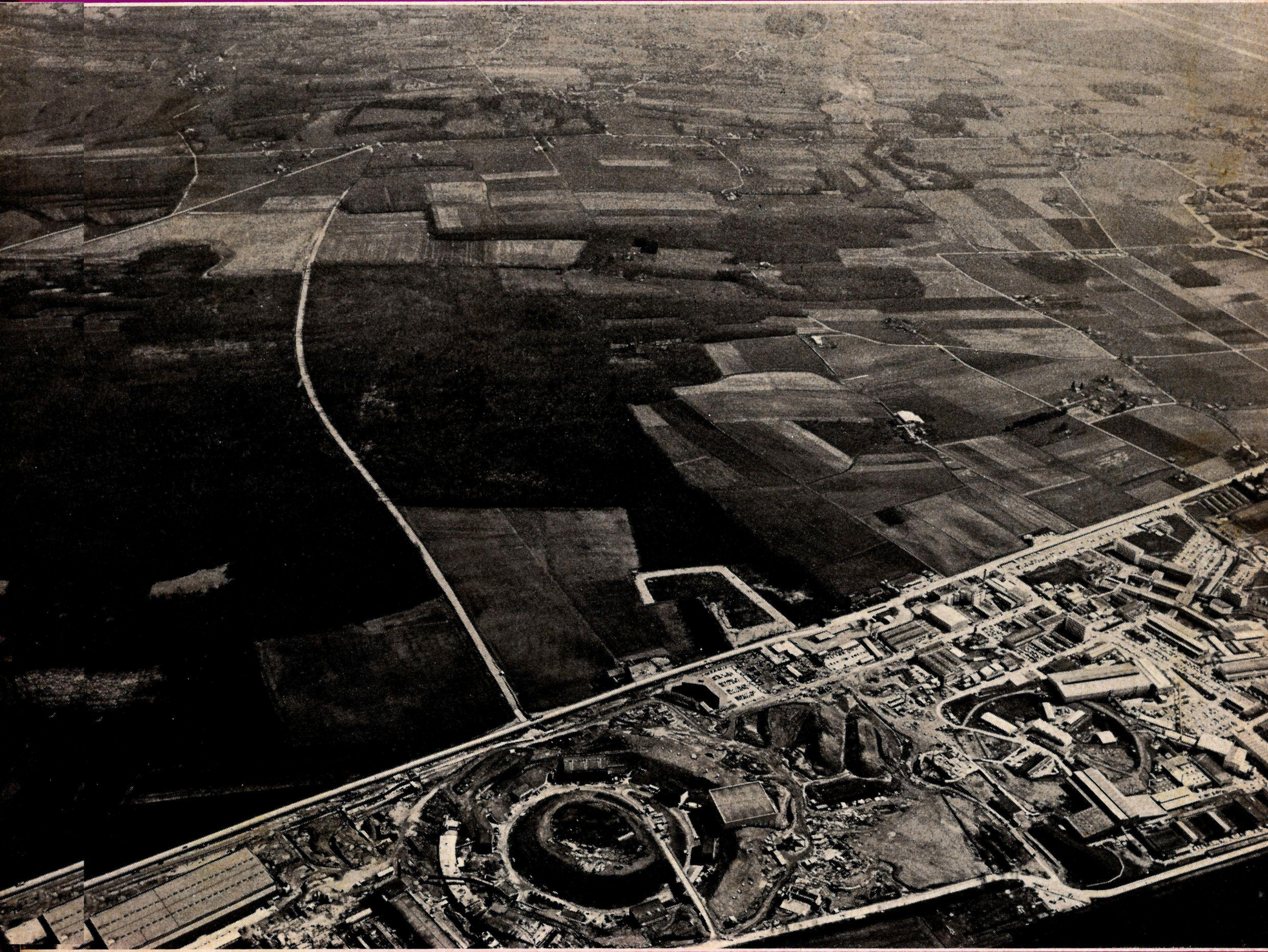
CERN COURIER

No 6. Vol. 10 June 1970

European Organization for Nuclear Research



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

The experimental programme is based on the use of two proton accelerators — a 600 MeV synchro-cyclotron (SC) and a 28 GeV synchrotron (PS). At the latter machine, large intersecting storage rings (ISR), for experiments with colliding proton beams, are under construction. Scientists from many European Universities, as well as from CERN itself, take part in the experiments and it is estimated that some 1200 physicists draw their research material from CERN.

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

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

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

Editor: Brian Southworth
Assistant Editor: Philippe d'Agraives
Advertisements: Micheline Falciola
Photographs: PIO-CERN photographic section

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

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

Contents

43rd Session of CERN Council 175

Discussions and decisions at the June Council Meeting — particularly concerning the alternative proposals for the realization of the 300 GeV project, collaboration with the European Southern Observatory, appointment of a new Director General.

DESY Magnet Conference 180

A report on topics from the Conference on Magnet Technology held at the DESY Laboratory — design of the main ring magnets for the 500 GeV accelerator being built at Batavia; progress in the effort to achieve pulsed superconducting magnets for use in a synchrotron.

CERN News

PS intensity 185

New peak intensity figures have been recorded at the 28 GeV proton synchrotron.

Preparing for a third 'g-2' 185

Studies on experimental apparatus to measure the 'g-2' of the muon with still greater precision.

HPD Minimum Guidance 186

Further simplification of the process of preparing film for measurement by the HPD automatic measuring machines.

PERT at CERN 187

Application of the PERT method of planning to the major projects at CERN.

Around the Laboratories

FRASCATI: Operation of ADONE 189

Performance of the electron-positron storage ring which is now in use for experiments.

ARGONNE: Hybrid operation of bubble chamber 190

Hydrogen bubble chamber operated in conjunction with electronic detectors triggering the chamber camera system.

DUBNA: Development of equipment 190

News of recent projects on the Dubna accelerators and on experimental equipment.

BERKELEY: Three-neutron resonance 192

Experiment at the Berkeley cyclotron detecting a three-neutron resonance.

Cover photograph: An aerial view of the existing CERN site (bottom of the picture) looking out across the Geneva-St. Genis road to the area which is under consideration as the site for the 300 GeV accelerator. The new proposals for construction of the accelerator alongside the existing Laboratory have taken care to cause as little interference as possible with the present environment. (CERN/PI 540.4.70)

43rd Session of CERN Council

300 GeV Project

The main topic of interest at the Council meeting was, of course, the 300 GeV project where the first reactions were heard from the twelve Member States of CERN to the alternative proposals to construct the accelerator alongside the existing Laboratory. The background to these proposals has been explained in the last two issues of CERN COURIER (page 107 and page 146). We restrict ourselves here to describing the proposals as they were presented to the Council. Following discussions in the European Committee for Future Accelerators (ECFA), the Scientific Policy Committee and within CERN itself, there have been a number of modifications to the initial presentation of two months ago.

The proposals are to build a 300 GeV proton synchrotron adjacent to the existing CERN Laboratory. Using a separated function magnet lattice for the main ring (which enables high energies to be reached with a smaller diameter ring than using a combined function lattice) and having one main ejected beam-line (rather than several emerging tangentially) the machine can be accommodated on a site on the opposite side of the Geneva-St. Genis road without intruding on built-up areas.

The 28 GeV proton synchrotron would be used as a ready made injector and, to get physics at higher energies going as quickly as possible, a beam-line would be built from the main ring to the West Experimental Hall which has been built alongside the Intersecting Storage Rings. (The West Hall will soon be equipped with advanced experimental equipment — the 3.7 m European hydrogen bubble chamber and the magnet—spark chamber assembly, 'Omega'.) Whilst the main ejected beam-line and new experimental area (North Experimental Area) were being constructed, higher energy physics would be under way in the West Hall.

To leave the way open for the use of pulsed superconducting magnets which could take ultimate peak energies much higher, the missing magnet design would be used and, at the start, conventional magnets would be ordered to fill up only half the ring (corresponding to an energy of 150 GeV). After three or four years, when the potential of superconducting magnets is better known, the decision could be taken whether to go straight to 300 GeV, by ordering the remaining conventional magnets to fill up the ring, or to leave room for the later introduction of superconducting magnets to give 400 GeV, or higher, peak energy.

A possibility for a subsequent stage then opens up ; the initially installed conventional magnets could be replaced by further superconducting magnets and the peak energy taken to 800 GeV or above. (This future possibility is not included in the project which Member States are now being asked to support.)

To use the 28 GeV synchrotron as injector imposes a definite ratio between the diameters of the two machines. Protons would be accelerated to 10 GeV in twenty bunches with the existing machine and these bunches would then be injected so as to distribute them evenly around the circumference of the 300 GeV ring. The discrete bunches would then be allowed to smear into a ribbon beam (debunching) before the radio-frequency accelerating system came on to re-form them into bunches for acceleration to the peak energy. For this process to be done with maximum efficiency, given the fixed diameter of the 28 GeV machine, the 300 GeV machine must have a diameter of 1.8 or 2.2 km. (Less efficient possibilities are 1.98 and 2.09 km). The initial proposal was for 1.8 km, but since costs do not depend dramatically on diameter, the 300 GeV accelerator could be distributed more liberally around a bigger circumference. This would then give the possibility of a still higher peak energy when packing this circumference with superconducting magnets at a later stage. The decision here depends on the site survey revealing the extent of the molasse rock, and on the solution of problems which might arise from intrusion on inhabited areas with a diameter larger than 1.8 km.

Construction of the accelerator is planned to cause as little disturbance as possible to the environment. The main ring would be tunnelled in the molasse rock some thirty or more metres below ground (mainly dependent on the findings of the

The Council met at CERN on 18, 19 June under the Presidency of Professor E. Amaldi. In the photograph, left to right, are : J. B. Adams (Director designate of the 300 GeV project), B. Gregory (Director General of CERN), E. Amaldi, G. H. Hampton (Director of Administration).

CERN/PI 200.6.70

site survey) and radiation levels on the surface would be well below tolerance. Farming of the land, etc. could quite feasibly continue exactly as at present. Six small buildings would be needed over the six machine straight sections but in an area of this size would be lost in the landscape.

Only where the ejected beam-line is tapped to bring beams to the surface and the North Experimental Area is constructed, together with offices and laboratories, would land need to be specifically reserved. This requires parts of a strip of land about ½ km wide and 4 km long.

The main ring and the beam-lines connecting with the 28 GeV accelerator and with the West Hall cross the Franco-Swiss border. This introduces special problems but such problems have been solved before in the existing Laboratory which also crosses the border. At present there is no site offer (in the sense of the previous site offers from Member States for construction of a new Laboratory) from France and Switzerland and the conditions on which the site could be made available have not been negotiated. The same is true for the essential services of electricity and cooling water and for the general conditions like housing and education affecting staff coming to join the project. It is hoped that these problems can be resolved before the end of this year.

The aim is to start the 300 GeV project at the beginning of 1971 and we now come to the vital figures on cost and timescale. The cost estimate for the total 300 GeV project spread over eight years is 1112 MSF. It divides as follows :

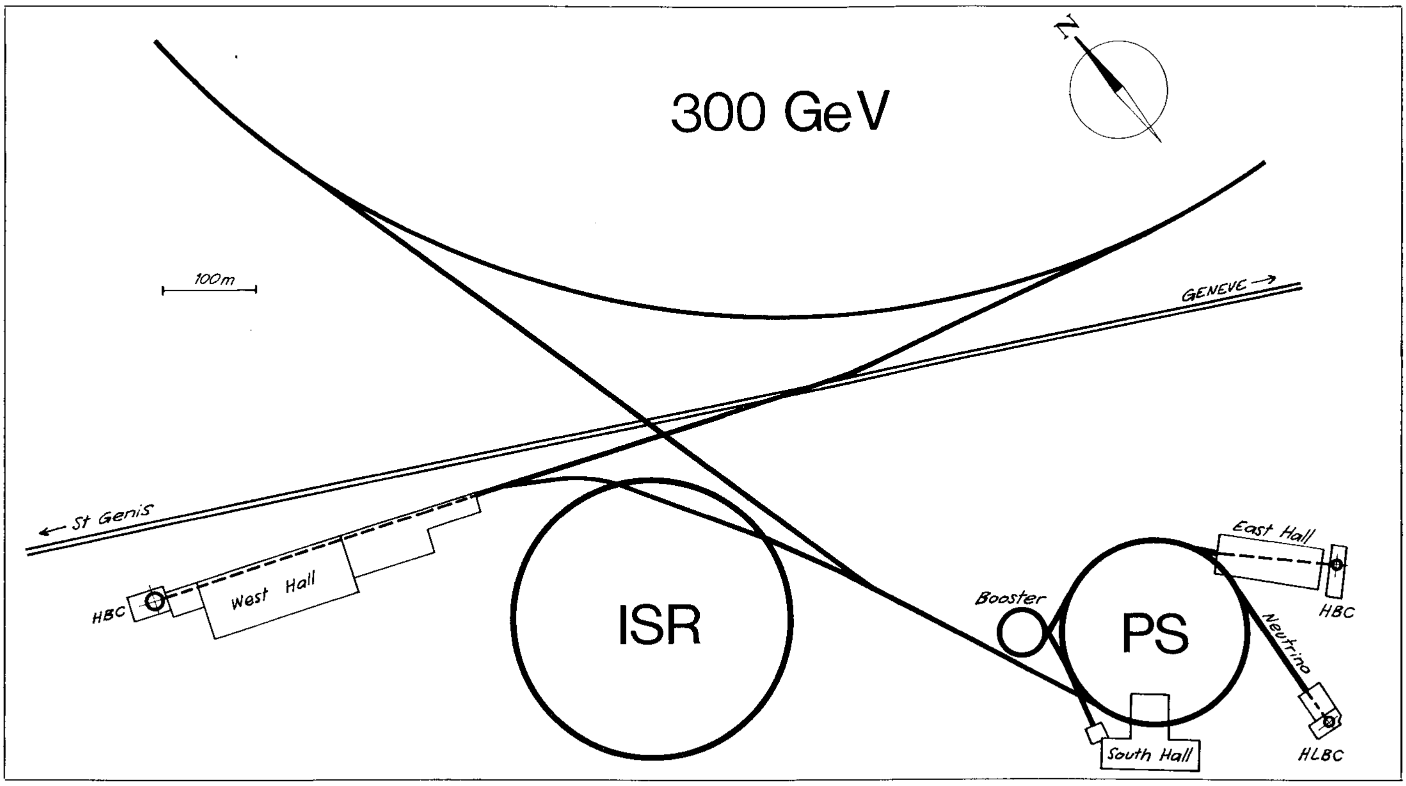
— the machine itself	584 MSF
— Laboratory and services	182 MSF
— preparation for research	216 MSF
— machine operation during the construction period	130 MSF
Total	1112 MSF

The costs are estimated on the basis of conventional magnets since no reasonably precise figures can be put forward for superconducting magnets at this stage. Note that the total for the whole project of 1112 MSF includes 130 MSF spent to operate the accelerator for physics in the West Hall while construction of the North Area is being completed. (It is proposed to cover the cost of the research during this period within the budgets foreseen for the existing Laboratory.)

