du réseau (+10 % à —12 %)	$\pm 10^{-3}$				
Stabilité globale (réseau-charge-température)	$\pm 5.10^{-3}$	$\pm 10^{-2}$	$+2{,}5.10^{-2}$	$\pm 10^{-2}$	$\pm 10^{-2}$
Coefficient de température de +10 °C à +45 °C	5.10^{-5}/°C	2.10^{-4}/°C			3.10^{-4}/°C
Dérive en fonction du temps 8 h 24 h. 6 mois	10^{-3} $\pm 3.10^{-3}$ $\pm 5.10^{-3}$				
Fluctuations en sortie crête à crête	⩽ 2 mV	⩽ 2 mV	⩽ 5 mV	⩽ 5 mV	5 mV
Réponse transitoire (overshoot et undershoot ⩽ 10 %)	⩽ 20 µs				
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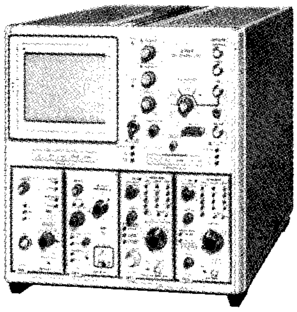

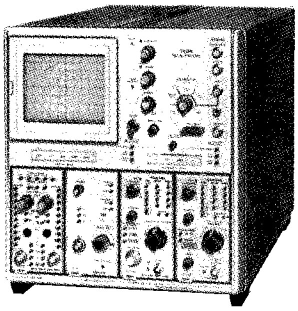

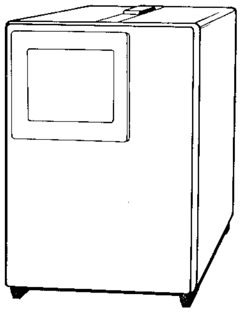

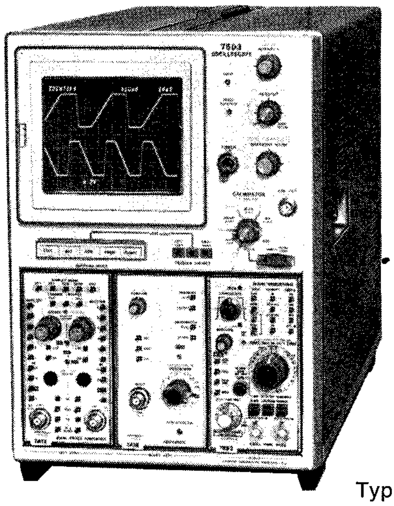

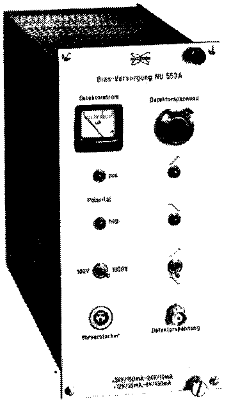

