EUROPEAN ORGANIZATION

FOR

NUCLEAR RESEARCH

ANNUAL REPORT

1957

CERN

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In accordance with the provisions of the Convention, the following report gives an account of CERN's activities in 1957 when Sir Ben Lockspeiser was President of the Council.

F. de Rose
President of the Council

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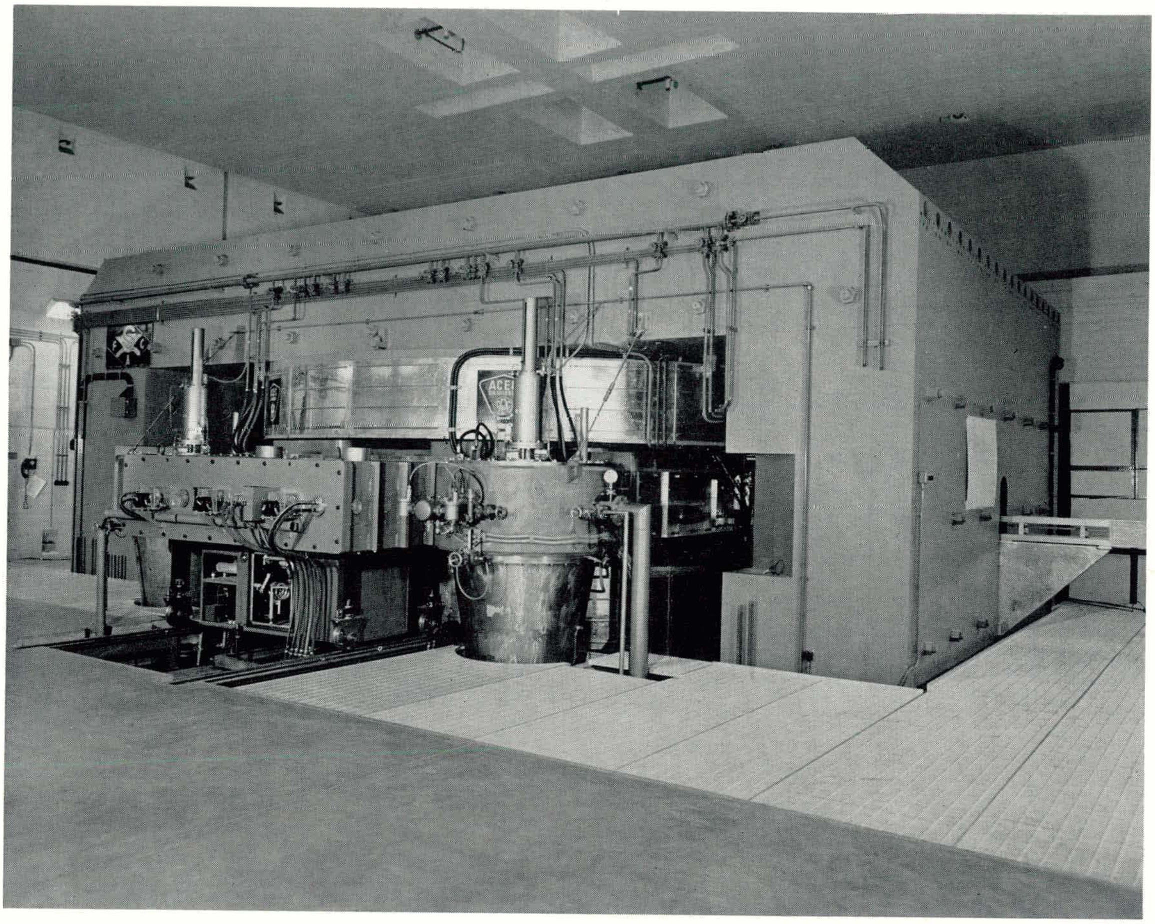
TABLE OF ILLUSTRATIONS



General view of the 600 MeV synchro-cyclotron.

INTRODUCTION

Since the synchro-cyclotron produced its first beams in August 1957, CERN is beginning to assume the rôle for which it was created.

CERN is already preparing for experiments with the 25 GeV accelerator whose construction is progressing.

It is also pursuing actively the study of problems for the future.

C. J. Bakker

Director-General

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PROGRESS AND STRUCTURE OF CERN

1. General activities

During the period under review construction work on both accelerators and the buildings on the CERN site at Meyrin progressed according to schedule. At the end of November 1957 practically the whole staff was installed on the site, so that co-operation between the various Divisions and the co-ordination of their work have been greatly facilitated.

On 1st August 1957, the CERN 600 MeV synchro-cyclotron came into operation, practically on the date foreseen many years ago. This fact has undoubtedly given rise to a new atmosphere in the Organisation, because the phase has now started when CERN scientists and visiting scientists from Member States can actually perform experimental research with a CERN machine.

An interesting programme of research will now be carried out, in which Professor Bernardini, who was recently appointed Director of Research in the Synchro-cyclotron Division, is taking an active and leading part.

The assistance which the Theoretical Study Division is always ready to give to the experimental physicists, is of the utmost importance. In this respect CERN might well be unique in the world as an example of extremely fruitful co-operation between experimental and theoretical physicists.

The Proton Synchrotron Division will also enter upon a new phase soon as, after many years of preparation, the actual assembly of the accelerator components will start early next year. Work progresses according to schedule and the machine can be expected to come into operation in 1960 as planned, provided that no unforeseen difficulties arise in the next few years.

Preliminary work has been started on the preparation of a research programme for the CERN 25 GeV proton synchrotron. The Theoretical Study Division prepared a draft programme, which was also discussed in wider circles at the international conference in Venice-Padua, in September. A research group is now being established in CERN in order to study the programme in detail and it will first be engaged on the design and construction of the heavy experimental equipment, required for research with the machine. Such equipment may take a few years to construct and it should be available by the time the machine is finished in order not to delay the starting of research work. Detection methods also have to be studied carefully. This research group will have its headquarters near the proton synchrotron, but it is considered essential that it should work in close co-operation with the experimental physicists in the Synchro-cyclotron and the Scientific and Technical Services Divisions, with the applied physicists in the Proton Synchrotron Division and with the Theoretical Study Division. The Group will be using the synchro-cyclotron to test apparatus and eventually to do some research. A joint effort of CERN should thus make it possible to evolve the best method of using the proton synchrotron for fundamental research in physics.

A group attached to the Proton Synchrotron Division is studying the possible applications of new techniques to the construction of high energy accelerators. These studies are especially important in case the Council of CERN should decide to extend the present CERN programme in future years.

In the Scientific and Technical Services Division, the rapid development of bubble chambers and of methods for the instrumental evaluation of track chamber pictures might be mentioned in this introduction as being of great value for experimental work with the machines.