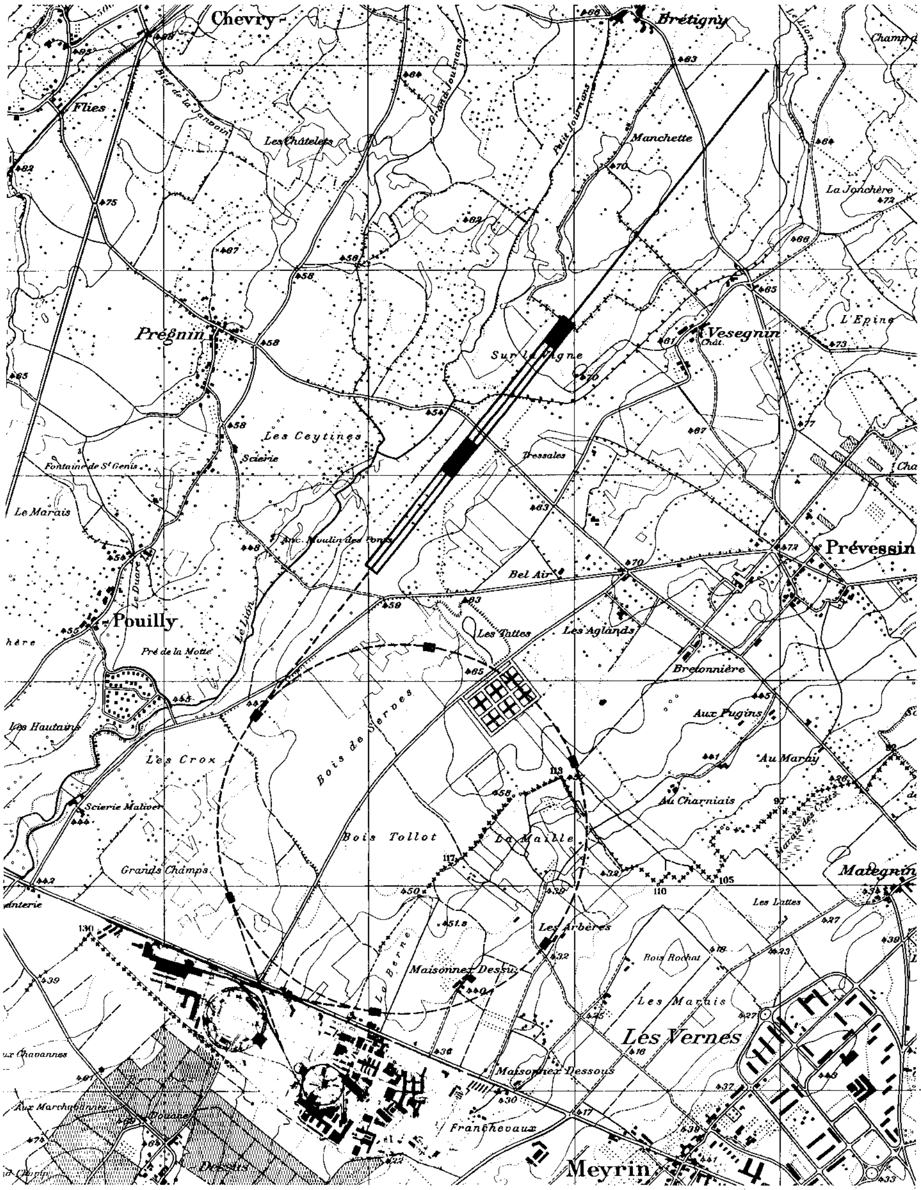
The timescales are then — eight years for the design and construction of the total project ; six years for the completion of a conventional ring to give 300 GeV. This means that, if the project starts at the beginning of 1971, physics at higher energies could begin from the end of 1976. (This is as early a start as was anticipated in the ECFA report of 1967.) If the decision is made to halt at the 150 GeV point, (to bring in superconducting magnets) physics could be started with 150 GeV beams at the end of 1975.

The staff estimates envisage a build up to a total of 980 staff associated with the 300 GeV project by the end of 1978. The staff would in that year be divided into Machine Group (400), Research Group (220) and Services Group (360).

The proposal to construct the new accelerator alongside the existing Labo-



A schematic diagram showing the proposed interlacing of the existing CERN installations with the 300 GeV accelerator. Beam-lines built underground would transport 10 GeV beams from the existing proton synchrotron to the 300 GeV (the PS serving as injector) and high energy beams from the 300 GeV to the West Experimental Hall (enabling higher energy physics to begin earlier using detectors which are already under construction).



A map of the region around the existing CERN Laboratory showing a possible position of the 300 GeV accelerator and its major ejected beam line feeding the North Experimental Area. The proposed accelerator, built deep underground, would intrude very little on the present use of the region.

ratory requires a reappraisal of the programme which was foreseen for the existing Laboratory under the assumption that the 300 GeV Laboratory would be built elsewhere. The use of the 28 GeV proton synchrotron as injector and the West Hall as initial experimental area further integrates the programmes and budgets which had previously been discussed separately. The existing Laboratory had been seen as carrying the full research burden for another eight years. If higher energy physics becomes possible from the end of 1975 or 1976 less will be required of the other facilities (there will, in any case, be an automatic transfer of interest to higher energy experiments).

With this new situation in mind, an attempt has been made to organize the budgets in such a way that the 'new money' required for the construction of the 300 GeV accelerator (that is the money over and above that which Member States would anticipate paying for the existing Laboratory) is at a level which enables the project to be realized quickly and which could attract all Member States to participate.

The CERN Scientific Policy Committee recommended that the 'new money' should be set at 900 MSF spread over eight years. Given the total 300 GeV project cost of 1112 MSF, this means that 212 MSF over the same period would have to be found from within the budgets foreseen for the existing Laboratory. Over the past year a 'plateau budget' for the existing Laboratory of 340 MSF has been accepted as reasonable by the Member States. This would be reduced to 310 MSF to find the money (212 MSF) during the construction years of the 300 GeV accelerator.

Budgets (in million Swiss francs) for the eight years would then look as follows:

	Existing Lab.	300 GeV Project	Existing + 300 GeV	'New Money'
1971	330	40	370	30
1972	320	110	430	90
1973	310	160	470	130
1974	310	160	470	130
1975	310	160	470	130
1976	310	160	470	130
1977	310	160	470	130
1978	310	160	470	130
Total	2510	1110	3620	900

The precise detail of how 30 MSF per year could be saved within the programme foreseen for the existing Laboratory has not been finalized but it seems possible to make these savings without eating significantly into the growth of physics research which has been planned with the improved proton synchrotron and the intersecting storage rings. Savings would come about via the transfer of staff (mainly accelerator and services people) though most of the 300 GeV staff would be newly recruited. Other savings could be made by delaying the start of high intensity programmes at the 28 GeV synchrotron and by reducing the exploitation of the West Hall.

To appreciate the attraction of the figures above, we can recall the equivalent figures used in the discussions three years ago. Then the cost of the project with its separate Laboratory was 1902 MSF (now 900 MSF 'new money') with a staff rising to a total of 2970 by the end of construction (now 980) and requiring a design and construction timescale of ten years before beginning physics at 300 GeV (now six years).

If the new proposals are accepted, Europe will have at the Laboratory near Geneva a most remarkable complex of facilities for high energy physics research — nuclear physics to energies of 600 MeV with the synchro-cyclotron, physics in the tens of GeV range with the improved 28 GeV proton synchrotron, colliding beam physics with the intersecting storage rings, physics in the hundreds of GeV range with the new project. Such a complex would give the flexibility within one Laboratory to swing over a vast range of research following the swings of interest in the physics itself. It would guarantee that Europe would retain its present front-line position in high energy physics research for decades to come.

The first reactions from the Member States can be summarized as follows... All regard the alternative proposals with positive interest. Those countries which had not declared their intention to participate in the 300 GeV project, as previously drawn up, indicated that the new proposals reopen the possibility of their participation. This opportunity to reunite all twelve Member States in the project is recognized by all countries as one of the great advantages of the new proposals.

The UK delegation stated that the refusal to join the project under the previous conditions no longer stands for the alternative proposals. The Science Research Council, which is responsible for UK expenditure in high energy physics, is unanimously behind the proposals and will advise the government accordingly. Participation would mean diverting a proportion of foreseen budgets from the national effort in high energy physics to the 300 GeV and, to reduce the impact on the national Laboratories, the UK would prefer to see the 'new money' set lower or the construction time extended by a year. Also, the UK considers that thought should be given to having the whole complex of the existing CERN Laboratory plus the 300 GeV under one Director General at least after the construction period. (This position with regards to cost and Laboratory management was also put forward by Sweden.) The UK declaration finished by asserting that we now have a splendid case.

The delegation of the Federal Republic of Germany, while expressing doubts about the desirability of concentrating research in one place in Europe, supported the proposals and insisted that a fast start and fast construction are important. It is necessary therefore to resolve quickly the questions concerning the site and related conditions and to assure that these are as favourable as those offered by Member States proposing sites for a completely new Laboratory. They preferred the 900 MSF figure for the 'new money' to avoid restricting exploitation of the existing research facilities too much. Undue emphasis on economy etc... should not be allowed to prejudice having, overall, a first class programme.

The French delegation recorded the interest of the government and the support of the scientists. There is some disappointment that the ultimate peak energy on a more restricted site would be less than that possible on other sites but this is seen as more than compensated by the advantage of starting research at higher energies much faster with the alternative proposals. They are concerned also that the facilities built up in the existing Laboratory should be as fully exploited as possible and prefer the 900 MSF 'new money' figure. The conditions with regard to the site remain to be worked out and the government is unable to give any assurances at this stage that the conditions would be the same as those discussed for sites elsewhere.

The Italian delegation said that the alternative proposals were being examined with positive interest but that Italy still prefers the previous proposals. In particular with regard to the site there had been long scientific, technical and financial preparations to arrive at optimum conditions. Similar thorough examination is needed for the new site to ensure that the same guarantees are arrived at. Any differences should be clearly brought out so that the final judgement can be made on the basis of a clear comparison. What is important is to implement a project which is the best possible for the future of European science as a whole.

Some points from the statements of other delegations not mentioned above — Austria: favourable to proposals and urges a fast decision since other research projects are affected by the delays on the 300 GeV. There should be publicity for the new proposals to establish a favourable climate of opinion as quickly as possible. Belgium : favourable to proposals and ready to see the site at Meyrin to further the interests of European science and international collaboration. Netherlands : favourable to proposals but need to find an acceptable compromise regarding exploitation of existing Laboratory. Switzerland : favourable to new proposals. The government and the Canton of Geneva are ready to help solve, together with France and CERN, the site problems as quickly as possible. Norway, Denmark and Greece all recorded a positive attitude.

After the discussion there was unanimous agreement that more detailed studies should proceed immediately and to this end all delegations supported a budget of 1 MSF for the remainder of this year. The appointment of J.B. Adams to lead these studies was confirmed.

The technical studies will concern continuation of design work on the machine and such things as the layout of the West Hall for higher energy physics, so as to be in a better position to start the project at the end of the year. There will be a series of borings carried out on the proposed site in order to determine the location and quality of the molasse rock.

In readiness for the Council Meeting scheduled for 8, 9 October, several important documents will be prepared — (1) a revised 'programme definition' setting out the framework in which the 300 GeV project will operate and the commitments of participating States ; (2) a site document laying down the conditions under which the site is made available for the project ; (3) a document detailing the impact on the research programme at the existing Laboratory.

The need for an early start is recognized and it is hoped that, following receipt of these documents in October, governments will be able to arrive at a decision on the project by December.

Collaboration with ESO

The possibility of collaboration between the European Southern Observatory organization and CERN was first brought to the attention of the Council last December. At the June meeting the text of a formal Agreement was presented and Council was unanimously in favour of collaboration. The Director General was authorized to finalize the text together with the Director General of ESO, Professor A. Blaauw. The final text will be sent to delegations for comments before being signed.

ESO are constructing a large (3.6 m) optical telescope to be installed at La Silla in Chile. Under the terms of the Agreement a Division of ESO will come to CERN where the final design, construction and testing of the telescope will be carried out. The Division will comprise about 50 astronomers, engineers and technicians.

The project involves an expenditure of about 50 MSF and is supported by six European countries — Belgium, Denmark, Federal Republic of Germany, France, Netherlands and Sweden. The Division will be able to draw on the experience at CERN in the engineering and administrative aspects of implementing a large project. The costs, including those in the services used by the Division, will be borne by ESO itself.

. This collaboration, which is under the terms of Article 8 of the CERN Convention, is welcomed by the Council and by the Council of ESO.

Appointments

The Council unanimously appointed Professor W.K. Jentschke to succeed the present Director General of CERN, Professor B. Gregory. Professor Jentschke will take office for four years beginning January 1971. His biography appears at the end of this report.

Other appointments were — J. Steinberger to succeed G. Cocconi as Director of the Physics I Department; W. Thirring reappointed às Director of the Theoretical Physics Department; B. Zumino to succeed J. Prentki as Leader of the Theoretical Studies Division; P. Standley reappointed as Leader of the Proton Synchrotron Division; G. Brianti reappointed as Leader of the Synchrotron Injector Division; G. R. Macleod reappointed as Leader of the Data Handling Division; C. Tieche reappointed as Leader of the Finance Division; G. Ullmann reappointed as Leader of the Personnel Division. M. Cresti has been appointed to succeed J. H. Mulvey in October of this year as Chairman of the Track Chamber Committee.

The President of the Council thanked Professors Cocconi, Prentki and Mulvey for the competence and enthusiasm they have brought to their work for CERN during their periods of office.

CERN/PI 68.6.70

Professor Willibald Karl Jentschke, nominated Director General of CERN from January 1971, was born in Vienna, Austria, on 6 December 1911. He obtained a Ph. D. in physics in 1935 and stayed at the University of Vienna until 1946 doing research on nuclear reactions, a precision measurement of the neutron mass, and studies on the fission of heavy elements.

From 1946 he spent a ten year period to the University of Illinois, USA, becoming Professor in 1956. During this time, after some initial work on infra-red spectroscopy, he turned again to nuclear physics working at a low-energy cyclotron. In addition to many measurements of nuclear reactions (checking the validity of different nuclear models), he studied angular correlations between successively emitted gamma rays to determine the magnetic and electric moments of excited nuclei. In 1955, he was involved in a reconstruction of the cyclotron to transform it into a 'spiral-ridge', variable energy accelerator.

Professor Jentschke returned to Europe in 1956 as Professor at the University of Hamburg, Federal Republic of Germany, and undertook the construction of a new Laboratory to house a 7.5 GeV electron synchrotron (DESY: Deutsches Elektronen-Synchrotron). The official foundation of the Laboratory took place in 1959 with Professor Jentschke as Leader of a five-man Directorate.

An intensive research programme with electron and photon beams has been under way at DESY since the synchrotron came into operation in 1964. In 1968 the addition of 3 GeV electron-positron storage rings was authorized and they are now under construction. During his period as Director, DESY has grown from a small University Laboratory to a centre of international repute playing a major role in European particle physics.

Professor Jentschke has been closely involved with CERN for many years. From 1964 to 1967 he was delegate of the Federal Republic of Germany to the CERN Council and a member of the Scientific Policy Committee. In 1968 he spent a year at CERN as Guest Professor and took part in the work of the Directorate. In 1969 he was appointed Chairman of the Intersecting Storage Rings Committee which has been working on the first proposals for experiments with the ISR.

Professor Jentschke will take up his post at a time when the burden of being Director General of the European Organization for Nuclear Research is likely to be as heavy as it has ever been, with, possibly, some completely new problems of policy and of organization to be confronted. We wish him very successful and enjoyable years as Director General of CERN.

DESY Magnet Conference

The Third International Conference on Magnet Technology was held at the DESY Laboratory in Hamburg from 19-22 May. This article selects a few of the many topics discussed.