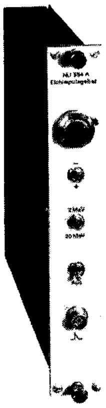

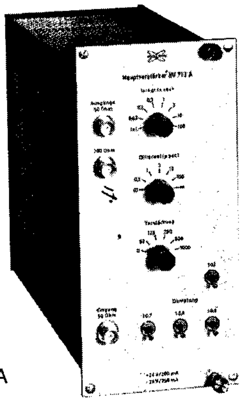

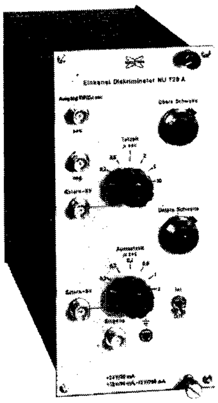

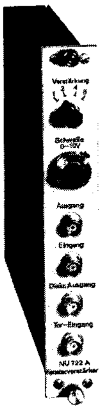

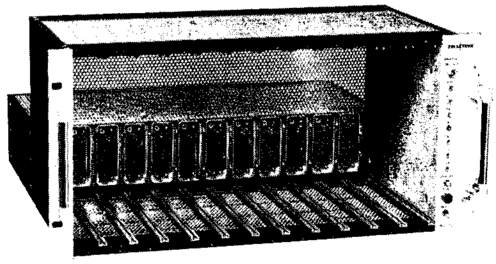

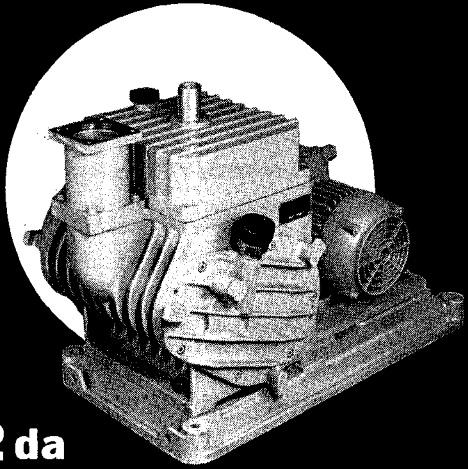

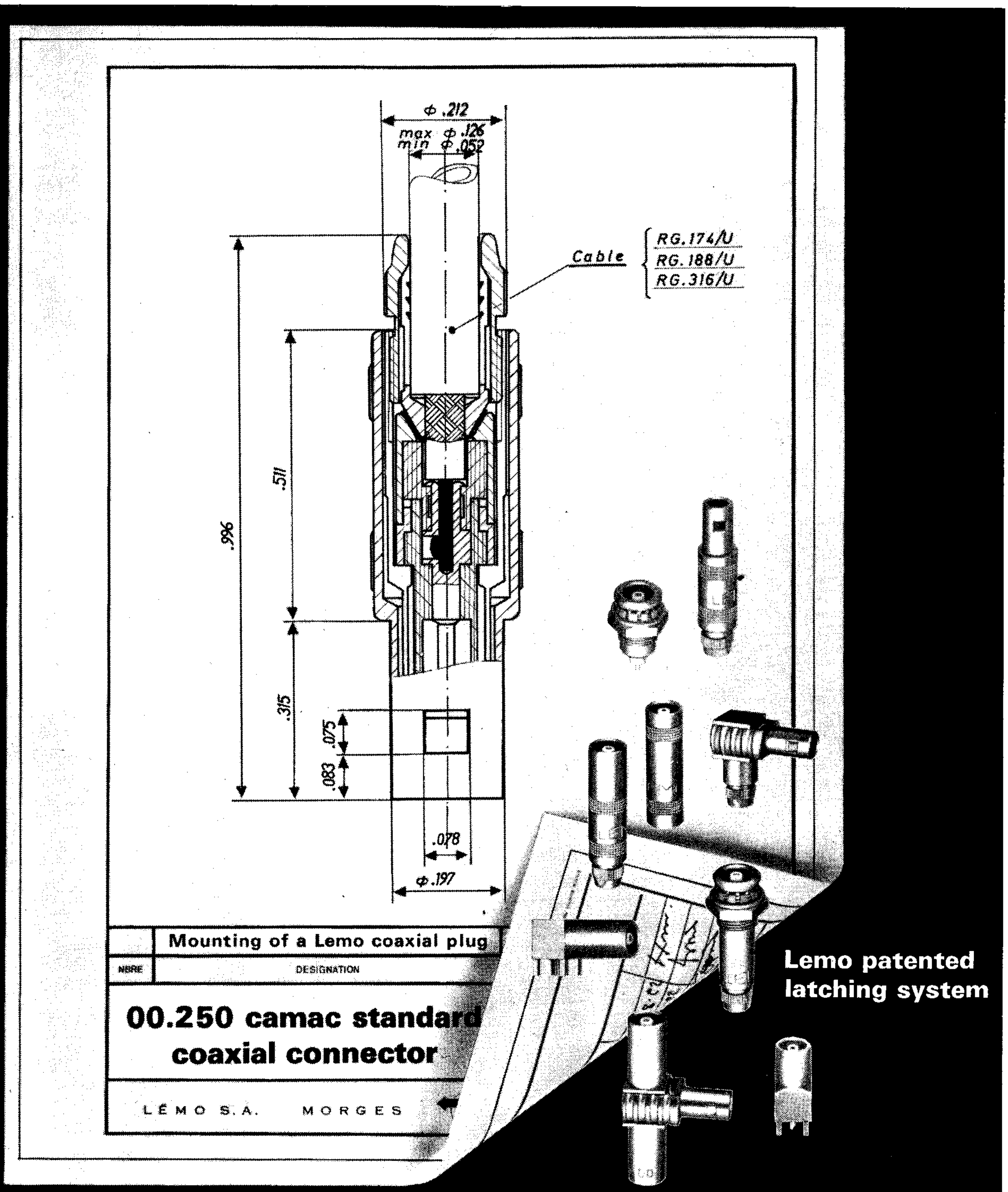

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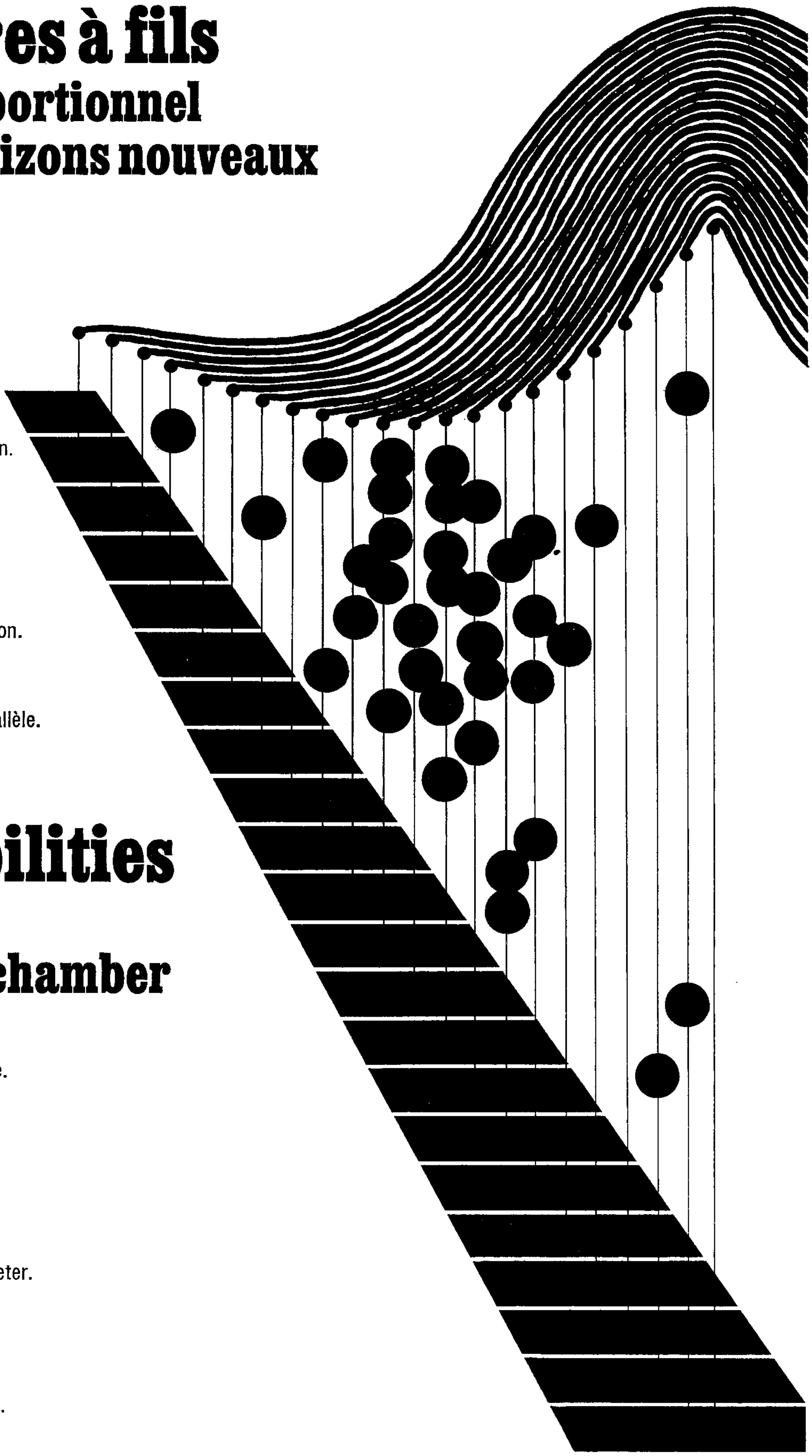