From 1st October 1957, theoretical studies were concentrated at CERN in Geneva, and the Theoretical Study Division in Copenhagen thus terminated its work. It is fitting to record here our gratitude to this Division which, initially under the leadership of Professor Niels Bohr and later under Professor Møller, has played a considerable part in establishing CERN's good name all over the world.

During August 1957, a first meeting was held of the Advisory Committee to the Director-General on the use of the synchro-cyclotron by visiting teams from Member States. Such co-operation is considered to be of great importance both to the Member States and to CERN.

Several first-class physicists from non-Member States are now pursuing their studies in the CERN laboratories through the grants offered by the Ford Foundation. This certainly adds considerably to the general standard of physics research and is of great benefit to the Organisation.

Preparations are being made for the Eighth Annual Conference on High Energy Nuclear Research to be held at CERN as a continuation of similar well known international conferences held for seven years in succession at the University of Rochester, Rochester (N.Y.) U.S.A.

The Director-General represented CERN in September 1957 at an international conference at the Weizmann Institute, Rehovoth, Israël, which he had been invited to attend by the organizers.

Several CERN physicists including the Director-General took part in the international conference on Mesons and Recently Discovered Particles, in Venice-Padua, in September 1957.

2. Council, Committees and internal structure

The following organizational chart reflects the changes which have occurred among the officers of the Council and its Committees.

The Theoretical Study Division at Copenhagen closed down on 1st October 1957. On the other hand, the Theoretical Study Division in Geneva, headed by Professor B. Ferretti, has considerably expanded its activities. Cosmic ray studies are still under the direct supervision of the Director-General, but pursuant to the decision taken by the Council at its 9th session on 19th December 1957, this work will come to a close during the course of 1958. The Public Information Service, set up during the course of the year, is also directly responsible to the Director-General.

The Electronics Group and the Main Workshop, which previously formed part of the Scientific and Technical Services Division, have respectively been transferred to the Synchro-cyclotron Division and the Site and Buildings Division.

LIST OF MEMBER STATES

AND

PERCENTAGE CONTRIBUTIONS TO BUDGETS FOR THE YEARS 1957, 1958 AND 1959

Member State	*Contribution %*
Belgium	4.89
Denmark	2.23
France	22.26
German Federal Republic	18.27
Greece	1.08
Italy	10.61
Netherlands	3.78
Norway	1.72
Sweden	4.85
Switzerland	3.48
United Kingdom of Great Britain and Northern Ireland	25.00
Yugoslavia	1.83

COUNCIL OF THE ORGANIZATION

STRUCTURE AND MEMBERSHIP

OFFICERS OF THE COUNCIL * President : Sir Ben LOCKSPEISER (United Kingdom)
Vice-Presidents : Professor J. HOLTSMARK (Norway)
M. F. de ROSE (France)

DELEGATIONS (Two delegates from each Member State **)

Belgium	Denmark	France	German Federal Republic	Greece	Italy	Netherlands	Norway	Sweden	Switzerland	United Kingdom of Great Britain and Northern Ireland	Yugoslavia
M. J. WILLEMS Professor M. de HEMPTINNE	Professor J. K. BØGGILD Mr. O. OBLING	M. F. de ROSE Professor F. PERRIN	Professor W. HEISENBERG Dr A. HOCKER	Professor T. G. KOUYOUMZELIS M. G. BENSIS	M. R. CARROBIO di CARROBIO Professor F. IPPOLITO	Mr. J. H. BANNIER Professor J. de BOER	Professor J. HOLTSMARK Professor E. HYLLERAAS	Dr G. FUNKE Professor I. WALLER	Professor P. SCHERRER M. A. PICOT	Sir Ben LOCKSPEISER Sir John COCKCROFT	M. S. NAKIĆENOVIĆ Professor I. SUPEK

SCIENTIFIC POLICY COMMITTEE

Chairman Professor W. HEISENBERG *
Vice-Chairman Professor L. LEPRINCE-RINGUET
Members Professor H. ALFVÉN
Professor G. BERNARDINI
Professor P. M. S. BLACKETT
Professor N. BOHR
Sir John COCKCROFT
Professor P. SCHERRER

COMMITTEE OF THE COUNCIL

Chairman
the President of the Council
Sir Ben LOCKSPEISER (United Kingdom)

Members
the Vice-Presidents of the Council
Professor J. HOLTSMARK (Norway)
M. F. de ROSE (France)
the Chairman of the Finance Committee
M. J. WILLEMS (Belgium)
the Chairman of the Scientific Policy Committee
Professor W. HEISENBERG (German Federal Republic)

Members of the Council *
M. R. CARROBIO DI CARROBIO (Italy)
Professor I. SUPEK (Yugoslavia)

FINANCE COMMITTEE

Chairman M. J. WILLEMS (Belgium) *
Members one delegate from each Member State

INTERNAL ORGANIZATION AS AT DECEMBER 31st 1957

Director-General: C. J. Bakker

Attached to the Director-General: Public Information Service; Cosmic rays

Theoretical Study Division (TH)	Proton Synchrotron (PS)	Synchro-cyclotron (SC)	Scientific and Technical Services (STS)	Site and Buildings (SB)	Administration (ADM)
B. Ferretti	J. B. Adams	W. Gentner	L. Kowarski	P. Preiswerk	Jean Richemond
Theory Co-operation in the preparation of experimental research	Construction of the proton synchrotron Research on new principles for the acceleration of particles Preparation of experimental research (in co-operation with TH, SC and STS Divisions)	Testing and operation of the synchro-cyclotron Experimental research (G. Bernardini) Electronics Chemistry	Instrumentation Bubble chambers Instruments for the evaluation of photographs Electronic computation Cryogenics Health physics Scientific information	Construction and fitting out of buildings Maintenance of buildings and plant Main workshop Common services	Finance Personnel Purchasing

* *Since 1st January 1958 :*

COUNCIL :
President : M. F. de Rose (France); Vice-Presidents : Professor W. Heisenberg (German Federal Republic); M. J. Willems (Belgium).

COMMITTEE OF THE COUNCIL :
(Other than ex officio members) : Professor J. K. Bøggild (Denmark); Professor T. G. Kouyoumzelis (Greece); Sir Harry Melville (United Kingdom).

FINANCE COMMITTEE :
Chairman : Mr. J. H. Bannier (Netherlands).

SCIENTIFIC POLICY COMMITTEE :
Chairman : Professor E. Amaldi (Italy).