The Magnet Conference, like its predecessors at Stanford and Oxford, brought together specialists in magnet theory and design from many different fields, from large Laboratories and from industry. Accelerator Laboratories predominated and it remains true that our Laboratories are the main test bench for much modern magnet technology — mounting research and development projects on a significant scale. The feed-back into industry, in terms of refinement of technology and of acquiring expertise in completely new technology, opens up applications in many other fields. After all, only a small proportion of the world's magnets sit in and around synchrotron rings.

This feed-back could prove to have quite exceptional importance concerning superconductivity. If the phenomenon can be tamed (and the struggle to apply superconductivity in accelerator Laboratories is contributing greatly to this), its potential impact on such things as power generation, power transmission, etc... is enormous. The Conference participants were not generally looking so far ahead; they were engrossed in the immediate problems.

But first we will cover the opening invited talk at the Conference which leads into the magnet design for the main ring of the 200-500 GeV accelerator under construction at the National Accelerator Laboratory, Batavia. The title of the talk was 'Development of Accelerator Magnets' and the speaker M. S. Livingston. There is probably no-one in the world more competent to cover such a subject for he has played a leading part in most of the major developments for over thirty years. Stan Livingston will be retiring soon (though it is difficult to believe he will ever be far from accelerators) and it is a particular pleasure to pay tribute to the brilliant contributions he has made to our field while reporting some of his talk.

He divided the development of accelerator magnets into four major stages — (1) Solid-core fixed-field magnets as used in cyclotrons (Livingston worked with E.O. Lawrence in the 1930's on the first cyclotrons at Berkeley); (2) Pulsed ring magnets (Livingston was a leading figure in the design and construction of the first large proton synchrotron, the Cosmotron, in the early 1950's at Brookhaven); (3) Alternating gradient magnets (Livingston, while thinking in 1953 about the proposed European accelerator eventually to become the CERN PS, had the first idea on alternating gradient machines which led to a dramatic reduction in synchrotron magnet size and cost); (4) Magnets for large diameter accelerators (Livingston is Associate Director at the National Accelerator Laboratory, Batavia, where the first machine of this type is under construction). The following is a precis of his comments on the NAL magnet design.

The highest energy synchrotrons currently in operation (at Serpukhov, Brookhaven and CERN) are all 'vintage 1955' in their magnet design concepts. C-shaped magnets for accelerators have become steadily more efficient in the intervening years but there has been no change in basic approach. There have, of course, been new ideas in this time. None of these actually originated at Batavia but Batavia has the good fortune to be the first Laboratory to put them into practice on a big machine. The three most important are:

1) The use of a separated-function magnet lattice where magnets responsible for bending the beam round the ring are separated from those responsible for focusing the beam. The advantages are that the bending fields can be pushed higher than with the more complicated pole profiles of combined-function magnets before magnet saturation sets in. The magnets are easier to design and the engineering simplicity can bring the costs tumbling down. The bending magnet field is used more efficiently and almost the entire magnet aperture gives 'good field' for the beam. The focusing quadrupoles can be deployed around the ring to give the best effect and they can be powered separately. This separates the 'tune' of the machine from the bending magnet field which dictates peak energy and the tune can be made lower for higher energies if necessary.

2) The use of a 'booster' synchrotron to feed the main magnet ring. Higher injection energy, besides overcoming space charge blow-up of intense beams avoids the problem of injection into less controllable low magnetic fields. Also injection of a beam in the GeV energy range means injection of a beam of small cross-section. This brings down the size of the required magnet aperture, in turn bringing down the required magnet cross-section, in turn bringing down the ring tunnel cross-section — all potential sources of cost saving. (Incidentally, the Batavia tunnel cross-section of 10 ft diameter has proved to have ample room but to have built too big a tunnel might prove to be a useful 'mistake' since it might just be possible eventually to squeeze a ring of superconducting magnets on top of the magnet ring now being built.) It is a remarkable fact that the Batavia machine, with potential for a peak energy of 500 GeV, has main ring magnets of a cross-section smaller than any proton synchrotron ever built for any energy.

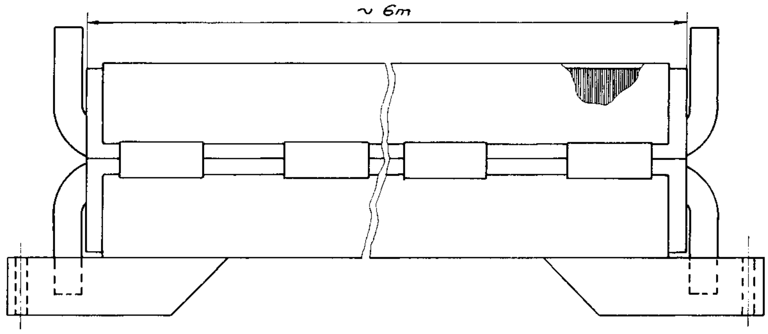
3) Use of long straight sections. Magnet systems have been developed to 'match' the beam across long straight sections, so that it does not go adrift in such regions between bending magnets. It simplifies the problem of ejecting the accelerated beam from the ring since more room is available for a series of ejection magnets. Coupled with the use of an electrostatic septum ejection magnet, this could make feasible very high ejection efficiencies (Batavia have designed for 99.9 %) reducing and localizing (in the ejection region) the radioactivity problem in the magnet ring. If the magnets are designed to be easily replaced, radiation damage could cease to be a headache even with very high intensity beams.

In absorbing these developments into the design the Batavia team, under the influence and driving leadership of Professor R.R. Wilson, have searched for every possible means to cut costs and reduce construction time-scales. Above all this has meant searching for simplicity in the design. The result is a completely new accelerator design with a simplicity and economy which is unique. Costs are within the predicted budget, despite inflation, and construction progress is ahead of schedule.

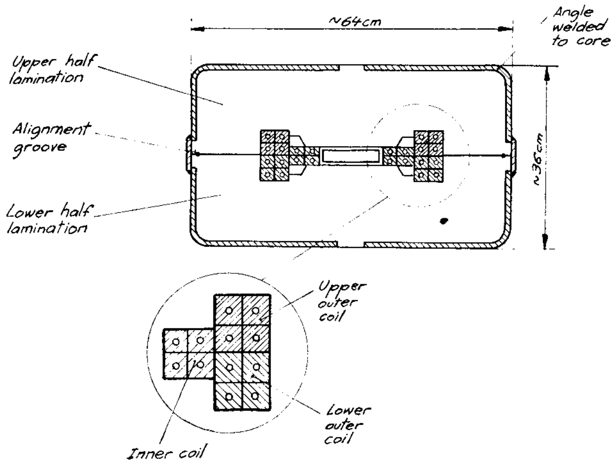
We now turn to some detail on the main ring magnets to illustrate the simplicity

Features of the Batavia main ring bending magnet design (type B1).

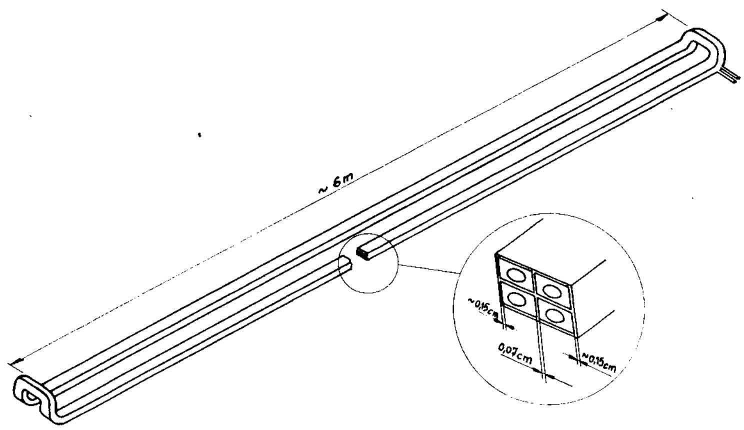
1. *Side view.*
2. *Cross-section showing the division of the magnet coil into three separate units.*
3. *A four-turn outer coil.*
4. *An end view of the magnet where the coils emerge.*



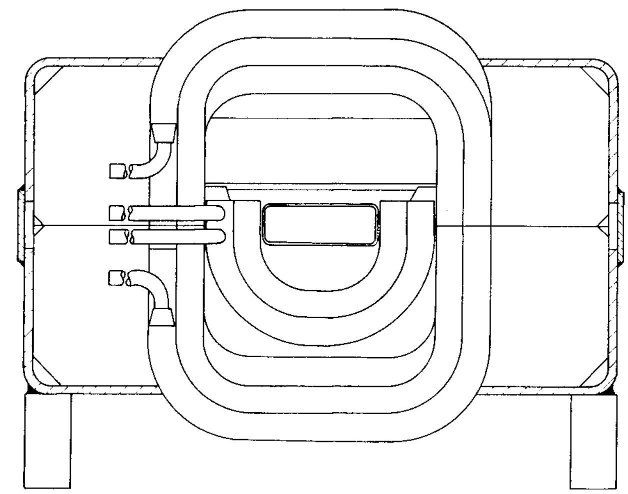
1



2



3

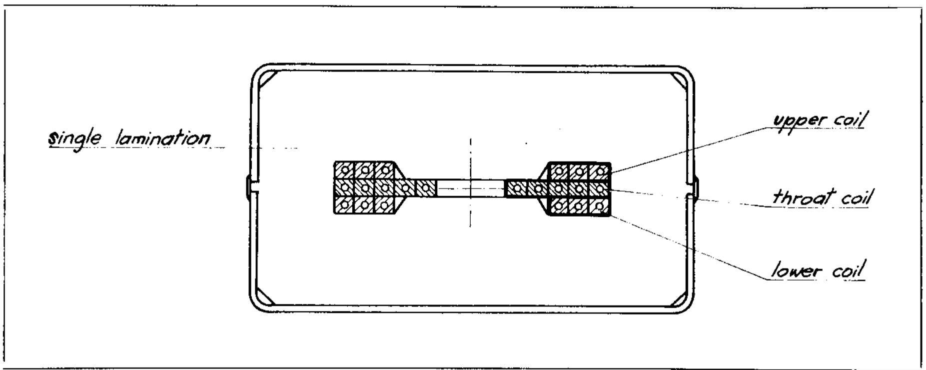


4

which has been achieved and ultimately its impact on the magnet costs. We should begin by recognizing that one of the major debates 'in the corridors' at the Conference concerned just how far to apply the 'Wilson philosophy' when constructing a major high energy physics facility — what percentage risk to accept for what percentage economy, what percentage reliability in operation must be assured and so on. Here we restrict ourselves to some information from Batavia which was the one component relevant to this debate which was presented at the Conference in a paper entitled 'NAL Main Ring Magnets' by H. Hinterberger and R. Sheldon.

The main ring will contain 774 bending magnets, each about 6 m long weighing just over 10 tons, and 180 quadrupoles, each about 2.1 m long weighing about 5 tons. In a strong focusing synchrotron the beam varies in cross-sectional dimensions as it travels around the ring. Shaping the bending magnets to the beam profile can give significant economies and the magnets are therefore of two types — B1 which has an aperture large horizontally and small vertically (12.5×3.75 cm^2) and B2 which has an aperture narrower horizontally and larger vertically (10×5 cm^2). Features of the B1 type are shown in the diagrams.

A major innovation is to locate part of the coil in the magnet gap. This brings down the magnet cross-section (to 64×36 cm^2) but requires careful alignment of the conductors close to the aperture (to about 0.01 cm). The final design has split the magnet coil into three — an upper outer coil (of four turns for B1 and six for B2), a lower outer coil (of four turns for B1 and six for B2) and an inner coil of four turns. The outer coils can be made to conventional tolerances and contracts for them have been placed with industry. They are unusual in their length but fabrication techniques are standard. They have 'saddle' ends and are potted in vacuum impregnated glass fibre reinforced epoxy resin system. The inner coils are made to tight tolerances in a factory set up by NAL in Chicago using hard drawn copper bars with preformed saddle ends brazed on. (The joints are made by butting the bars to the saddle



ends with an unperforated foil of silver solder in between — during the braze the foil covering the water channel collapses completely.) The inner coils are potted in a glycidyl amine resin system which is more radiation-hard than resin systems used in other accelerator magnets.

The core is built up of 1.6 mm thick decarburised steel laminations, a cross-section of the magnet having two symmetric lamination pieces top and bottom. The half-core laminations are stacked on a slightly sloping fixture, which engages the coil opening to ensure alignment, and compressed between end-plates. Two angles are then placed along the length of the stacked half-core and welded to the end plates and to the laminations at intervals along the length.

The magnet is assembled by placing a half-core on a series of posts on a rigid table (the posts bow the core upwards by about 5 mm in the centre so that the assembled magnet is horizontal when supported at its ends). The coil aperture is coated with resin and the lower outer coil, the inner coil, the stainless steel vacuum vessel and the upper outer coil are placed in position consecutively (resin coating being added at each stage). Two steel rods are placed in alignment grooves to ensure alignment as the upper half-core is then lowered into place. Small steel plates are welded to the two half-cores at intervals along their length to complete the assembly. When removed from the table and supported at the ends the magnet is flat to within 0.5 mm. Total assembly time is about three hours.

The acceptance tests on the coils include leak, water flow and electrical insulation, and sample tests on such things as the copper-insulation bond. Tests on the assembled magnets include measurements of twist and sag, and water flow. The magnets will be powered briefly but it has not been decided whether magnetic field measurements will be carried out on all the magnets before they are placed in the ring.

The first main ring magnets which have been tested give sufficient 'good' field region up to a 22.5 kG (approximately 2.5 cm at peak field) to enable a beam to be accelerated to 500 GeV (there is hardly any loss of good field region over 18 kG or 400 GeV). The focusing quadrupoles however are beginning to wince at correspondingly high field gradients and would not have sufficient good field aperture for 500 GeV beams. To get round this, the tune of the beam will be altered for highest energy operation so that the quadrupoles can operate at lower gradients. The first bending magnet was wheeled into the Main Ring on 15 April and the installation procedure successfully tested. When the construction and assembly reaches its peak, magnets will be prepared for the ring at a rate of 25 per week.

Before giving the figures which show what a dramatic reduction in magnet costs has been achieved we should say a word about the NAL contract policy. To turn out magnets at such a rapid rate it was necessary to have more than one manufacturer providing each major component. As contracts have been placed, part of the contract has been held back to be given to the manufacturer producing high quality units at speed and at reasonable cost. It is very encouraging from a European point of view to note that three European firms (Alsthom - France and Lintott-UK for bending magnet coils and English Electric-UK for quadrupole coils) have shown themselves capable of producing coils of a quality, at a speed and at a price as good or better than their USA counterparts.

The average price of a bending magnet is $ 10 365 and the average price of a focusing magnet is $ 4 440. Most of the contracts are 'fixed price' and the final costs are unlikely to exceed these figures by very much if at all. The total cost of the manufacture and assembly to the magnets for the main ring is $ 9.2 million.

A way of pushing magnet costs still lower has been suggested by P.J. Reardon and R. Sheldon in a NAL internal report (TM-246). The proposal involves building up the magnet yoke from single piece laminations, each lamination being a full cross-section of the yoke (compared with the two piece laminations currently used). Three single layer pancake coils (an upper, a lower and a 'throat' coil) would be slid consecutively into the stacked laminations. The throat coil at least would need bending up to have saddle-shaped ends, taking it out of the beam path, but it has been shown that bending single layer coils without damage is feasible. Two U-shaped angles would fit around the stacked laminations welded along the length of the magnet providing a resin tight box. The whole assembly would be finally impregnated using epoxy resin. Considerable savings could be possible on magnet core fabrication (stamping and stacking of laminations), on coil production (man-hours involved) and on magnet assembly time.