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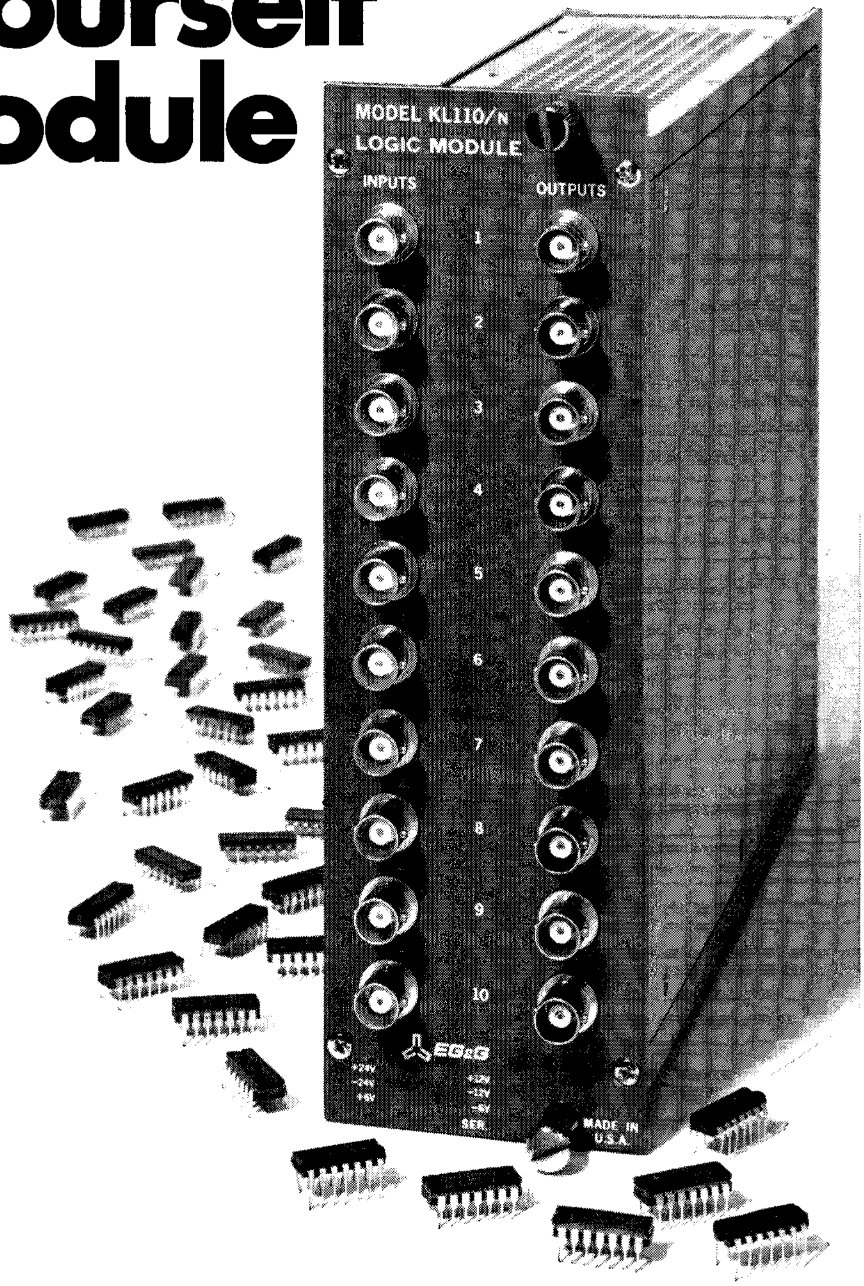