** *Present at one session of the Council :*

Professor E. Thomas (Belgium); Dr S. Rozental (Denmark); Professor W. K. Jentschke, Professor H. Kopfermann (German Federal Republic); Professor S. A. Wouthuysen (Netherlands); Mr. J. Cappelen, Professor H. Wergeland (Norway); Professor T. Gustafson (Sweden); Mr. D. W. Fry (United Kingdom); M. B. Komatina (Yugoslavia).

CERN SENIOR STAFF

Theoretical Study Division

D'ESPAGNAT, B.
PRENTKI, J.

Proton Synchrotron Division

BONAUDI, F.
DECAE, A.
GERMAIN, P.
GRUETTER, F.
HEREWARD, H.
HINE, M.
LAPOSTOLLE, B.
RAMM, C.
SCHMELZER, Ch.
SCHOCH, A.
STANDLEY, P.
ZILVERSCHOON, C.

Synchro-cyclotron Division

BROADBENT, D.
CITRON, A.
VON DARDEL, G.
HEDIN, B.
LUNDBY, A.
MERRISON, A.
PIZER, H.
SCHMITTER, K.

Scientific and Technical Services Division

AMIOT, P.
COBLANS, H.
GOLDSCHMIDT-CLERMONT, Y.
NEWTH, J.
PEYROU, Ch.

Site and Buildings Division

WEBB, F. A. R.

Administration Division

PENNEY, R. W.
SCHOU OLSEN, F.
TIÈCHE, C.

ACTIVITIES CARRIED OUT UNDER AUTHORITY OF THE DIRECTOR-GENERAL

1. Cosmic rays

1) General

Since the publication of the Second Annual Report it has been decided to terminate the two cosmic-ray experiments for which CERN has been responsible. The K-meson experiment in Geneva has already been stopped and some members of the Group have been transferred to other Divisions within CERN. Experimental work at the Jungfraujoch will cease at the end of April 1958, and the team of physicists now working there will be disbanded at the end of July.

2) Geneva Experiment

The decision to stop the Geneva K-meson experiment was taken after it had been clearly demonstrated that a reasonable yield of K-meson decays could only be obtained by making large modifications to the counter control system of the cloud chambers. Even so, it was clear that the experiment could hardly hope to compete with the large accelerator experiments.

The large multiplate cloud chambers have been brought to a high level of performance and a reduced team of three physicists has been testing their suitability for use with one of the CERN accelerators. It is hoped that some trial photographs will be taken shortly using a beam from the synchro-cyclotron.

3) Jungfraujoch Experiment

By the end of April 1958 the Group at the Jungfraujoch will have between 200 and 300 photographs showing high-energy (> 25 GeV) nuclear interactions produced in paraffin. The analysis of these interactions is well under way and should be completed in the summer.

Earlier work of the Jungfraujoch Group on the production of K-mesons and hyperons in different materials was reported at the Padua-Venice conference and has been accepted for publication.

4) Further work

A proposal to extend the work on the study of high-energy interactions was put before the Scientific Policy Committee in November 1957. The apparatus envisaged was costly and the Scientific Policy Committee recommended that CERN should not itself undertake the proposed experiments but should consider supporting any initiative that might come from Member States.

2. Public Information Service

Owing to the growing interest taken in CERN, the Public Information Service which previously formed part of the Scientific and Technical Services Division, was expanded and placed under the immediate supervision of the Director-General.

This Service is responsible for relations with the press, the preparation of documents for journalists, the organization of visits and CERN's participation in exhibitions.

1) Press, broadcasting and television

CERN is now being approached regularly by journalists and scientific correspondents, which is a proof of the interest that the daily papers as well as specialized periodicals take in the Organization.

It emerges from the press cuttings received that 450 newspapers, in every part of the world, have mentioned the Organization's activities. Such specialized periodicals as " Atomenergie ", " Industries atomiques ", " Discovery ", " The New Scientist ", etc., have also published articles on CERN. In response to the interest thus shown, the Service receives members of the press and it provides them not only with relevant explanations but also with documents such as photographs, copies of plans, etc.

Film producers have been coming to CERN for news material and CERN has also supplied information for documentary television shows.

Photographers on the staff of various periodicals are admitted on the site and given all facilities to take the pictures they require.

Finally, press releases are issued by the Service whenever important gatherings are held at CERN or notable events occur.

2) Visits

During the past year, 451 visits were paid to CERN by 4 229 people coming from 37 countries or territories. Many of these visitors were nuclear physics specialists, scientists, professors, high level officials, trade-union leaders, etc.

They were given detailed explanations and visited the various installations under the guidance of a member of the Service. On account of the development of these activities, the Service has had to limit the number of visitors.

3) Exhibitions

CERN participated in the "Het Atoom" international exhibition in Amsterdam. Its exhibits consisted of models of the laboratory, the two accelerators, the magnet blocks, the proton synchrotron and an aerial view of the site. The Service is also getting ready to represent the Organization at the Brussels universal exhibition in 1958, in the science hall, nuclear science section.

THEORETICAL STUDIES

MEYRIN

1. General

Unlike the other Divisions of CERN, the Theoretical Study Division is not bound to follow a construction time schedule and it has already reached normal operational status. On account of its international character, it provides young theoretical high energy physicists with an educational centre that is unique in Europe. It also attracts senior physicists from many countries.

Its scientific output is already considerable and it will certainly be stimulated when the CERN experimental groups working with the accelerators become fully operative. The Division will then enjoy the benefit of being able to obtain its data at source.

2. Organization of the Theoretical Study Division

The Theoretical Study Division at Geneva, which consisted of 7 members (5 staff members and 2 fellows) at the beginning of 1957, was considerably enlarged and, by the end of 1957, it had reached a complement of 29 members (7 staff members, 1 guest professor, 18 fellows, 7 of whom were remunerated under the Ford Foundation grant, 3 visiting scientists). Though the number of staff members has increased by only 1, that of fellows and research associates has gone up from 2 to 19. The Division also provided facilities for guest physicists who had come at their own expense or at the expense of their parent institution in order to work in an international research centre and establish scientific contacts.

To facilitate the selection of fellows for the Theoretical Study Division, every Member State puts forward a list of candidates from which CERN makes a selection, taking into account the candidates' special aptitude for theoretical studies in the field of nuclear research.

These young theoreticians constitute a special group which is not only given an opportunity to exchange views with senior theoretical physicists, but which is also deliberately kept in close touch with experimental physicists; the contacts thus established facilitate the experimental checking of theoretical ideas, on the one hand, and make it possible, on the other hand, to set fresh theoretical problems as new experimental facts come to light.