This method of construction has not yet been tried and how much further saving could be realized in practice remains to be seen. It is possible that some magnets for the ejected beam-line or secondary beam-lines at Batavia will be made in this way. It has been decided incidentally, to string the ejected beam-line from the roof (as, for example, is done with the magnets in the VEPP 3 storage ring at Novosibirsk) mainly so as to get in close to the ring with the first magnets. Judging by experience, NAL will soon be sounding out the market for cheap string.

The sessions on superconductivity opened with an excellent review paper by G. Bronca of Saclay, 'Problems and Recent Developments Concerning A.C. Superconducting Magnets for Synchrotron Accelerators', summarizing the advances which have been made in the last few years and the problems which remain to be solved. But first we will clear d.c. superconducting magnets.

Many papers were given on magnets in operation, under construction or being planned, showing how quickly d.c. superconductivity is moving out of the stage of being adventurous new technology. It is now almost an automatic choice, that can be confronted without qualms, whenever the need is for high fields, a compact magnet or cheaper large magnet running costs.

The big projects at the moment all use niobium-titanium alloy as the superconductor. Several papers covered the

Cross-section of a proposed magnet design which could achieve lower costs by using single laminations for the magnet yoke cross-section and single layer coils.

efforts to master niobium-tin which is capable of giving much higher fields but is difficult to fabricate. Magnets capable of 150 kG should be possible if production problems are finally overcome. (It is relevant at this point to insert news from the Dallas meeting of the American Physical Society at the end of March. The work of B. Matthias, T. Geballe and E. Corenzwit (from Bell Telephone Laboratories) on new superconducting alloys was reported. They have produced a niobium-aluminium-germanium alloy which remains superconducting at 4° K in the presence of a field of 410 kG. The material has been tested by S. Foner and E. McNiff at the National Magnetic Laboratory, MIT. However general use of this alloy is likely to be very much further away than niobium-tin because of the even greater difficulties of fabrication in a suitable form to wind magnet coils).

The following is a list of some of the d.c. superconductivity projects for particle beam-line magnets reported at the Conference. Los Alamos: 15 cm aperture quadrupole doublet for beam transport at LAMPF; one quadrupole completed and tested. CERN: 10 cm aperture quadrupole completed and being tested (see vol. 10, page 42). Saclay: 20,30 cm aperture quadrupole doublet for beam transport at Saturne; nearing completion. Karlsruhe: 12 cm aperture quadrupole; under construction. Batavia: 3 m 35 kG bending magnet and 2 m quadrupole for beam transport; final stage of design, 75 cm dipole model built. CERN: two 1.4 m 45 kG bending magnets for beam transport to European bubble chamber; under study.

Reports were given on two of the monster d.c. superconducting magnets for bubble chambers. The magnet for the 12 foot chamber at Argonne was first operated in December 1968 (see vol. 9, page 43). There were some teething troubles particularly with regard to refrigeration but they have been cleared and more thorough testing started at the beginning of this year. The magnet is performing very well and pictures have been taken in the chamber. Stored energy is about 80 MJ, with a peak current in the superconductor of 2000 A; using the dump resistor has proved to be a simple operation. No heat load is evident when the magnet is on. Control is better than 1 part in 10^4. The superconducting magnet for the 3.7 m European bubble chamber to provide a field of 35 kG is under construction at CERN. The winding of the coil was described in vol. 10, page 38. By now over a quarter of the magnet has been wound.

Other d.c. superconductivity projects were reported from plasma physics Laboratories including an exotic superconducting 'Levitron' being built at Culham (UK).

Now, we return to the crucial topic of pulsed superconducting magnets and their use in a synchrotron. There are teams in five Laboratories launching an attack on this problem — Rutherford (UK), Saclay (France), Karlsruhe (Federal Republic of Germany), Brookhaven and Berkeley (USA) — while appropriate conductors are available from Imperial Metal Industries (UK), Thomson Houston (France), Vacuumschmelze (Federal Republic of Germany), Airco and Supercon (USA). We will begin by considering the features of superconductors operated in a pulsed regime which seem to be well understood and then discuss the features which remain to be mastered before they can be used in a synchrotron.

Pulsed operation inevitably produces hysterisis losses in a superconducting coil. Theory indicates that for a given type and size of conductor, within some limitations, the losses per cycle should be independent of the pulse frequency and independent of the shape of the pulse (dependent only on the maximum field). Also theory indicates that, in general, the losses are directly proportional to the width of the superconductor in the direction perpendicular to the field. To feed in some figures — for a field of 60 kG, superconducting filaments of 10 microns should keep the losses per cycle down to about 0.06 joules per cm^3 of material. Such filaments need to be supported in a matrix and to reduce power loss, due to induced current loops between filaments, the filaments must be twisted typically with a pitch of about 1 cm.

Experiments have been carried out on small coils built to the above criteria in a number of Laboratories. Losses have been measured using three methods — by continuous recording of the magnetization cycle, by calorimetry (measuring the helium which boils off as a result of heat produced in the coil) or by a technique using the Hall effect (measuring the net electrical energy flowing into the coil). In general, the results agree closely with the theoretical predictions and these fundamental features of a.c. behaviour can be considered as well understood. It will be interesting to push to still smaller filament dimensions (down to a few microns) but already it can be stated that superconductor suitable for pulsed magnets can be made.

This is only half the battle. A considerable number of technological problems in the use of such superconductor in a practical synchrotron magnet has to be solved and several years of work with bigger coils than have been built so far are likely to be needed to sort them out.

With a separated function lattice in the synchrotron the requirement would be for superconducting quadrupoles and superconducting bending magnets. The bending magnets present the greater difficulties. They would typically need apertures in the range 5 to 10 cm and be several metres long. The first difficulty is to produce the required field configuration accurate to one part in a thousand or better (despite thermal changes from room temperature to liquid helium temperature and despite the electromechanical effects of pulsing).

The field is dictated by the distribution of current in the coil and can be tailored either by sending different currents through different parts of the coil or by an appropriate distribution of conductors which carry the same current. Coil shaping is receiving a lot of attention at the moment and coils with distributed conductor are being tried at Rutherford and was one of the topics in a paper by J.H. Coupland 'Towards the Design of Superconducting Magnets for a Proton Synchrotron'. Accurately dimensioned spacers are introduced into the windings to distribute the conductors appropriately.

Another influence on the field is, obviously, the accuracy with which coils can be wound and positioned around the beam aperture. From the point of view of reducing the stored energy, the coils should crowd as close to the aperture as possible. But, to avoid field errors due to misalignment of conductors, it may be necessary to retreat a few centimetres from the aperture.

Iron shielding is needed around the coils to protect the surroundings from the high stray field of the magnet and the magnet aperture from any disturbance due to magnetic materials in the vicinity. If the shield is circular, perfectly symmetric with respect to the coils and of constant permeability, it should not distort the field in the aperture. Care will have to be taken with the shield positioning since otherwise mechanical forces will be high in addition to disturbing the field.

However saturation effects in the iron cause changes in the field pattern as a function of current in the superconductor. Most Laboratories have settled for a shield well away from the coil outside the cryostat. This relieves the additional cooling problem which would be caused by losses in the shield which can be of the same order as those in the coils. Brookhaven however, are going at this stage for a shield immediately around the coil to gain a bonus in peak field from the iron concentrating the field in the aperture.

'End effects' with superconducting magnets will be high but present indications are that the consequences should not be too serious since they tend to cancel out around the equilibrium orbit. It should also be possible to design coil ends so that the effective length of the magnet does not vary across the aperture.

Cooling of the coils, on the other hand, is still not out of the wood. Good heat conduction to the helium will be essential since as little as 0.1° K rise in temperature lowers the peak current which can be carried by superconducting niobium-titanium by 5 %. Conductor dimensions and coil configurations will be constrained by the necessity of efficient cooling. As with d.c. magnets the use of supercritical helium is being considered.

Next comes the problem of 'potting' the coil in some suitable material like epoxy resin. This will almost certainly be necessary to support the conductors in a rigid structure, preventing the tiny conductor movements which occur as a result of the electro-magnetic forces produced when the magnet is pulsed. If the conductors are able to move, the friction produced will be a source of heat leading to greatly increased power losses and even possibly destroying the superconducting property. The integral structure of conductor plus potting material will have to stay integral throughout the thermal change from room temperature to liquid helium temperature. An appropriate material has not yet been found but resins plus additives can now be obtained with such a variety of characteristics that the solution may not be far away.

A number of these remaining problems will probably be solved during the next round of research on pulsed superconducting magnets. Several Laboratories are building large dipoles. Saclay have under construction a 50 cm long, 10 cm aperture dipole using 4 micron filaments to give a 60 kG field, to be completed late summer 1971. Brookhaven have under construction a 75 cm long dipole using 8 micron filaments to give a 60 kG field. Rutherford have under construction a 40 cm long 12 cm aperture dipole using 8 micron filaments operating at 6000 A to give a 50 kG field, to be completed about the end of 1970.

There is another challenging piece of technology which is not concerned with the pulsed magnets themselves but which should probably be treated as an integral part of the development of superconducting synchrotrons. It concerns the production of power supplies to cope with the enormous stored energy in the superconducting magnets. A 1000 GeV machine might have something close to 2000 MJ flowing back and forth at each pulse (for comparison the CERN PS figure is under 100 MJ). Superconducting power supplies seem essential. Ideas of P. F. Smith at Rutherford for superconducting power supplies are now taking a shape where hardware can be assembled to test their feasibility.

A small cloud drifted across the superconducting horizon following a paper by W. H. Hassenzahl of Los Alamos on 'Radiation Damage in Niobium-Titanium Superconducting Wires'. Los Alamos wanted to test the conductor to be used in the lens doublet, mentioned above, for a LAMPF beam-line. They subjected samples of the wire to irradiation by gammas and neutrons (produced using an electron linear accelerator) and by protons from a 14 MeV Van de Graaff. The superconductors in and around accelerators will inevitably experience high radiation levels and their ability to withstand radiation without deterioration of the superconducting property is crucial.

Several experiments have been carried out and have shown that, if anything, radiation (below very high levels) tends to improve the superconducting property. Two features of the Los Alamos tests, which had not been general in the previous experiments, were the use of conductor such as is commercially available and the use of proton irradiation. The longest proton irradiation was of 1.5×10^{17} protons per cm^2 on the wire. Micro-ohm resistances were measured suggesting that the superconducting characteristics of the niobium-titanium were destroyed in at least one region of the wire. Extrapolating the results to synchrotron magnets would spell disaster.

However, no-one collapsed in dismay. The experiments are tricky to perform and it is difficult to be confident of the measurements in a clear, unequivocal way. Nevertheless, these experiments obviously have to be repeated. They will be continued at Los Alamos and other Laboratories are planning similar tests. If the results are not confirmed, as everyone obviously hopes they will not be, the experiments will at least have concentrated more attention onto this problem from which we should emerge with a better understanding of the effects of radiation on superconductors. Every cloud has a silver lining.

And there we end our report. It goes almost without saying that the Conference was organized with traditional DESY efficiency and hospitality and that, in an environment like Hamburg, the hours of the Conference were not the only ones when people could continue their eduction.

CERN News

Intersection region I3 of the ISR. Three of the eight regions have now been fitted out, like this one, with vacuum chamber X-sections.

The ultra high vacuum is achieved in these regions by titanium sublimation pumps. On test, after the chamber had been baked out three times at 300° C, a pressure of 2 to 3 $\times 10^{-11}$ torr was obtained, with at least 90 % of the residual gas consisting of hydrogen. It could be improved further, if necessary, by adding a liquid nitrogen cooling system to the pumps.

The chamber and pumps for the other regions are being installed and the last set should be in place by September.

PS intensity

Some new peak intensity figures were achieved at the 28 GeV proton synchrotron during the first week of June: 2.06 $\times 10^{12}$ protons per pulse on one cycle, 2.01 $\times 10^{12}$ ppp average over ten cycles, 1.97 $\times 10^{12}$ ppp average over eight hours and 1.85 $\times 10^{12}$ ppp average over a week.

These figures are not very different from those reported as the previous records in July 1969 (CERN COURIER, vol. 9, page 227). A closer look, however, shows that the machine is performing some 15 % better. This is because —

a) the method of measurement used in 1969 gave a more optimistic result (by about 7 %) than the currrent transformer now emloyed

b) there are now only fourteen r.f. accelerating cavities in use rather than fifteen (experience has shown that the maximum intensity of the beam drops by about 7 % when the number of cavities is reduced from fifteen to fourteen).

The reasons for the improved performance of the synchrotron seem to be —

1) a high intensity beam from the linac with a constant energy spread over the entire duration of the pulse

2) excellent corrections made to the closed orbit, where it has been possible to reduce oscillations to 2 cm (peak-to-peak) at injection and to 1 cm (peak-to-peak) at high energy

3) better vacuum (an average of 1.7 $\times 10^{-6}$ torr in the ring instead of 1.9 to 2 $\times 10^{-6}$ torr previously) following the recent installation of new pumps in one sector of the vacuum chamber

4) a simple ejection programme with two internal targets and one slow ejection (no fast ejection eliminating the interference caused by the fast ejection septa).

It has been a great comfort to observe that the slow ejection efficiency has stayed at 90 % in spite of the higher intensity of the accelerated beam.

Preparing for a third 'g-2'

Preparations for a third experiment to measure the 'g-2' of the muon are well advanced. The experiment is designed to push still further the accuracy with which this parameter is known.

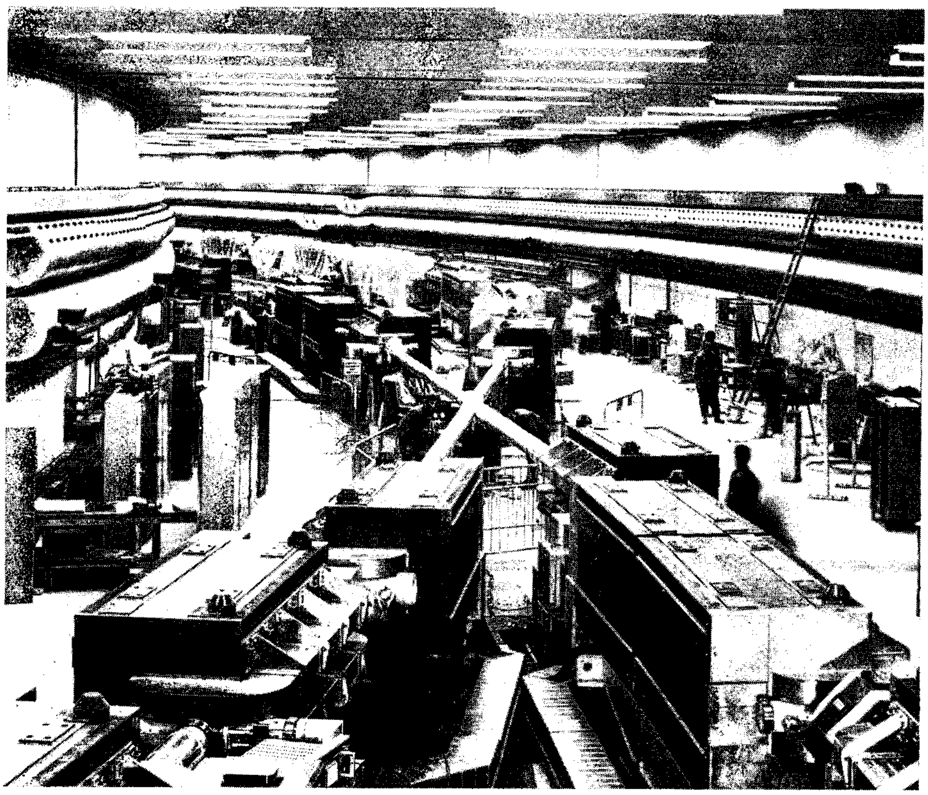
The second experiment (see vol. 6, page 152; vol. 8, page 244) improved the accuracy by a factor of twenty over its predecessor giving a value of (116616 $\pm$ 31) $\times 10^{-8}$ compared with the theoretical prediction of (116588 $\pm$ 1) $\times 10^{-8}$. The new experiment hopes to improve the accuracy of the experimental value by a factor of ten.