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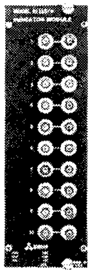

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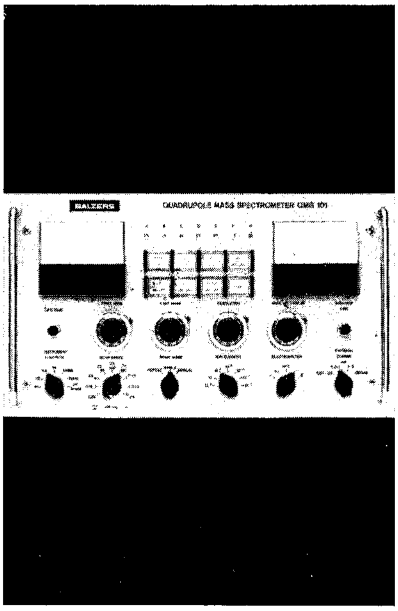

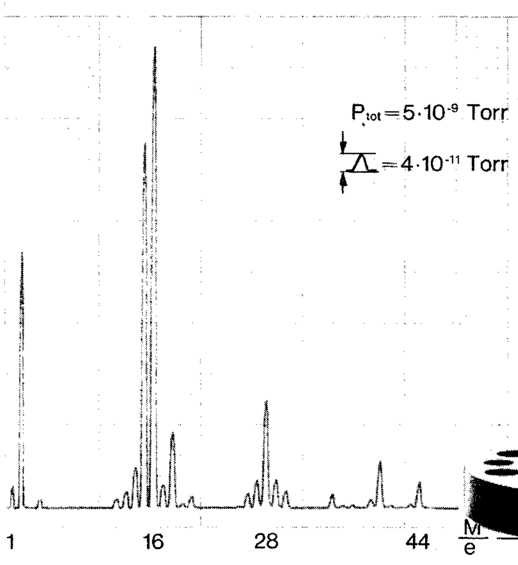

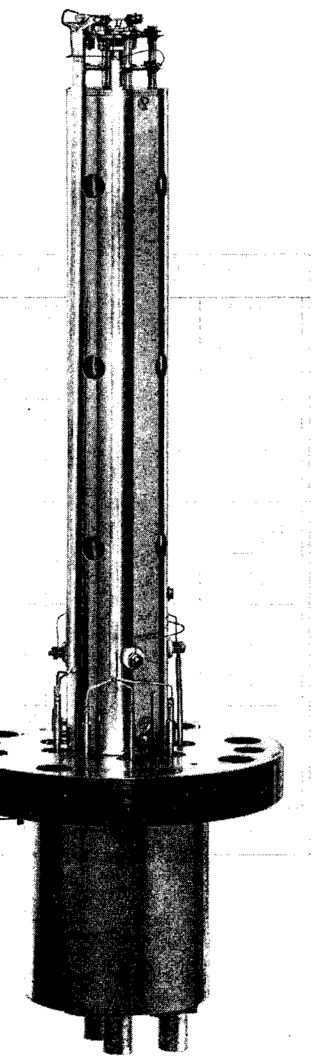

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- Good resolution $(\frac{M}{\Delta M}\ 10\,\% = 100)$
The resolution can be readily adjusted to suit particular problems and reproducible setting.
- The analyser can be baked-out up to 400° C. The high precision rod system provides perfect and reproducible mass separation, and can be very easily dismantled and re-assembled if necessary.
- Open, immersion ion source, which can be effectively out-gassed by ion bombardment. The hot cathode is protected against excessive pressure rise, and can be changed without additional adjustment.
- Very compact construction; the complete supply and control instrument is contained in only one 19″ rack unit.
- Indicating instruments and controls are clearly visible for simplicity of operation.
- The instrument is non-magnetic and therefore free from stray magnetic fields.