It is not intended that fellows should stay at CERN purely for educational purposes. They do, in fact, take an active part in research, and it is, for instance, to this new talent that the Division owes two of the studies carried out in 1957, namely a study on radiative pion-nucleon scattering and the development of a new and remarkably simple method of solving integral equations which occur in the general theory of pion-nucleon interactions. This method opens the way to calculations which seem likely to prove very useful in relation to the interpretation of experiments contemplated at present by the synchro-cyclotron experimentalists.

As for the Theoretical Study Division's research associates, their functions do not appreciably differ from those of fellows, but in view of their wider experience, their education is of far less concern than the active part they take in research.

The Ford Foundation fellows come from countries that are not members of the Organization. They usually are senior physicists, either from scientifically highly developed countries or from countries whose scientific effort deserves encouragement.

Finally, the Theoretical Study Division welcomed a number of visiting scientists with whom very profitable exchanges of views took place. Special mention should be made in this connection of the visit paid to us last summer by Professor Yang who enabled us to bring right up to date our knowledge in the field of weak interactions and of the two component neutrino theory. Since September, Professor Weisskopf, the eminent theoretical physicist from the Massachussetts Institute of Technology, has been giving research workers an added stimulus through his enlightening advice.

3. Scientific activities

The main object of the Theoretical Study Division is the investigation of the so-called elementary particles, their number, eventually their structure, their properties and their interactions. Such investigation is inseparable from the deeper study of the quantum field theory as a whole. On the other hand, a study of such phenomena as beta decay, though they are generally classified as " low " energy phenomena, is indispensable for a better understanding of a very important range of interactions between elementary particles. The Division therefore also devoted some attention to low energy theoretical nuclear physics.

a) *Study Groups*

As the Division increased in size, study groups consisting of physicists with similar interests were set up.

(1) Activities of Group (a)

Group (a) is mostly concerned with pion-nucleon interactions, on the one hand, and with the general study of the quantum field theory on the other. These two activities, though usually separate, complement each other fairly well since the new mathematical discoveries in field theory have their most immediate application in the study of pion-nucleon interactions (e.g. dispersion relations). This group also naturally deals with electromagnetic interactions in relation to strong interactions, with the structure of the nucleons and with the properties of anti-nucleons. Amongst the results obtained during 1957, mention should be made of the following, in addition to the two studies already referred to above :

i) a detailed study of the production of a meson in a pion-nucleon collision;

ii) a study of the scattering of high energy electrons by nucleons.

These two studies may have practical results in the experimental field;

iii) on a purely theoretical plane, the complete study of a one-dimensional model of field theory in which it is easier to overcome the difficulties encountered by the physical theory. This model could subsequently be used as a guide for the latter.

(2) Research undertaken by Group (b)

Group (b) is particularly concerned with the general study of the so-called elementary particles (nucleons and hyperons, pions and k-mesons, leptons) and of the various interactions which seem to occur between them. This group deals with very high energies, for most of the phenomena it studies can be observed only if very high energy particles are available, such as those obtained from very large accelerators. However, some of the interactions it studies give rise to phenomena that can be observed at a lower energy (e.g. pion and μ-meson decay). Among recent achievements by this group, mention should be made of :

i) a detailed study of μ-meson capture by nucleons, which may soon have practical experimental applications;

ii) the formulation of several theories intended to explain certain facts recently observed in hyperon or K-meson decay (branching ratios of Σ^+, comparison between mean lifetimes of Σ^+ and Σ^-, non-conservation of parity in these types of decay);

iii) a general description of weak interactions, in which new particles are incorporated and which accounts not only for decays without leptons but also for decays with leptons;

iv) a theoretical study of the conservation of the number of baryons and of the implications this might have;

v) a detailed study of the Bremsstrahlung of polarized electrons.

(3) Progress of Group (c)

Finally, Group (c) devotes its attention to theoretical nuclear physics : nuclear models, excited states of the nucleus, etc. Significant progress appears to have been made in the recent phenomenological theory of nuclear matter, which is mainly intended to reconcile the fact that nuclear forces have a short range with the data from the shell model of the nucleus. The compatibility of the shell model with other models has also been studied. One member of the group has continued his theoretical research on fission.

b) *Collaboration with other Divisions*

The Division endeavoured to remain in close contact with experimentalists and to render its work useful to CERN as a whole. These constant contacts have already borne fruit and given rise to ideas for new experiments.

In 1957, the Theoretical Study Division took over the organization of colloquia, which are not in fact all purely theoretical. Physicists usually from outside CERN are invited to talk on scientific problems, mostly those connected with high energy physics.

Furthermore, theoreticians periodically give talks for experimentalists. Two series of talks have been given, namely one on the various forms of representation used in quantum mechanics and the density matrix and the other on the modern theory of pion-nucleon interactions. The programme of these talks was to a large extent drawn up by experimentalists.

In order to prepare a first draft of the programme of experiments to be performed with the proton synchrotron, the Theoretical Study Division drew up a preliminary list of phenomena which, as far as could be estimated so much in advance, were likely to be interesting subjects to study with this accelerator. It also studied the problem of evaluating the relative numbers of different types of particles which could be extracted from the machine under different angles and in varying circumstances. In spite of the practical importance of this work, the results obtained in our present state of knowledge can be regarded only as rough approximations.

Besides more or less planned working programmes, informal meetings between research workers which are rendered easier by the lay-out of buildings at Meyrin, has led to fruitful discussions on a wide variety of subjects, such as the transformation of the spin of a particle in relativistic motion (μ-meson, electron), the experimental consequences of the non-conservation of parity and the various methods of observing the latter, the possible interpretation of certain experimental results obtained by the cosmic-ray group, the desirability of looking for certain details in multiple production, methods for measuring the polarization of electrons in beta decay, etc.

The list of colloquia held at the Institut de Physique in Geneva until 19th June 1957 and at the Meyrin site since that date is given in Appendix B.

CERN publications originating from the Division are listed in Appendix A under the following reference numbers :

CERN 57-6, 19, 22, 25, 26, 41, 44, 46, 56.

COPENHAGEN

1. General

The Theoretical Study Division in Copenhagen continued to work on the same lines as in the preceding years until 1st October 1957, on which date it terminated its activities as it was necessary to build up at Meyrin a theoretical Division which would be large enough to co-operate efficiently with the experimental work in progress or in preparation on both accelerators.

2. Activities in Copenhagen

The composition of the Division was the same in 1957 as in 1956. However, one additional fellow joined the Division in January 1957.