The interest in this pursuit of further decimal places has been described in some detail in the articles mentioned above. Briefly, it is, on the one hand, a search for a difference between the muon and the electron (two seemingly identical particles whose difference in mass could be due to a force felt by the muon but not by the electron) and, on the other hand, a test of the validity of quantum electrodynamics down to extremely small distances. In calculating the theoretical value, there are refined components due to the contribution of the strong interaction and the weak interaction. The result will reflect back on these calculations also.

The experiment will use new apparatus, mainly a 14 m diameter muon storage ring consisting of forty bending magnets and an electrostatic quadrupole. Studies of the ring units and of the inflection and detection system are reaching the stage where contracts can be placed. It is planned to install the ring in the West Experimental Hall.

The principle of the experiment is similar to that of its predecessor but with considerable improvements in apparatus to achieve the greater accuracy. The main differences are as follows:

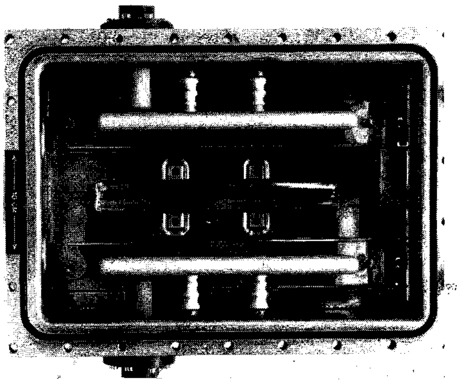
1) Unlike the previous storage ring, the magnetic field in the ring will be constant (with no gradient radially across the gap). It is thus possible to eliminate the effect of radial variations in the muon orbits; it has been shown possible to



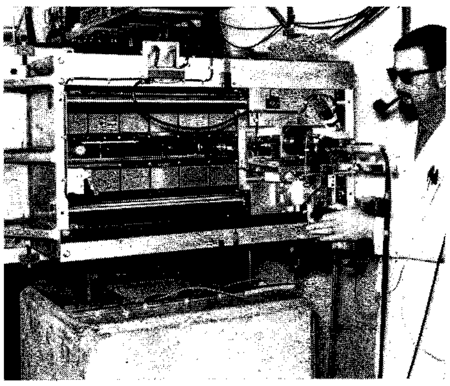
CERN/PI 219.1.70

Overhead view of an electrostatic quadrupole magnet to be used in the new g-2 experiment. Only the two side electrodes and the bottom electrode are visible. The top electrode, which is attached to the cover, has been removed.

Half scale model of a set of two magnets for the muon storage ring of the new g-2 experiment. The model is equipped with a device for measuring the magnetic field.



(CERN/PI 82.3.70)



(CERN/PI 222.3.70)

provide a uniform field to within a few 10^{-5} by dint of extremely careful corrections on the magnet poles, an optical alignment system (using a rotating laser beam), a highly developed power supply stabilization system, a set of automatically adjusted compensating windings and heat regulation.

2) Vertical focusing will be achieved by use of an electrostatic quadrupole. Normally, the magnetic moment of the muon is sensitive to the electric field but there is a 'magic' energy (3.1 GeV) at which the magnetic moment is no longer sensitive to the electric field. This energy has therefore been selected for the stored muons. In obtaining high gradient electric fields in the presence of strong magnetic fields and of particle beams, however, other problems arise. Preliminary studies have shown that the problems although difficult, are not insoluble.

3) In the previous g-2 experiment, the protons fast ejected from the PS were directed on to a target inside the muon storage ring. A considerable energy spread was given to the pions (which produced the muons on decaying) in the proton-target collisions which gave some unwanted side effects.

In the new experiment, the pions will be generated in a target outside the ring, and only those with accurately monitored momentum will be injected by means of a pulsed inflector. The pions will orbit the ring once and those which do not decay into muons will be lost on striking the inflector.

4) A higher intensity muon beam will be stored. This is possible partly due to the increased PS intensity. Several hundreds, instead of a few tens, of muons should be stored and this will improve the statistical accuracy of the results.

5) Operating at higher energy (3.1 GeV rather than 1.3 GeV) will make it possible to observe the muons for about two and a half times as long. This is due to the relativistic effect of time dilation. As observed in the laboratory the muon lives longer, before decaying into an electron, because it is travelling closer to the speed of light. This again will contribute to the statistical accuracy of the result.

The experiment is an unusually complex one. A year's running, is anticipated to get to know the apparatus and to find the systematic errors. The actual data taking will also involve about a year and the experiment should finish in 1974. Final analysis of the results may then take until 1975. This is a long haul for a few decimal places but they are very important decimal places.

HPD Minimum Guidance

Work has been under way for many years to automate the scanning and measurement of film from bubble chambers and spark chambers. The purpose is to reduce to a minimum (or, ideally, to eliminate altogether) human intervention between the stage of recording particle tracks on film and the stage of extracting the required information on the interesting events.

The HPD (Hough Powell Device) is one of the most successful automatic measuring machines. As was mentioned in CERN COURIER vol. 10, page 46, the HPD 'Full Guidance' System has been handed over to the Track Chambers Division to be used in production measurement of bubble chamber film. Full Guidance requires that, before film is passed to the HPD for measurement, there is manual pre-digitizing of the vertex of each interaction of interest and a further two pre-digitizings on each relevant track. The HPD system can then find its way to the information required.

The next step towards full automation was to develop a Minimum Guidance System. Work began in 1966, in collaboration with the Rutherford Laboratory, and the system is now in production. It requires manual pre-digitizing of the vertex of each interaction, and the end point of each very short track.

Experience to date has shown that the rate of film preparation for measurement is roughly doubled, as compared with Full Guidance, without deterioration in the measuring rate at the HPD, in the precision of measurements on tracks, or in the quality of the ionization (bubble density) information. The price paid is, of course, somewhat greater use of the central computers (which need more cleverness built into the computer programs to be able to extract the required information given less guidance), and it has been an important design criterion to keep this within acceptable limits.

The central part of the system is an off-line program, MGFILT, which filters out interesting tracks from the eighty thousand or so HPD digitizings of a typical frame-view from the 2 m hydrogen bubble chamber, knowing only the position of the vertex to about 100 μm in the film plane. The MGFILT program, while written in Fortran has a basic code routine to get access to the digitizings in any 'area' of the picture. An area is defined, in the general case, as being enclosed by two straight parallel sides and parabolic top and bottom edges, and as containing not more than 750 digitizings.

The initial areas chosen are the wedge-shaped ones pointing to the vertex (see diagram). Within each of these areas, straight pieces of tracks, or 'elements', pointing to the vertex are sought by a specialized histogramming technique. When any such track element is found, it is 'followed' both towards the vertex and away from it.

A schematic diagram illustrating the procedure in the HPD Minimum Guidance detection and track following.

Track following means extrapolating the track over a few mm in the film plane, picking up the digitizings in an elongated area covering the extrapolated track, finding the appropriate element in this new area to link to the track, and so on. Each track element is retained simply as one 'average point', equivalent to a coordinate pair from a manual measuring device, together with bubble density information. The elongated area used in track following is analogous to the hardware slit of other measuring devices such as the Spiral Reader. It is wide enough to allow simultaneous detection of adjacent tracks which are likely to cause confusion.

Within an area, two distinct local pattern recognition techniques are used to find track elements, namely (1) stringing or associating together clusters of digitizings such as occur mainly on black tracks (or film scratches) (2) histogramming of distances of digitizings to a line having the same angle as the expected track, usually repeated over several angles. There is an elaborate logic for composing track elements from the results of these two techniques, as there is also for the linking of elements to tracks.

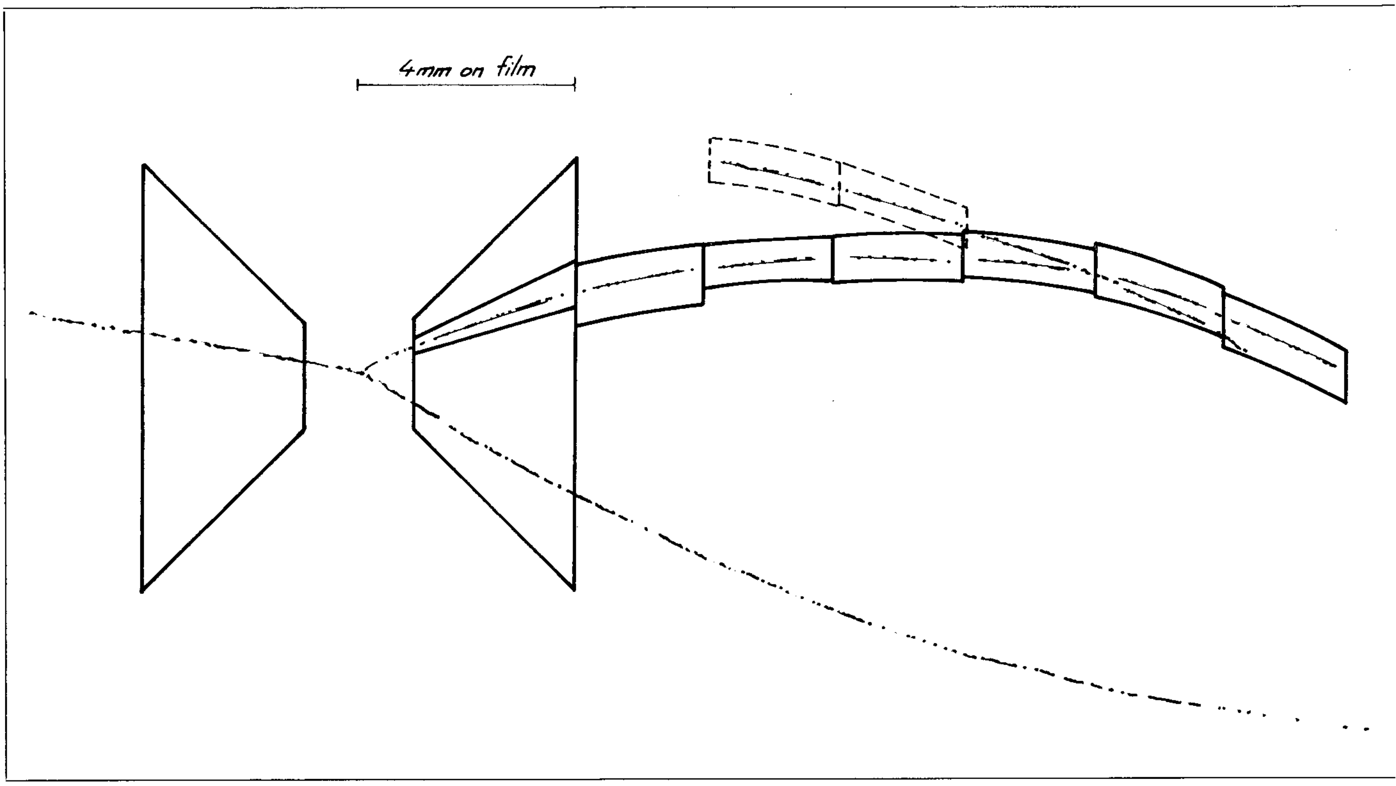
Leaving aside here some other complications such as that caused by the HPD orthogonal scan, the sets of average points from track images on all three views are then sent to another program called MGTHRESH, for matching and reconstruction in three dimensions. Track-matching for Minimum Guidance has to take into account the fact that, in addition to the tracks of the interaction, an unwanted track or track image may be picked up because it satisfies the criterion of passing near the vertex, and also that a track image may occasionally not be found on one view. These problems are not unique to Minimum Guidance, and the facilities developed in MGTHRESH are also used for the Spiral Reader.

The Minimum Guidance System is in use at the Zeeman Laboratory (Amsterdam), and at Brookhaven, and is under active study at DESY, at the Rutherford Laboratory, and at Saclay. At CERN, it is envisaged that it will be used more and more ; in addition, work is continuing in an attempt to dispense with pre-digitizings altogether, initially on a small angle scattering experiment.

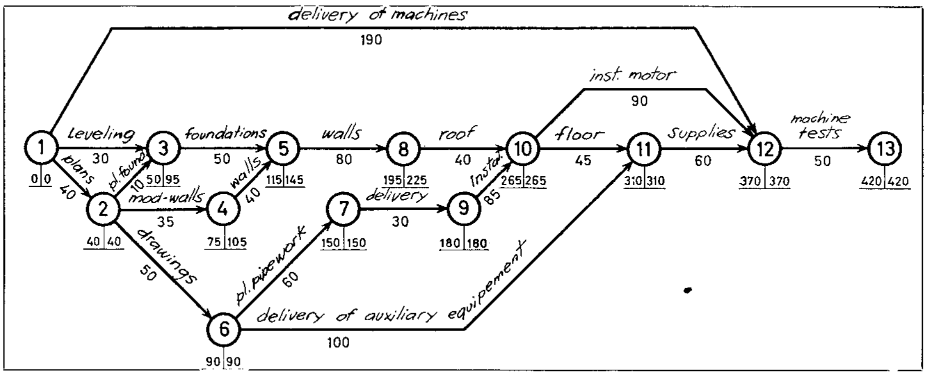
PERT at CERN

Project planning becomes more necessary, as the number of operations evolving one from the other increases and as time limits are reduced. Methods of planning have progressed a great deal since the time-honoured Gantt graph. The need to deal with extensive problems of logistics was the starting point for a development which, with the parallel improvements in computers, reached the point about 1960 when methods (often known under the generic name of PERT — Project Evaluation and Review Technique — or the 'critical path' method) were devised for dealing with large industrial projects.