BALZERS will be pleased to supply full details.

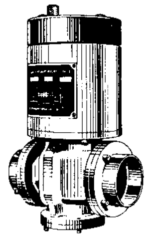
BALZERS®

HIGH VACUUM TECHNIQUE

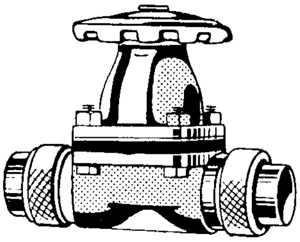
BALZERS AKTIENGESELLSCHAFT
für Hochvakuumtechnik und Dünne Schichten
FL-9496 Balzers · Fürstentum Liechtenstein

EDWARDS – FOR ALL THOSE VITAL BITS AND PIECES FOR VACUUM PLANT

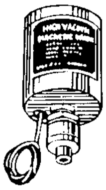
VALVES



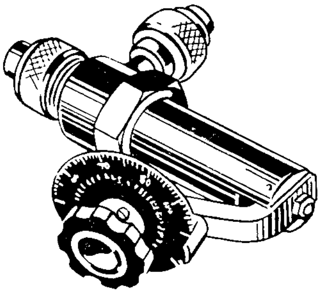
SOLENOID



MANUAL



SOLENOID AIR ADMITTANCE

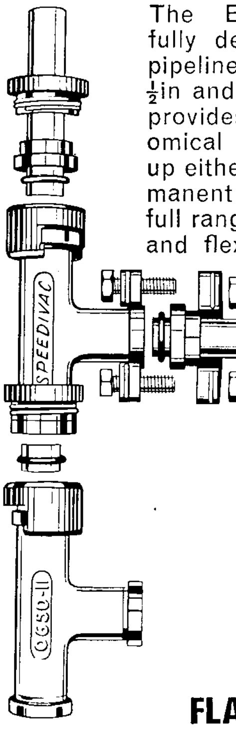


NEEDLE

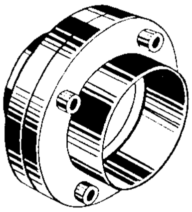
Edwards manufacture and supply every type of valve required for in-line or panel mounting and for manual or automatic operation — from the famous 'Speedivalve' to vacuum needle valves for extra fine control.

VACUUM CONNEXIONS

The Edwards solderless fully demountable vacuum pipeline coupling system in ½in and 1in nominal ranges provides a quick and economical method of building up either temporary or permanent vacuum systems. A full range of vacuum unions and flexible connexions is also available.

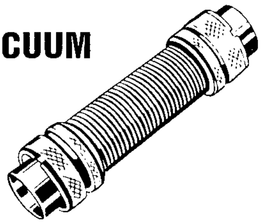


PIPELINE COUPLING SYSTEM



FLANGED VACUUM UNION

FLEXIBLE VACUUM CONNEXION

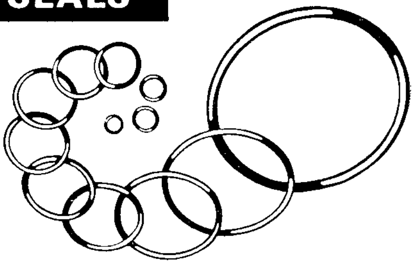


VACUUM SEALS

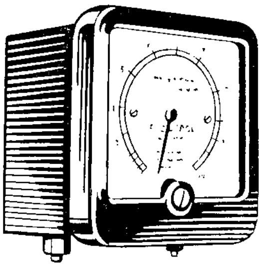
'O' RINGS

EXTRUDED CORD

SHEET

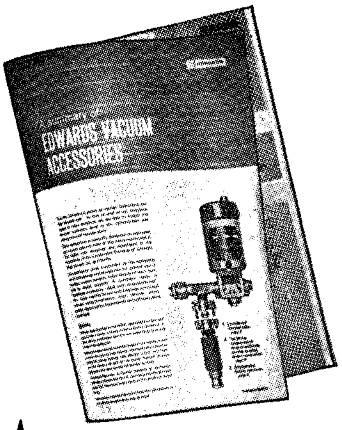


FLOW SWITCHES SUCTION and PRESSURE CONTROLLERS



'FLOWTROL' FLOW SWITCH

Available either with or without flow rate indicating dial, the 'Flowtrol' is operated by pressure differential across an adjustable orifice. A typical use is the protection of water-cooled and liquid flow equipment against damage resulting from inadequate or excessive flow.