During the course of 1957 the following physicists who visited Copenhagen gave lectures to members of the Division and took part in their discussions :

J. P. Elliott
M. Levy
V. Fock
P. O. Löwdin
D. R. Hartree
W. Pauli
E. Hylleraas
R. E. Peierls
S. Johansson
C. Porter
O. Klein
D. ter Haar
H. Wergeland

The following members of the staff of the Institute for Theoretical Physics of Copenhagen University and guests of that Institute gave lectures for the Division :

J. M. Blatt
M. Preston
R. M. Eisberg
M. Scharff
S. Kamefuchi
R. Sheline
P. Meyer
G. M. Temmer
A. S. Wightman

A list of the Division's publications and preprints is included in Appendix A.

Appendix C also gives a list of the lectures and colloquia held in the Division in 1957.

3. Co-operation with other scientific Institutes

April :	Rochester Conference on High Energy Nuclear Physics, Rochester, N.Y., U.S.A. Meeting of the American Physical Society, Washington, U.S.A.
May :	Theoretikertagung at the Math. Forschungsinstitut der Universität Freiburg, Oberwolfach, German Federal Republic.
June :	Colloques internationaux du Centre National de Recherche Scientifique. Problèmes mathématiques de la théorie quantique des champs, Lille, France.
September :	International Conference on Nuclear Structure, Rehovoth, Israël.

C. Møller was invited to give a series of lectures at the Physical Institute in Pisa, in March, and G. Källén was invited to lecture in Milan and in Paris in May.

G. Källén also paid visits to the Physikalisches Institut der E.T.H., Zurich, Institute for Theoretical Physics, University of Milan, Ecole Normale, Paris.

B. Mottelson visited the Institute for Theoretical Physics, Uppsala University, in May, and lectured on " Collective motion in the nuclear shell model ". In July he gave a series of 8 lectures on " Coulomb excitation and nuclear structure " at the Yugoslav Summer School on Mali Lošinj, Yugoslavia.

The following are the reference numbers of the CERN publications dealing with theoretical studies conducted in Copenhagen, listed in Appendix A.

CERN 57 - 3 - 4 - 7 - 8 - 13 - 15 - 16 - 17 - 18 - 20 - 23 - 24 - 27 - 31 - 32 - 33 - 34 - 35 - 36 - 37 - 38 - 40 - 43 - 49 - 50 - 51 - 52 - 53 - 54 - 55.

PROTON SYNCHROTRON

1. General

During 1957, the greater part of the Proton Synchrotron Division continued to concentrate its effort on the construction of the accelerator (buildings and machinery). For its part, the special Research Group on new principles for the acceleration of particles directed its initial research work towards electron plasma rings and beam stacking methods.

Finally, a number of physicists and engineers co-operating with some members of the Synchrocyclotron, Theoretical Study and Scientific and Technical Services Divisions have made a start on preliminary work for experimental research (first draft of a research programme, apparatus and instrumentation).

The buildings are practically completed; only the internal fittings of the Power House remain to be finished.

In regard to the machine itself, many components of the linear accelerator have been delivered and are in the course of assembly. The initial components of the magnet have also been received on the site without appreciable delays, and magnetic and mechanical tests have been carried out and have so far proved entirely satisfactory.

The Division is now past the design, planning and ordering stage, and has entered upon the most active phase of the construction of the machine and of its ancillary equipment.

The last major contract, namely that for the vacuum pumping equipment, was placed at the end of the year. Only minor contracts remain to be placed. Some members of the Division are on permanent detachment at the contractors', where they supervise the manufacture of the equipment, carry out trials and test the apparatus before delivery.

The whole Division is now installed at Meyrin and the old offices and laboratories at the Institute of Physics in Geneva have been completely vacated.

There are 165 staff members engaged on the design and construction of the proton synchrotron, plus 9 fellows in the Research Group studying new ways of accelerating particles (3 CERN fellows, 3 Ford fellows and 3 physicists detached from outside laboratories).

2. Orbit theory

(a) *General problems*

After a fairly complete understanding of the effects of imperfections of the guiding field on orbit stability had been reached for static working conditions of the synchrotron, the behaviour of betatron oscillations under dynamic working conditions (Q-values sweeping through a subresonance) has been studied in more detail. Under dynamic conditions particles may " lock-in " at a subresonance and upset the effect of the stabilizing nonlinearities. The practical conditions on the rates of sweep and exciting pertubations to avoid the " lock-in " have been established. Experiments on the dynamic behaviour at subresonances, using the electromechanical betatron oscillation analogue, are still in progress. (See page 27).

This oscillation analogue was improved by two additions : (1) a direct display of the phase plane paths of one dimensional particle motion on an oscilloscope screen, (2) a pulse generator producing 20 adjustable kicks per revolution for the simulation of misaligned magnets. This device will be used for the study of methods to straighten a distorted closed orbit.

Most of the experiments done earlier in order to check orbit perturbation theory were repeated using the improved technique of display. The analogue was also used for the study of " beam stacking " in the CERN synchro-cyclotron, a phase oscillation problem which could be satisfactorily simulated by the analogue and fit in well with the study of the dynamic crossing of resonances, which is still under way.

For the study of the mechanism of particle loss by betatron oscillations, a second analogue has been devised and partly constructed, using electrons " suspended " in a combined magnetic and electric field. In this analogue, a bunch of electrons can be subjected to all the kinds of perturbations likely to be encountered in our machine.

The work carried out with the new betatron oscillation analogue was mainly dependent on obtaining the high vacuum required. 10^{-9} mm. Hg have now been reached. Under these conditions an electron would carry out more than 10^6 oscillations per collision time, so that the development of this analogue is justified.

Theoretical studies have been started with a view to using the information supplied by pick-up electrodes in order to determine the shape of the beam inside the proton synchrotron.

(b) *Special problems*

A programme for computing orbits in the CERN synchrotron to take account of all known systematic errors in the magnet (fringing fields, eddy current and saturation effects) was run on the National Physical Laboratory computer in England. With this information the precise lengths and n-values of the magnets were determined, and the effects of the various correcting lenses and poleface windings have been investigated. A more elaborate programme, including random errors and misalignments, simulating the finished synchrotron as closely as possible, is being prepared.

However, the implementation of the big computing programme (orbits in the proton synchrotron) has been seriously held up because of delays in the delivery of the computer. A reduced programme for use on a machine outside CERN is being worked on.

In connection with the specifications for the poleface windings and the vacuum chamber, the orbit perturbations caused by eddy currents in the vacuum chamber and the merits of a slowed down rate of rise of the magnetic field at injection have been reexamined. The effects of ripple of the magnet supply on the orbits was also reconsidered at the same time. The problems likely to arise in connection with the magnet block testing programme have also been studied.

Work has been started on procedures to be adopted during the running-in period of the synchrotron, so that adequate measuring and control equipment should be ready in time and the testing programme be drawn up.