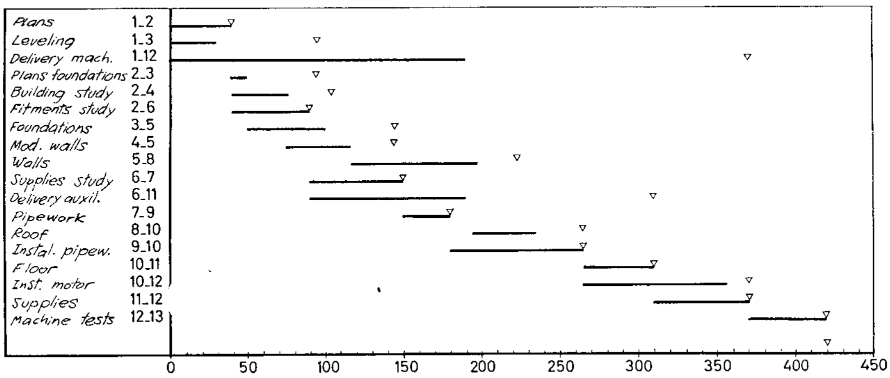
PERT is used for both the evaluation of time-schedules and, particularly, for the revision of programmes. If, for example, a project must be completed by a certain date, and it appears in the course



Planning a project by PERT begins with a 'network' (figure 1) in which each operation is shown in the form of an arc which runs in the direction of time. The arcs connect up series of 'nodes' which represent the various stages of advancement. Each operation is assessed to determine its completion time and the 'critical path' (i.e. the longest chain) is then found, since this dictates the time required to complete the programme. These operations are 'critical' because the lengthening of any one of them will delay in the programme. Once the starting date has been fixed, the dates at which the various events should occur are determined and the programme completion date assessed. If, however, it is the completion date which is fixed, the calculations are made by working backwards, and the latest commencement date obtained. If these two dates are fixed and the completion time between them is exceeded, this leads either to a conclusion of impossibility (if the available resources cannot be increased) or to a revision of the programme ; the merit of PERT is that it provides great flexibility in this respect. The dates can be met either by re-arranging the available resources among the various operations or by providing additional resources. An example of PERT applied to plant installation (MBLE graphs) is shown.



1.



2.

of the programme that some part is behind time, it is possible by carefully studying all the operations, to save time on some of them — possibly by employing extra-labour, by using a sub-contractor, or even by omitting an operation if it is not absolutely essential. PERT can show where the pressure needs to be applied.

PERT is based on a particular type of graph which forces the planner to spell out aspects of his programme in detail by illustrating each of the operations, the time each requires and, above all, the way in which the operations are interrelated. In the case of simple programmes, consisting of a hundred or so operations, these graphs can be dealt with manually. As the complexity of the programme increases, however, the computer comes into its own. It can extend the method to projects involving thousands of operations.

When the PS improvement programme and the ISR construction project were about to be tackled, CERN considered applying PERT. In 1966, J. Pollock, an American PERT expert working at the time at Argonne and now engaged in planning at Batavia, adapted his existing computer programs for CERN. Since then, PERT has been used for most large CERN projects (Booster, European bubble chamber, ISR, experimental areas and large buildings) for both the civil engineering work and the installation of equipment. One example of a typical application of this 'CERN PERT' was the installation in December 1969, of the fast ejection 16 (see CERN COURIER vol. 10, page 148). This was a programme involving about 150 operations to be carried out during the short period of the PS shutdown and worked very well.

Since 1966 CERN has trained its own PERT specialists who, in 1968 and 1969, rewrote the programs with the aim of producing a simpler program adaptable to a wide variety of cases. It is, to-day, the only one in use at CERN, and can encompass a maximum of 2000 operations.

PERT is an 'individual' tool. While there are competent PERT specialists in several Divisions who can provide advice, it is only exceptionally that they can do the preparatory work for others. However, the method is quickly learned (within a few days) but its efficient application does require some experience and a great deal of judgement. It is often difficult to assess timescales, especially when other people's work is concerned, to ensure that they are kept, etc. But such problems are common to all large projects.

A yellow report (70-15) on PERT and a 'PERT Manual' are available for those interested from the CERN Scientific Information Service.

Around the Laboratories

A view of the ADONE storage ring hall where experiments are now set up and taking data at intersection regions of the electron and positron beams.

(Photo Frascati)

FRASCATI
Operation of ADONE

Operation for experiments of the 1.5 GeV electron-positron storage ring, ADONE, at the Frascati Laboratory began at the end of November 1969. We report here some information on the operation of the storage ring through to the beginning of April and on the experiments currently taking data.

The luminosity varied between 3 and 6×10^{32} cm^{-2} hour^{-1} in the energy range 800 MeV to 1 GeV. At present only one r.f. cavity is in operation and this limits the maximum energy to 1.25 GeV. A second cavity is ready for installation as soon as higher energy colliding beams are called for by the experimenters.

The time taken to store the two beams in the ring is typically 10 % of the time for which the beams can then be used for experiments (about 20 minutes filling time every three to four hours for the injection of 20 to 40 mA per beam, depending on the final energy). The halving-time for the luminosity is of the order of three to five hours (lower at higher energy) and the pressure rise with current, after adequate vacuum chamber conditioning, is about 10^{-11} torr/mA at 1 GeV.

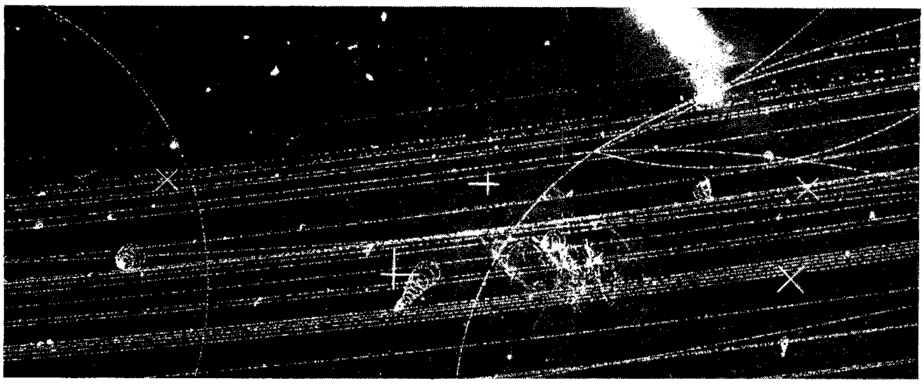
Up to 31 March, the effective time for two beam operation was 661 hours and the time for one beam operation (for background measurements) was about 120 hours. Reliability has been getting steadily better and the month of March saw 250 hours of effective two beam time and 100 hours of one beam time. This is from a total of 348 hours of nominal two beam time (which includes access to the ring hall and to the injection system). The integrated luminosity during the period considered was about 2×10^{35} cm^{-2} per experimental section.

Four experiments have been running :

1. In section 3 a Rome, Frascati collaboration is studying electron-positron annihilation into two gammas, neutral pion plus gamma or eta plus gamma ;
2. In section 5 a Bologna, CERN, Frascati collaboration is searching for leptonic quarks and heavy leptons ;
3. In section 9 a Naples, Pavia, Frascati collaboration is studying boson production ;
4. In section 11 a Genoa, Padua, Rome, Frascati collaboration is studying production of muons and pions.

The four experiments are collecting data simultaneously. A typical reference event is Bahba large angle scattering whose rate is around ten events per hour, depending on the solid angle of the detection system and on the beam energy. Many hundreds of other annihilation events (like gamma-gamma, muons, pions) have been collected and events giving more than two charged prongs in the spark chambers have also been observed. Theoretical work is in progress to interpret the preliminary hadronic results.

A Naples, Frascati collaboration to study proton-antiproton production began preliminary tests in the second half of April. An Istituto Superiore di Sanita experiment to study the phi resonance requires a luminosity at 500 MeV higher than can be obtained at present and it has not yet been installed.



1. Frame 44 646. A photograph, which has a six prong event with a fast forward neutral particle, taken in the 30 inch hydrogen bubble chamber at Argonne in the course of an experiment being carried out by a team from the University of Wisconsin.

2. The companion optical spark chamber photograph, No. 44 646, taken downstream of the bubble chamber. The neutral particle emerging from the chamber has interacted in a steel plate giving a fast proton which is recorded in the spark chambers.

(Photos Argonne)

ARGONNE

Hybrid operation of bubble chamber

About six months ago, modifications began on the 30 inch Argonne — MURA hydrogen bubble chamber to adapt it for use in conjunction with auxiliary counters and spark chambers. The aim was to develop a facility capable of triggering the chamber camera system to photograph only these expansions in which events of interest occur in the chamber. Physicists from the University of Wisconsin proposed the facility and cooperated actively with the Argonne chamber operating team in bringing it into being. They are now carrying out the first experiment with the new facility where the events of interest are those producing fast forward-going neutral particles.

The facility can be used to study two general classes of reactions of considerable current interest:

1) $\pi^- + p \rightarrow n + (X^\circ)$

2) $\pi^- + p \rightarrow p + (M^-)$

$M^- \rightarrow K^\circ_L + (m^-)$

In these reactions (X°), (M^-), and (m^-) are not necessarily resonances but only symbols for collections of charged particles having the overall total charge shown. In the first case, the reaction occurs in the backward direction (the neutron is produced with a relatively high momentum and travels forward at a small angle with respect to the incident beam). In the second case, the same applies to the neutral kaon (though this would generally be considered a forward production process since the nucleon would have a relatively low momentum). The backward production reactions provide a means for studying baryon exchange processes. The K°_L reactions provide a means for studying boson resonances that have a $K\overline{K}$ decay mode (such as the A2).

The facility consists of three basic components:

1. A beam-tagging wire chamber positioned immediately upstream of the bubble chamber;
2. The 30 inch bubble chamber with a new beam exit window and with the downstream plug removed from its magnet yoke;
3. A downstream detection system for neutral particles consisting of a lead gamma ray converter followed by a large scintillation counter in anti-coincidence (to eliminate gammas from the decay of forward-going neutral pions), followed in turn by an array of scintillation counters, steel plates, and optical spark chambers. The neutron or K°_L interacts in the steel plates and the charged reaction products are detected with the optical chambers.

There is, in addition, a large anti-coincidence counter positioned immediately downstream of the bubble chamber magnet to prevent triggering on events with fast, forward, charged particles.

The new facility can be operated in either triggered or tagged modes. In the former, only expansions containing events which satisfy the electronic trigger conditions are photographed. In the latter, all expansions are photographed but the pictures containing events which satisfy the trigger conditions are electronically tagged for future identification.

The 30 inch chamber is admirably suited for this kind of operation in view of its rapid cycling capability. It has been successfully operated for physics at five expansions per pulse of the Zero Gradient Synchrotron (see CERN COURIER vol. 8, page 312). However, during the recent Wisconsin run it was operated with two expansions per ZGS pulse since the accelerator was running with only a fast spill at the time. Some 80 000 pictures were taken in the tagged mode during this running period. The incident beam was of 7 GeV/c negative pions and the chamber was filled with hydrogen (future operation with deuterium is contemplated). The observed trigger rate was 1 per 25 expansions. A fast pulsed magnet was actuated to remove the beam from the chamber each time a trigger was recorded. As a consequence, the tagged pictures contain, on average, only half the tracks in the beam and a fairly intense beam could be used.

Preliminary analysis suggests that a third of the triggers are true fast forward neutral events, the remaining two thirds being background from two or three main sources. Although analysis of these pictures is just beginning, it already appears that the direction of the fast forward neutral can be determined quite well from the downstream spark chamber photographs.

The next scheduled period for operation of the 30 inch chamber begins in October (this chamber and the 40 inch heavy liquid chamber are run alternately for budgetary reasons). Conventional runs are scheduled for π^+p, $\overline{p}p$, K^-p, and π^+d experiments. It seems likely that valuable experience could be gained by making these runs with the neutral trigger facility operating in the tagged mode and some thought is currently being given to this possibility. After this, further running is scheduled for the Wisconsin group.

DUBNA

Developments of equipment

Gas jet target

A gas target (hydrogen) has been designed for experiments on the elastic scattering of protons on protons at small angles. The target has been installed for use with the

1. *The first units of the ejected proton beam at the Dubna 10 GeV synchro-phasotron.*

2. *A photograph showing the actual size of the ejected beam at its first focus situated 16 m from the exit of the synchro-phasotron vacum chamber.*

internal beam of the 76 GeV accelerator at Serpukhov.

The jet is shaped by a system of co-axial nozzles one of which serves as the shaping jet and others as collimators. The density of the jet in the region of interaction with the beam is 3 to 5 x 10^7 particles per cm^3. The hydrogen jet is collected by means of a helium condensation pump and intermediate pumping of the hydrogen between the nozzles is also by a helium condensation pump. An electromagnetic hydrogen injection valve operates synchronously with the accelerator cycle (one pulse every 7 seconds).

The initial vacuum in the machine is 4 to 6 x 10^{-6} torr, and when the hydrogen is injected, the vacuum in the target region drops to 4 to 6 x 10^{-4} torr. The time taken to restore the vacuum depends on the hydrogen consumption and rises to 500 ms for a hydrogen consumption of 300 to 350 cm^3 per cycle. The length of time for which the target can operate without attention (about two hours) is governed by the volume of liquid helium in the dewar (50 litres). When the dewar is replaced, the target heats up and sublimation of the hydrogen takes place. Helium is then again poured over the target system.

Precision liquid hydrogen target

This target has been designed for an experiment to measure the total scattering cross-section on hydrogen.

The main component of the installation is a cylindrical target containing liquid hydrogen which is composed of an inner vessel and a vacuum casing with a multi-layer insulating material between them. The working volume of the target is contained in a cylindrical 'dummy-shell', which ensures a uniform hydrogen density in the working volume. Boiling of the liquid hydrogen as a result of heat transfer from the surrounding medium occurs in the gap between the dummy-shell and the inner vessel.

At the ends of the inner vessel and the vacuum casing are thin windows. The windows of the inner vessel are made of two films having equal pressure on either side and therefore remaining flat. Containing the working volume of liquid hydrogen in the target between these flat parallel films and within the dummy-shell ensures an identical quantity of hydrogen along the path of all particles in the beam which traverse the target. The accuracy with which the quantity of hydrogen along the particle trajectory can be determined is between 0.05 and 0.1 %.

The pressure of the liquid hydrogen in the target is maintained constant (with an accuracy of ± 0.5 torr) by means of a stabilizer. The target is filled with hydrogen by gravity flow from a vessel situated over the target and can operate continuously for fifty hours. The vessel and two targets (one is the target filled with liquid hydrogen, the other is empty and is used for the measurement of background levels) are installed on a movable structure which enables the targets to be located in succession in the particle beam.

Study of rare decays

By means of multi-layer cylindrical spark chambers operating in a magnetic field, a search has been made for the decay

$$\pi^+ \rightarrow e^+ + \nu_e + e^+ + e^-$$

This decay may occur not only on account of electromagnetic interactions, but also if there exist 'exotic' interactions, such as the six-fermion or anomalous interactions of four leptons, which have so far not been observed.