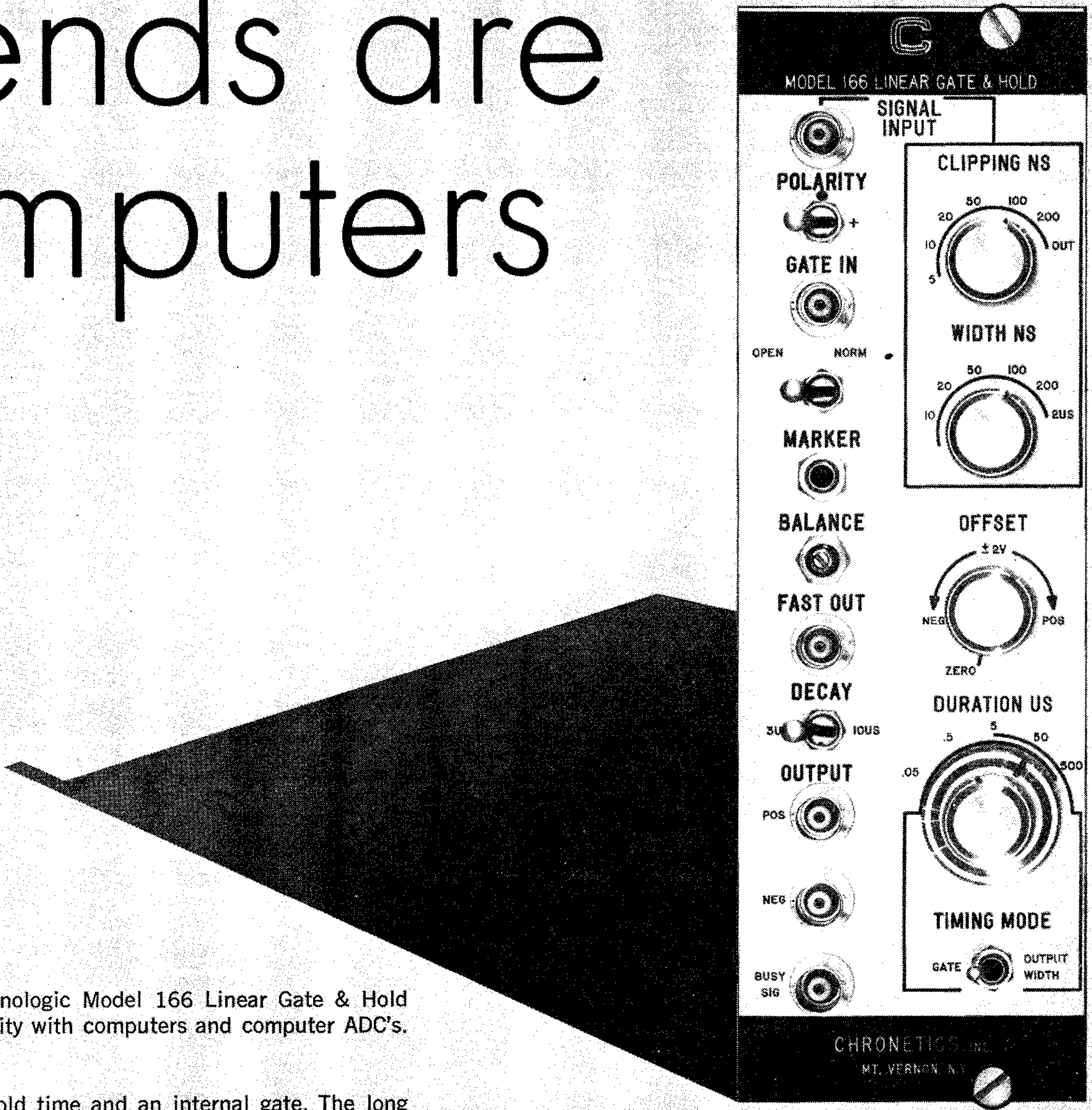
★

For fuller descriptions send for Publication 08643— "A Summary of Edwards Vacuum Accessories"