3. Research on new ideas for accelerators

The setting up of a group for research on new ideas for accelerators was reported in the previous Annual Report. The first subject taken up by this group was the scheme of a plasma ring accelerator proposed by Budker at the CERN Symposium in 1956. In this scheme the magnetic field inside a high electron current thread forming a closed ring is used to guide particles which can be accelerated to high energies. The main advantage of this scheme over conventional accelerators lies in the possibility of obtaining stronger guide fields, and therefore smaller radii of curvature of the accelerated particles. The primary difficulty, which has to be overcome before such a scheme becomes a practical possibility, is the formation of a very thin high current plasma thread, having sufficient stability and lifetime to permit one acceleration cycle. Budker's proposal is based on self-constriction of a high current electron beam whose space charge is partially compensated by positive ions. It seemed reasonable to form such a beam starting with a neutral plasma in a toroidal chamber situated in a betatron type field which is used to accelerate the electrons in the plasma and so produce the required circulating current.

Theoretical studies have been made of the conditions for obtaining continuous acceleration of electrons (" run-away " electrons) in a plasma (against friction due to collisions with ions), and of the mechanism of self-constriction, which is an oscillatory phenomenon in general.

Experimental studies have begun with an air-cored betatron which has been designed and constructed complete with a condensor bank (about 10^3 joule of stored energy) for powering it, and the necessary timing and triggering circuits. The toroidal chamber of the betatron (26 cm orbit radius) can be filled with hydrogen plasma produced by a gas discharge at one point on the circumference which spreads around the torus guided by a longitudinal magnetic field. The properties of this plasma are being measured at present and about 10^{10} — 10^{11} electrons per cm. length of the toroidal chamber have been obtained. If all these electrons are accelerated to relativistic velocities, the resulting current would be 50 — 500 ampere. A few devices for measuring the total plasma current and the electron energy have been prepared. (See page 27).

Various methods of ionizing hydrogen at very low densities have been tried, such as d.c. discharges in a Penning gauge arrangement, hollow hot cathode discharges, and high frequency discharges where the diffusion is quenched by a high frequency electric quadrupole field. The last method looks interesting because it does not need magnetic fields.

Furthermore, the problem of the stability of a pinched ring current against bending perturbations (kinks) has been studied theoretically. Concerning this problem many questions have yet to be answered, but it seems clear that a plasma ring current cannot be maintained without applying powerful stabilizing forces in addition to that due to the magnetic field shaping the ring.

It is expected that the experiments which are now under way will indicate the general utility of plasma ring discharges as accelerator guide fields.

As a second subject, the study of methods of " beam stacking " is being taken up.

4. Magnet

(a) *Magnet blocks*

Work on the production of the magnet blocks is proceeding satisfactorily and according to the programme. The design of the blocks was frozen to correspond with a prototype delivered at the beginning of the year and block production began on 15th July. A mixing and handling procedure for the steel sheets was developed. Two representatives of the Magnet Group are permanently stationed at the works to undertake comprehensive steel tests, to supervise the filling of the steel store and to act as liaison officers with the blockmaker.

The steel store contained on 15th October 1957, i.e., one month ahead of the contract date, some 4 030 tons of steel of excellent magnetic properties. It is planned to utilize one half of the steel store for closed block manufacture and one half for open blocks; the second half of the steel store is finally arranged and ready for use. For all practical purposes the two halves of the store are identical and the overall situation concerning the magnetic properties is better than was anticipated.

Manufacture of the closed type magnet blocks has commenced. The first production blocks have already arrived at Meyrin and have been studied magnetically. The trend of production is encouraging. Excellent manufacturing apparatus was constructed and installed by the blockmaker, and it is hoped to reach the maximum production rate shortly. (See page 30).

(b) *Coils and other main components*

Important contracts that have been placed are for the magnet coils, supporting girders, jacks, bolts and coil protection boxes. The magnet coils are in full production. About one hundred coils are ready and being tested in the factory. Eight coils have been delivered to CERN and delivery is proceeding continuously.

Delivery of the supporting girders, jacks, coil protections and many other items has started and a total of some 90 000 pieces for the construction of the magnet is already in stock at CERN.

The contract has been placed for the delivery and installation of the complete bus bar system by which the magnet coils will be connected in a series chain. These bus bars of aluminium will be water cooled and insulated in the same way as the magnet coils.

(c) *Power supply for testing gear*

Two motor generators sets have been installed. One of these of 1 100 kW peak output is functioning satisfactorily and has been used to power the first model unit. In spite of a delay of several months in the delivery of the coils for the block testing machine this machine was ready in September as required.

(d) *Measuring programme*

The block measuring machine functions satisfactorily and it is possible to detect differences in the magnetic field gradient from one block to another of the order of a few parts in 10 000. Much effort has gone into the study of the best methods of operating the machine for the block measuring programme and a satisfactorily rapid procedure has been developed, so that we may confidently expect to keep the measuring programme abreast of the block production programme.

Parts of the unit measuring machine are already installed. The 7 000 ampere unit connections have been completed.

Apparatus has been designed and constructed for the magnetic testing of the constructional materials of all items which may influence the magnetic field seen by the protons during their acceleration in the machine. In the case of the vacuum chamber sensitive production permeability and resistivity tests are in progress at the premises of the supplier of the stainless steel.

(e) *Poleface windings and magnetic lenses*

Serious practical problems have been presented by the construction of the poleface windings. It is believed that these are now solved and a contract, based on satisfactory samples, was placed. Contracts for the quadrupole lenses and their power supplies have also been placed and tenders are being considered for the poleface winding power supply (peak power 1 400 kW) and for the sextupole and octupole lenses and power supplies.

Studies are in progress to develop electronic control systems to ensure that the excitation of these various correcting devices will be adequately automatic and reproducible. The basic methods of excitation to be used rest on systems which have been developed over the past three years and successfully tried on the various power supplies, namely the 1 100 kW power supply for unit testing and the 300 kW power supply for the block measuring machine.

(f) *Unit assembly and installation problems*

Preparations are being made for the magnet unit assembly and installation on the concrete ring girder. Assembly jigs have been manufactured and tested, and recent trials of handling apparatus for the 34 ton units proved satisfactory. Once the magnet blocks have been delivered, the course of the unit assembly programme will be determined in accordance with the results of the magnetic measurements. (See pages 28 and 29).

5. Radio frequency

(a) *Accelerating units*

Several improvements upon the original design of the accelerating units have been worked out and incorporated into the final prototype. The improvements are mainly in the automatic tuning system and the automatic volume control circuit. The testing procedure for the prototype has been worked out and the necessary test gear has been assembled.