Processing the data obtained from about 6 x 10^9 stopped positive pions in the target, not a single decay of the above type has been found. This sets the relative probability of such a decay at :

$$\frac{W(\pi^+ \rightarrow e^+ + \nu_e + e^+ + e^-)}{W(\pi^+ \rightarrow \mu^+ + \nu\mu)} \leqslant 3.4 \times 10^{-3}$$

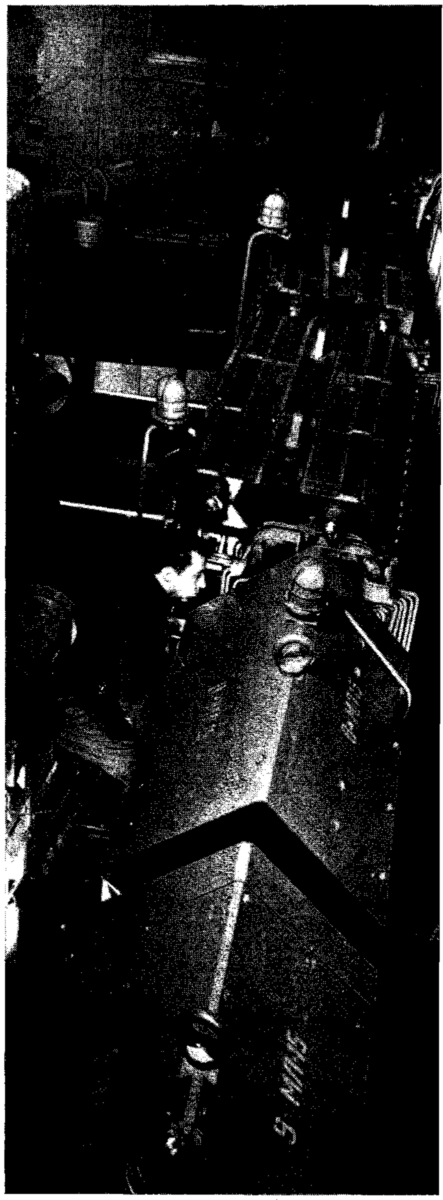
with 90 % certainty. The upper boundary of probability obtained for the decay improves by several times the estimate of the binding parameter of the six-fermion interaction, previously made on the basis of the results of neutrino experiments. With the data obtained it was also possible to make an estimate of the probability of the $\mu^+ \rightarrow e^+ + \gamma$ decay :

$$\frac{W(\mu^+ \rightarrow e^+ + \gamma)}{W(\mu^+ \rightarrow e^+ + \nu_e + \nu\mu)} \leqslant 2.9 \times 10^{-8}$$

with 90 % certainty.

Resonance ejection at synchro-phasotron

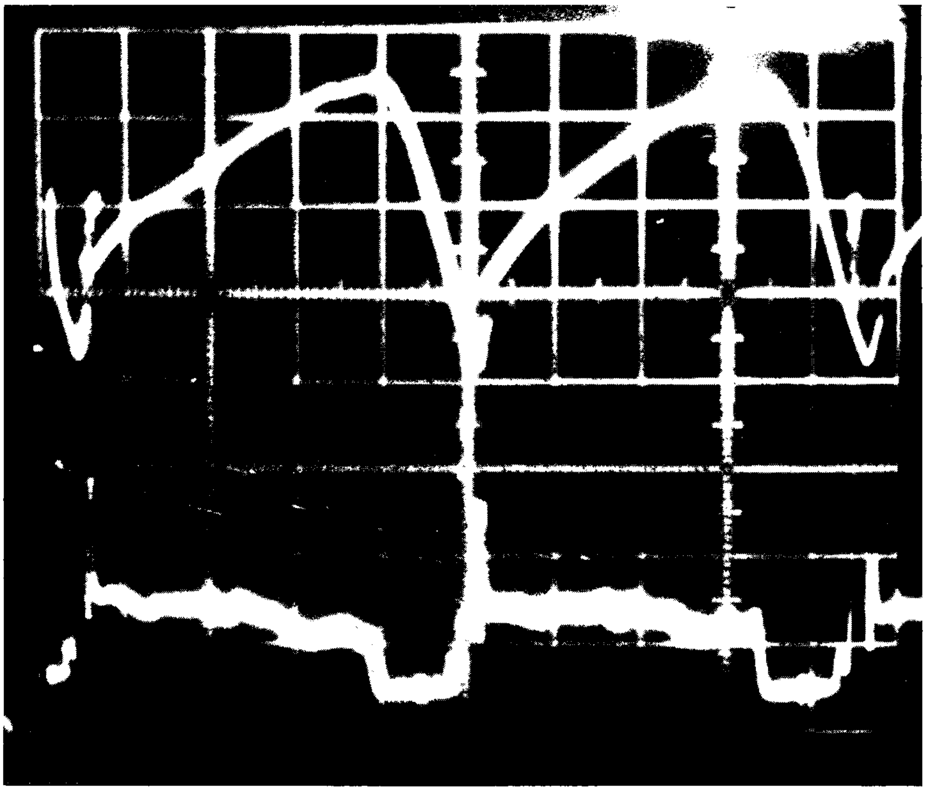
At the Dubna 10 GeV synchro-phasotron, an ejection system is in operation using the half-integral resonance of the radial



1.

2.

3. The top trace is an oscillograph of the saw-tooth pulses of current feeding the magnet coils of the beam stretching system on the Dubna 680 MeV synchro-cyclotron. The bottom trace is an oscillograph of the secondary beam with a duty cycle of about 70 %.



3.

betatron oscillations to take the circulating proton beam into the ejection septum magnet. The accelerator's parameters give an increase in oscillation amplitude which exceeds 10 cm per oscillation and this enables more than 80 % of the primary beam to be deflected by the septum magnet, while maintaining in the beam an energy spread of ± 1 MeV at 10 GeV. The area of the beam spot at the first focus is about 1.5 cm^2.

Ejection is effected in 100 microseconds. Work is at present in progress on a system capable of increasing the time to several tenths of a second.

Beam stretching in synchro-cyclotron

Successful work has been under way to improve the duty cycle of the beams from the 680 MeV synchro-cyclotron. In normal operation, secondary beams emerge from the machine in a burst lasting 0.9 ms, i.e. about 10 % of the acceleration cycle, but if account is taken of the micro-structure which appears in the beams at the r.f. frequency the true duty cycle is down to 1 to 2 %.

A 'beam stretching' system has been used for many years to improve this. It involves accelerating the primary proton beam out to a particular radius where it is parked and debunched by switching off the r.f. A special magnet can then be powered from a pulsed source to bring the beam onto a target, providing secondary beams with a much longer duty cycle.

The use of the beam stretching system with a pulse of sinusoidal current (amplitude 170 A) applied to the magnet and a pulse duration of 7.5 to 8 ms has enabled the duty cycle to be increased to 25 to 35 %. The duration of the secondary particle beam pulse is 3 to 3.5 ms (2 to 2.5 ms at half-height of the intensity pulse), and in addition there is no micro-structure in the beam. The intensity of the meson beam is 55 % of the intensity during normal operation (without beam stretching).

When the magnet coils are excited with saw-tooth pulses of current with a rise time of 6 to 6.5 ms and an amplitude of 130 A, the duration of the bursts of the meson beam is about 70 % of the acceleration cycle of the primary beam. This doubling of the beam duty cycle which retains the same beam intensity as was obtained with the sinusoidal current makes possible a much more efficient use of the accelerated particles.

When the amplitude of the saw-tooth pulses of current was increased to 170 A, an increase was observed in the intensity of the emerging secondary beam from 55 % (with sinusoidal pulses) to 70 %.

BERKELEY

Three-neutron resonance

The double charge exchange of negative pions of energy 140 MeV has been used to observe the interactions of three neutrons by studying the reaction

$$\pi^- + {}^3He \rightarrow \pi^+ + 3n$$

A beam of negative pions from the 184 inch cyclotron at Berkeley was directed on a liquid helium 3 target. The momentum and direction of the positive pion produced at an angle of from 15 to 40 degrees were measured with a magnetostrictive-readout wire chamber spectrometer consisting of two wire chambers on each side of an analyzing magnet.

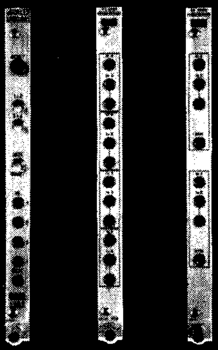
Interactions amongst the three neutrons significantly distort the momentum distribution of the positive pion from the four-body phase space, producing a resonance shaped bump. This effect has been interpreted as being due to a resonance in the three-neutron system a few MeV above threshold and with a width of about 12 MeV. A similar effect has been reported by L.E. Williams, C.J. Battes, B.E. Bonner, C. Tschalar, H.C. Benohr, and A.S. Clough in Physical Review Letters 23 (1969), 1181. They investigated the reaction

$$p + {}^3He \rightarrow 3p + n$$

and saw very clearly the resonance between the three protons.

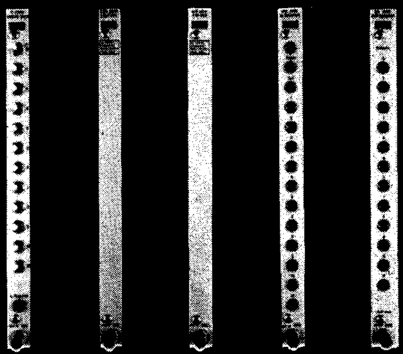
The results of the Berkeley experiment were reported at the April meeting of the American Physical Society. A paper entitled 'Evidence for a Low Energy Resonance in the Three Neutron System' by J. Sperinde, D. Fredrickson, R. Hinkins, V. Perez-Mendez, and B. Smith which describes the experiment has been submitted to Physics Letters B.

CAMAC SYSTEMS



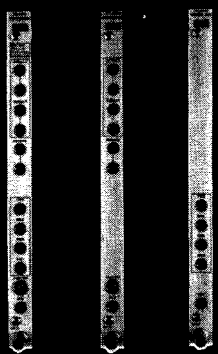
SCALERS

4 S 2003	Four fold 16 bit scaler meets CERN 003 specs.
4 S 2004	Four fold 16 bit scaler, 30 MHz, convenient input gating, L-mask, really low cost.
2 S 2024	Dual 24 bit 150 MHz scaler, the fastest Camac scaler available, surprisingly low cost.



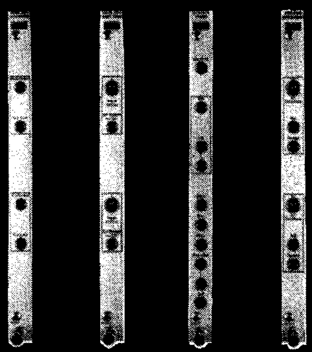
IN/OUT REGISTERS

P 2005	12 bit switch register with L-request.
2 OR 2008	Dual 16 bit output register, provides 32 bits as TTL levels.
2 IR 2010	Dual 16 bit input register, samples and stores 32 TTL levels.
SIR 2026	Strobed input register, accepts 12 narrow NIM pulses.
OR 2027	12 bit NIM output register, the way to control fast NIM electronics at about $15 per control variable.



CRT DISPLAY MODULES

A truly modular and expandable system: DD 2012 for random or sequential point plots, CD 2018 for ASCII character generation, VG 2028 the vector generator for the ultimate in graphics convenience. DD 2012 and CD 2018 can be used alone or coupled, DD 2012 is prerequisite for VG 2028. Provision for light pen or joy stick.



CONVERTERS, TIMER

2 DA 2011	Dual 10 bit D-to-A converter.
2 DVM 2013	Dual digital voltmeter, integrating converter, ± 100 mV range.
RTC 2014	Real time clock, to be used as computer clock, time interval meter or preset scaler.
2 IPE 2019	Dual Incremental Position Encoder, digitizes X-Y motion with any type of incremental transducers.

Ask for data sheets and descriptive literature.

Other modules are available or in the development stage: A-crate controller, Five-fold scaler for magnetostrictive spark chambers, "Busy-Done Module"...

Leasing facilities available.

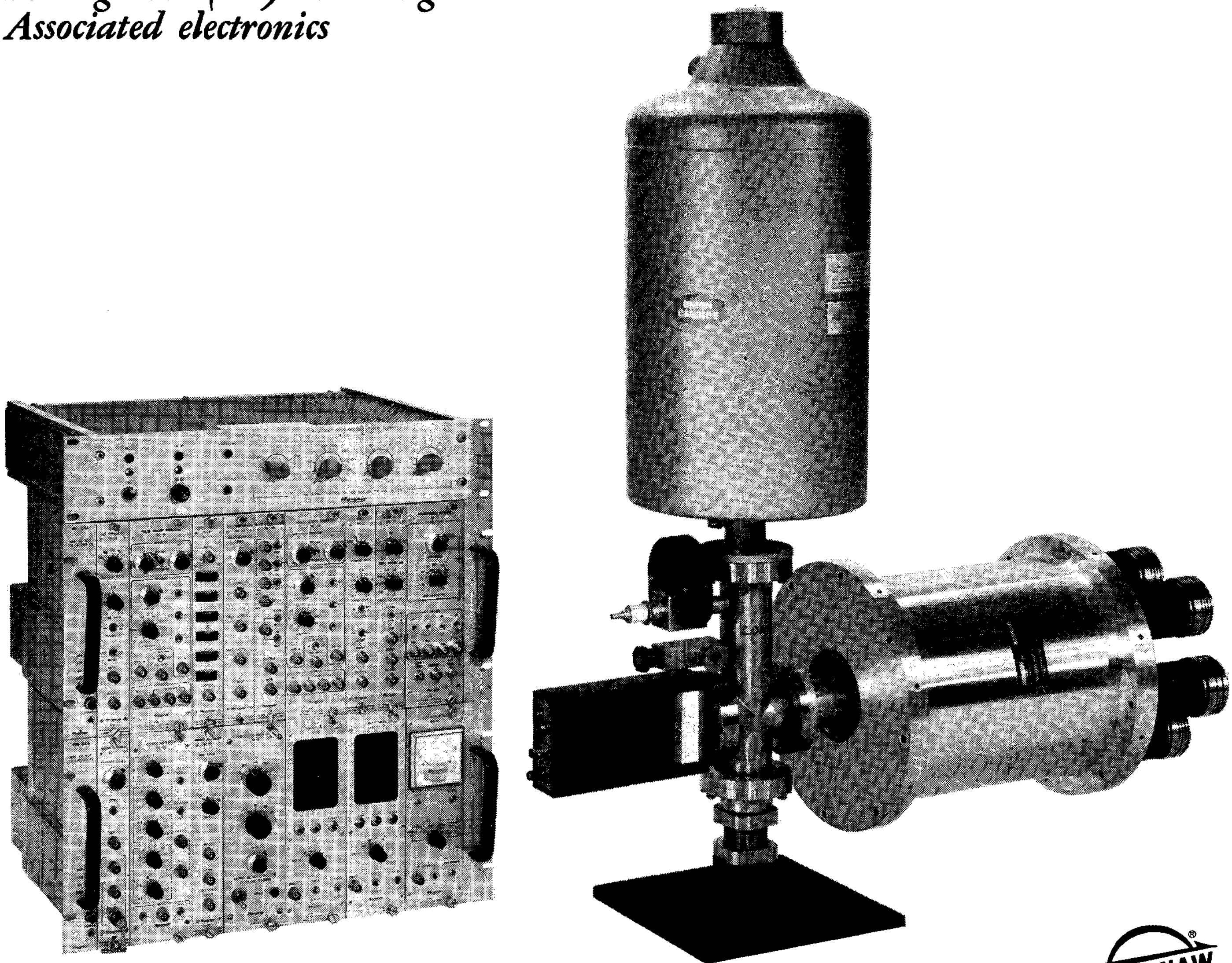
SEN

ELECTRONIQUE

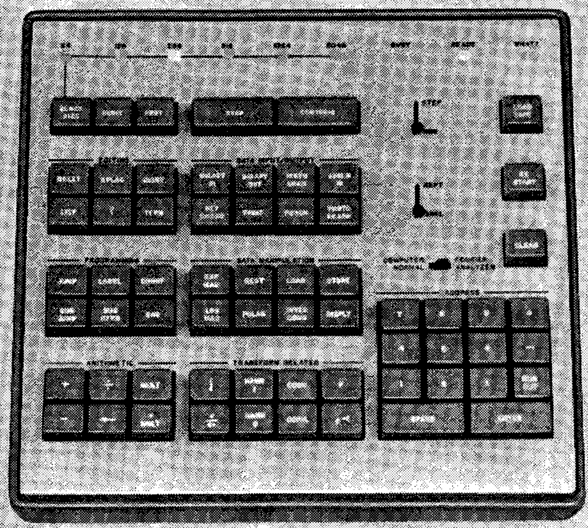
HARSHAW

the world's leading supplier of sodium iodide scintillation detectors, offers complete ***anti-compton*** *and* ***pairspectrometry*** *systems including:*

A high performance Ge(Li) detector
A large NaI(Tl) shielding
Associated electronics



For information please contact:
Harshaw Chemie N.V., P.O. Box 19, De Meern, Holland
Harshaw Chemie GmbH, Wermelskirchen, Viktoriastrasse 5, W-Germany



These pushbuttons let you perform almost any frequency analysis known to man

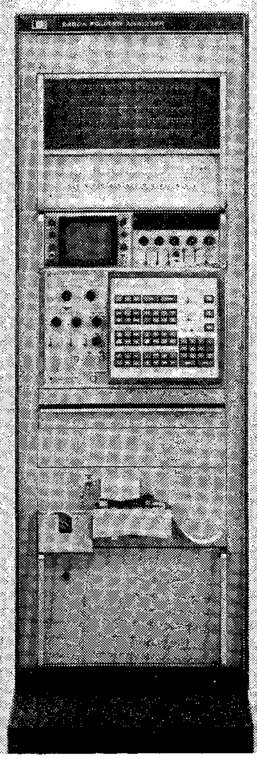
They're on the keyboard of our new 5450A Fourier Analyser (which requires no digital computer knowledge; yet, with the flick of a switch, becomes a general-purpose digital computer!).