Edwards

Edwards Vacuum Components Limited A member of the BOC group
Manor Royal, Crawley, Sussex, England
Telephone Crawley 28844 Telex 87123 Edhivac Crawley

some of our best friends are computers



We designed our Nanologic Model 166 Linear Gate & Hold for direct compatibility with computers and computer ADC's. Now, **that's** friendly.

We gave it a long hold time and an internal gate. The long "hold" permits direct compatibility with analog to digital converters and also allows enough time to multiplex several linear channels with a single ADC. The internal gate permits application of an external trigger to the gate circuit - with front panel control of gate time.

Input signals from 2 ns to DC. Internal gate 5 ns to 500 us. "Hold" output is flat within 0.5% at .5 ms (Model 166-1 "holds" flat to 50 ms). "Busy" signal for pulse pile up prevention. Pedestal adjustable through zero. And four outputs: Fast Out (2 ns risetime), Hold Outputs (Positive and Negative, risetime approximately 300 ns, amplitude linear with input signal amplitude, selectable width, falltime and mode), Busy Out.

The internal gate generator can be used to control either the width of the "flat topped" output or the gate "open" time. Stability is better than 0.1%/°C; gate transients less than 15 mv, 2 ns wide.

Overall quality? Nanologic.

Model 166. Its best friends are computers, ADC's and PHA's. Make one happy this week—buy it a Model 166.

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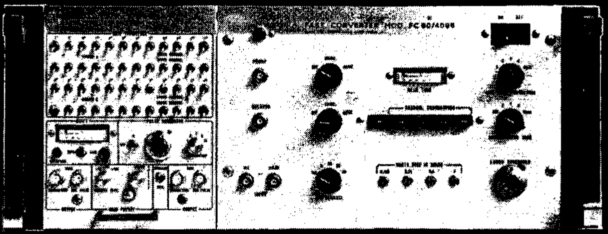
the ADC that opened a new era in data conversion techniques LABEN FC 60/4096



Patents: Laben 745348
Cise 699271

utilizes the sliding scale method to achieve a unique combination of high speed conversion and excellent differential linearity for any type of input signal

- 12 μsec fixed conversion time
- 0.1 % differential linearity
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- 3 input modes: AC or DC coupled, DC restorer
- used everywhere with any computer or pulse height analyzer
- equipped with all solid state Spectrum Stabilizer Mod. SS 60

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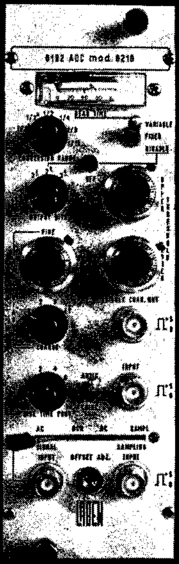

Mod.	Mod.	Mod.
8210	8211	8212
8192	4096	1024

channels

LABEN SERIES 8000
WILKINSON TYPE ADC's
now available
in a **DOUBLE-WIDTH NIM MODULE**
with good differential linearity at a
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- 0.7 % differential linearity
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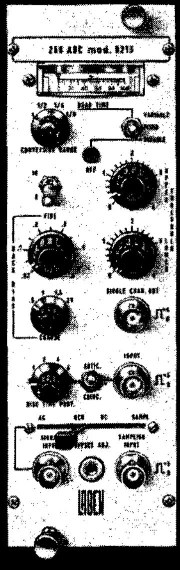

If you need several
and cost is a problem
Mod. 8213
256-channel ADC
is ideal for your multiparameter experiments

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