The pre-prototype of the accelerating units was delivered in September and underwent thorough tests. The overall performance of the unit was in general satisfactory. It was necessary, however, to make changes in the physical layout of the electronic parts, to improve screening and to adapt the controls to the proton synchrotron control system. The corresponding redesign was carried out in close and efficient co-operation with the manufacturers.

A screened test-bay for acceptance tests of the accelerating units was erected, and the complete installation of the test-bay will be finished by the end of January 1958.

Apparatus for measuring the ferrite rings was installed at the manufacturer's plant, where continuous checks of the ferrite production are carried out, partly by CERN staff. The method of construction of the ferrite cylinders and cooling jackets was improved and the delivery of the ferrite cores for the accelerating resonators is proceeding according to schedule. Thirty out of 38 cylinders have already been delivered and the quality of the ferrite was still improved compared with that of the test samples sent along with the tender which was already satisfactory. For instance the cores built into the pre-prototype showed a decrease of R.F. losses by nearly a factor of two compared with the values expected from the tender samples.

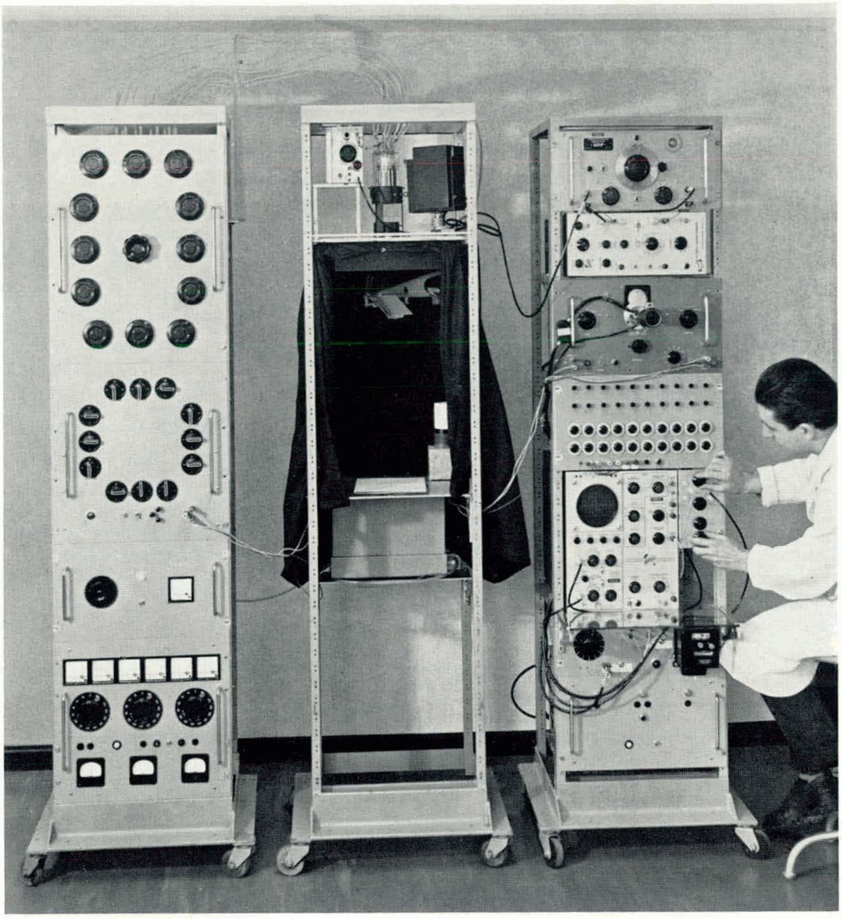
(b) *Hall computer*

The construction of Mark I computer is finished and the computer has undergone a series of performance tests, especially with respect to reproducibility over long periods of time. The reproducibility over 4 weeks is $\pm$ 1 part per thousand for magnetic fields between 200 and 12 000 gauss. On the basis of experience gained with this model, Mark II computer was designed and its construction was completed. It is now undergoing a very thorough series of tests. The reproducibility over 8 hours without any readjustments is equal to about $\pm$ 0.5 parts per thousand at injection fields and better at higher fields. The computer reproduces the theoretical frequency v. field law within $\pm$ 3 parts per thousand. Considerable improvement upon this degree of accuracy is possible, though not intended. Instead, means of arbitrarily modifying the frequency programme within $\pm$ 2% have been developed, partly in order to take care of changes of effective magnet length during the accelerating cycle, partly for experimental purposes during the running-in time of the machine.

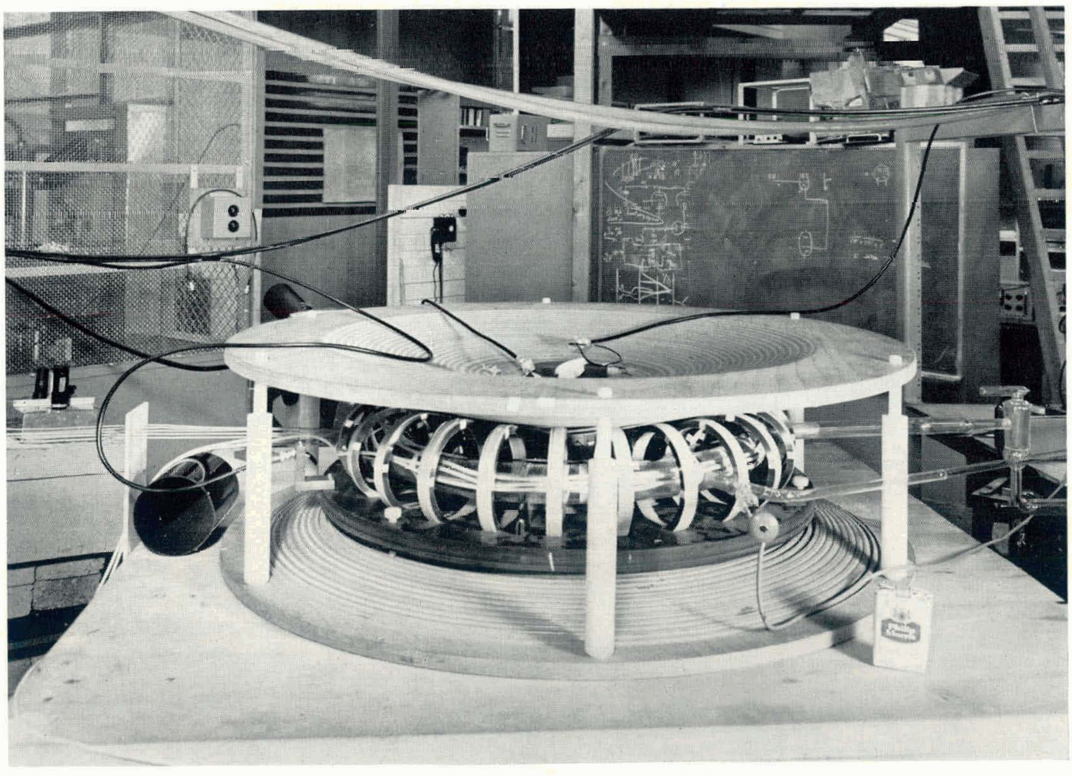
(c) *Programmed generator*

A model of a spin generator has been constructed and thoroughly tested. The performance proved to be adequate for our purposes, but the signal to noise ratio is too low because it is operated over a large frequency band.