Our pushbutton Fourier Analyser also lets you program ☐ power density spectrum ☐ auto-and-cross correlation ☐ convolution ☐ histogram ☐ hanning and other weighing functions ☐ ensemble averaging ☐ integration differentiation and all arithmetic operations on the accumulated data.

It may look and sound complicated, but it's very simple to operate (doesn't even require computer programming knowledge).

It's applications? Almost unlimited.

For all the details, write or call

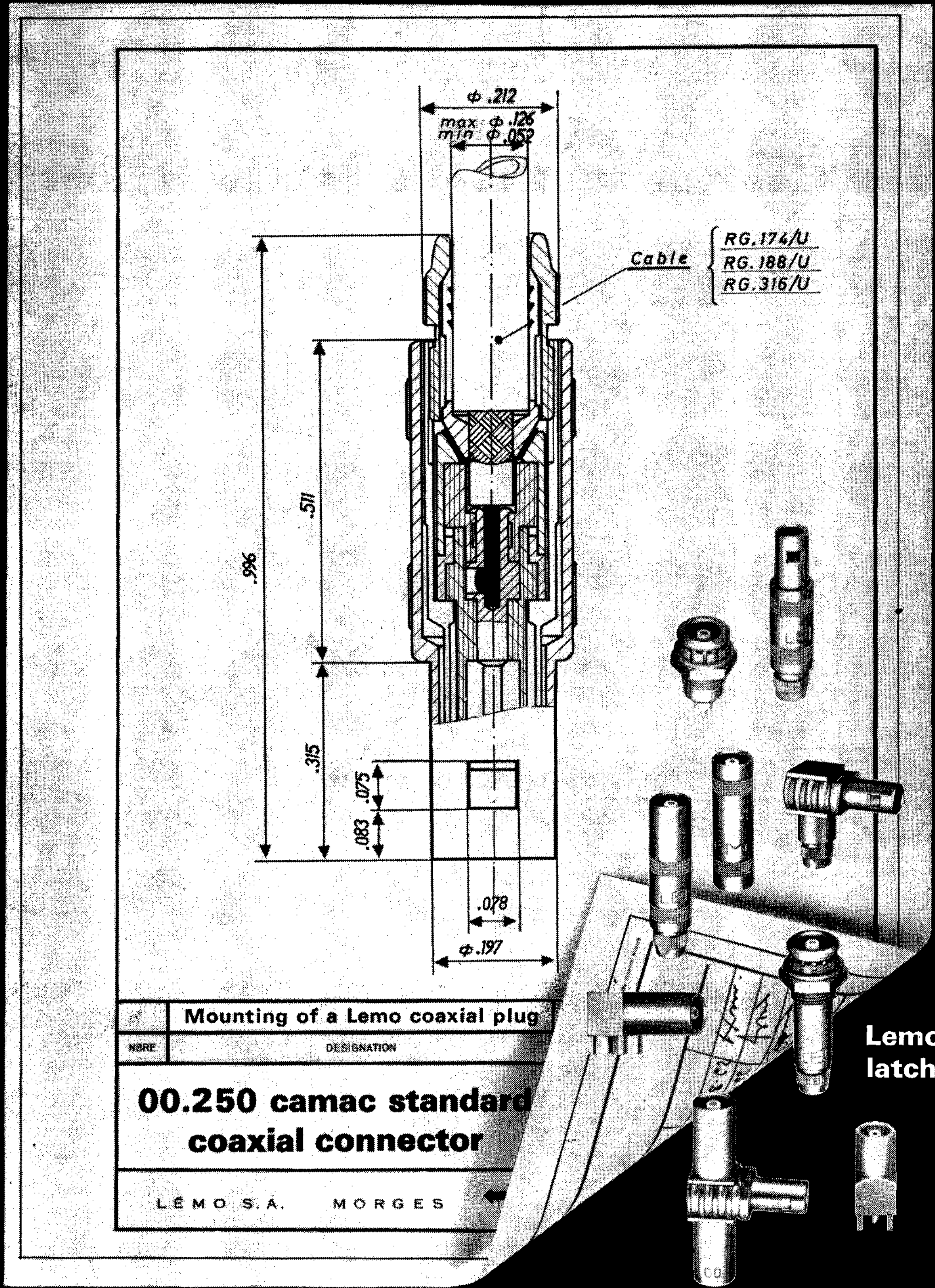


European Headquarters: Hewlett-Packard S.A.
Rue du Bois-du-Lan 7, 1217 Meyrin 2 Geneva,
Tel. (022) 41 54 00

28 sales and service offices throughout Europe

HEWLETT hp PACKARD

5450A



Lemo patented latching system

General specifications

Composition
Shell : brass 59 A
Insulator : teflon PTFE
Contact : brass 59 A

Finish
Shell : nickel + chrome
RP + RPL types gold plated 3 microns
Contacts : nickel and 3 microns gold plated
Operating temperature range : –55° C +150° C

Electrical specifications

Characteristic impedance : 50 Ω ± 2 %
Frequency range : 0-10 GHz
Max VSWR 0 ÷ 10 GHz : 1 : 12
Contact resistance : < 8 m Ω
Insulator resistance : > 10^{12} Ω under 500 V. DC
Test voltage (mated F + RA) : 3 KV. DC
Operating voltage (mated F + RA) : 1 KV. DC

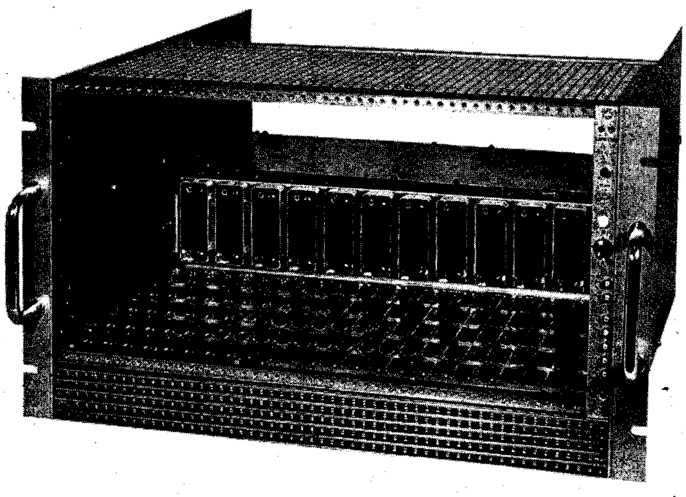
Normal maximum cable diameter : • 126
Special arrangement : • 157

LEMO S.A.

Tél. (021) 71 13 41 Télex 24 683 1110 MORGES (Switzerland)

C7 ALN 13

CHÂSSIS ALIMENTATION NIM



- **Ce châssis pour tiroirs modulaires est destiné à l'alimentation des éléments fonctionnels normalisés NIM-TID 20 893.**
- **Permet le montage de 12 tiroirs**
- **Utilise l'alimentation P 7 ALN 10 délivrant:**
  + & — 24 V 3 A
  + & — 12 V 3 A
  + & — 6 V 6 A
  + 200 V 0,1 A
  117 V 50 Hz 0,5 A
  Puissance utile 200 watts
- **Trois ventilateurs pour le refroidissement des tiroirs**
- **Brochage du connecteur: 42 contacts.**

+ 200 V	+ 24 V	— 24 V	+ 12 V	— 12 V	+ 6 V	— 6 V	117 V alt.	0 V	Masse spéc.
8	28	29	16	17	10	11	33 et 41	34	42

CARACTÉRISTIQUES PROVISOIRES

Tension de sortie	± 24 V	± 12 V	± 6 V	+ 200 V
Plage de sortie	± 5 %	± 5 %	+5 % à —18 %	± 10 %
Régulation pour 100 % de variation de charge et les variations du réseau (+ 10 % à — 12 %)	$\pm 5.10^{-4}$	$\pm 5.10^{-4}$	$\pm 10^{-3}$	$\pm 5.10^{-2}$
Coefficient de température de 0 °C à +60 °C	2.10^{-4}/°C			
Dérive à long terme à charge constante après 24 h et sur 6 mois	$\pm 3.10^{-3}$			
Ondulation résiduelle et bruit crête à crête	⩽ 2 mV	⩽ 2 mV	⩽ 3 mV	5 mV
Réponse transitoire (overshoot et undershoot inférieurs à 10 %)	⩽ 20 µs			
Impédance de sortie dynamique jusqu'à 100 kHz	0,3 Ω	0,3 Ω	0,15 Ω	
Sécurité individuelle par limitation du courant réglé à	3,3 A	3,3 A	6,6 A	fusible
Plage de température	0 °C à +50 °C sans derating			
	de +50 °C à +60 °C avec derating de 3 %/°C			
Protection thermique	2 vigithermes: > 50 °C Lampe orange > 60 °C Lampe rouge et coupure de l'Alimentation			
Visualisation d'une surcharge	un voyant par tension			
Réseau	220 V 50 Hz (possibilité 117 V)			
Dimensions	483 × 525 × 6u			

SAPHYMO-SRAT

DÉPARTEMENT ALIMENTATIONS

SERVICES COMMERCIAUX

51, RUE DE L'AMIRAL-MOUCHEZ
75-PARIS XIIIe
Tél. 588 45 39 - 588 16 39

The end of your search for discriminators starts here.

The T105/N:
New general purpose dual discriminator with low threshold.

Variable threshold:
10-turn calibrated potentiometer for −50mV to −500mV threshold settings. One and only one output per threshold crossing.

Output width:
Typically 4 nsec plus delay of WIDTH cable; 3 nsec FWHM in MIN WIDTH position with cable removed.

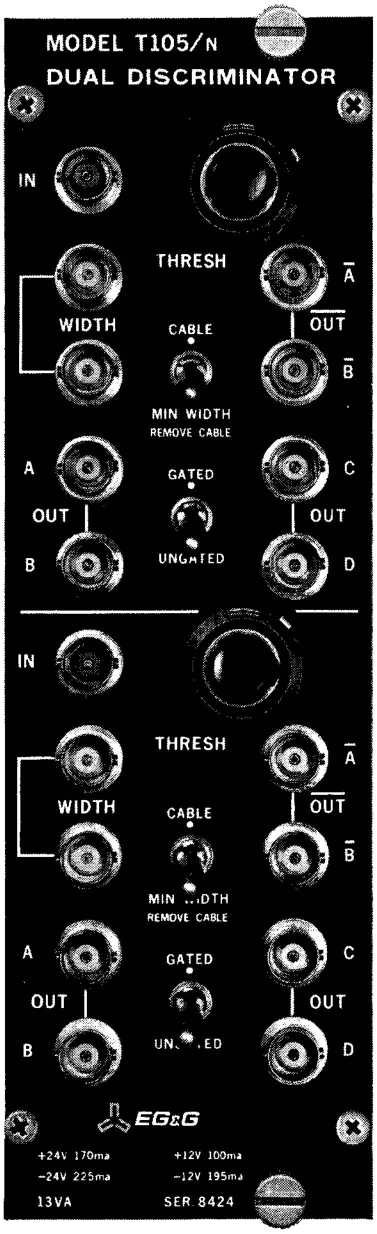
Stability:
WIDTH cable assures invariant output width and deadtime. Sophisticated circuitry guarantees threshold stability.

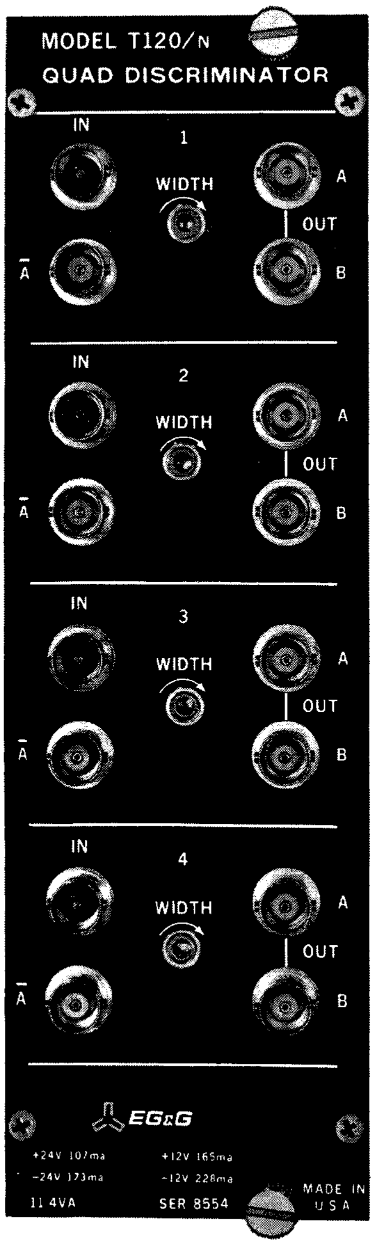
Inputs:
50-ohm termination with dc or transient reflections less than 5%; fully protected.

Slewing:
Less than 1 nsec from threshold to 10X threshold.

Rate:
Greater than 150 MHz CW or pulse burst for full NIM logic output signals.

Fanout:
3 Dual Outputs.





The T120/N:
New quad updating discriminator, designed for low-cost-per-channel.

Threshold:
−100mV, internally adjustable from −80 to −200mV.

Updating Timer:
Guarantees pre-selected output pulse width after most recent threshold crossing, independent of previous operating history.

Inputs:
50-ohm termination with dc or transient reflections less than 10%; fully protected.

Output width:
Continuously adjustable from 5 to 150 nsec.

Bin gating:
All sections controlled by single rear panel toggle switch.

Slewing:
Typically 1.0 nsec from threshold to 10X threshold.

Rate:
100 MHz CW. Pulse pair resolution typically 8 nsec.

EG&G
NUCLEAR INSTRUMENTATION DIVISION

For detailed data on the T105/N or T120/N - or information on the complete line of system-engineered EG&G instruments - contact EG&G, Inc., Nuclear Instrumentation Division, 36 Congress Street, Salem, Massachusetts 01970. Phone: (617) 745-3200. Cables: EGGINC-Salem. TWX: 710-347-6741. TELEX: 949469.