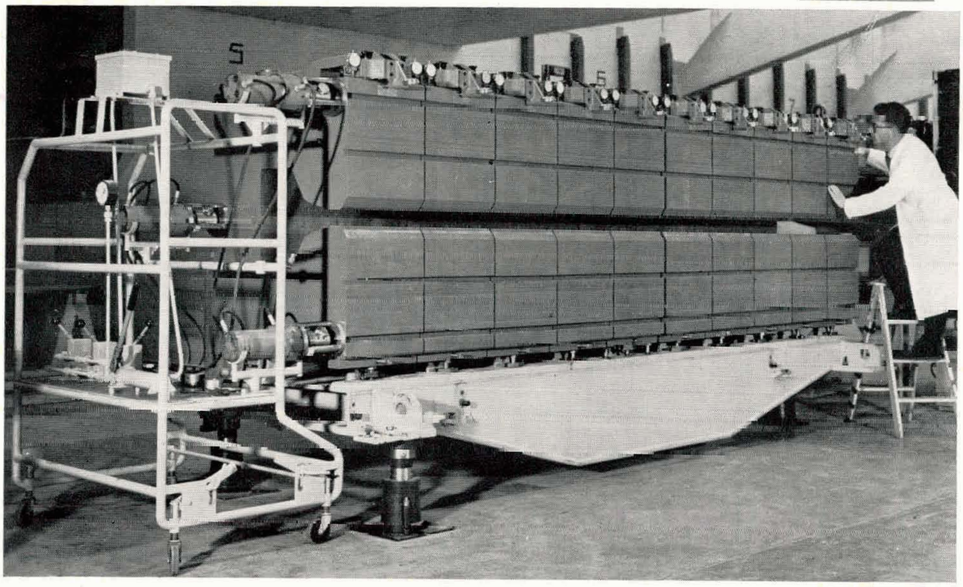
In parellel with this development, a solution using a servo-controlled oscillator was therefore studied. As a result of this study it was decided to give up the spin generator and to concentrate all efforts on the development of the servo-controlled generator. Preliminary experiments with a linear fre-



Mechanical analogue for the study of betatron oscillations.

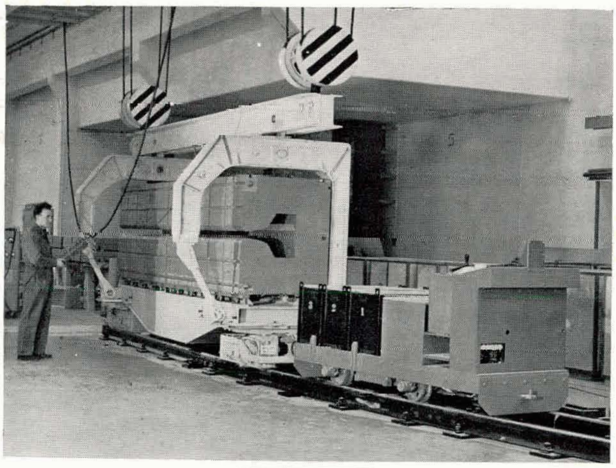


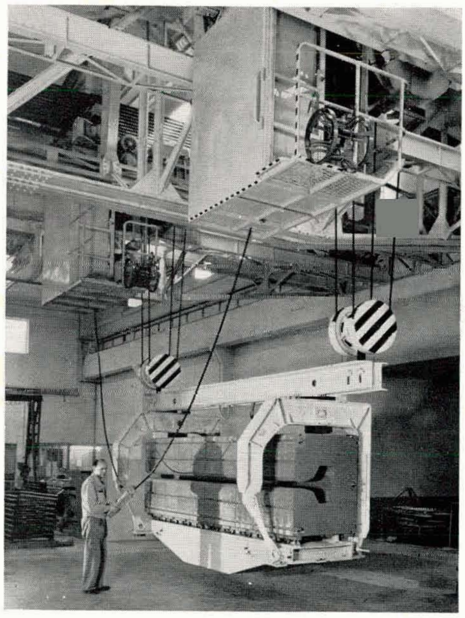
Plasma experiment.

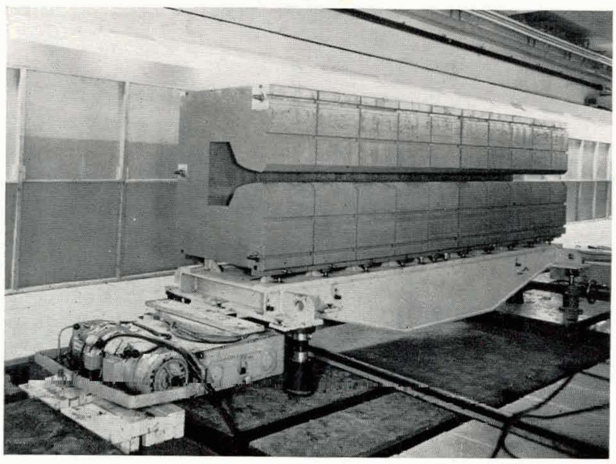


Optical checking of the alignment of ten magnet blocks.

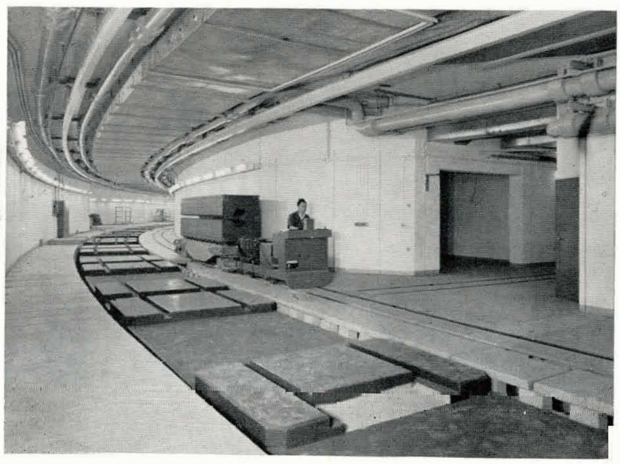
Positioning of a magnet block alignment test unit with its platform on the two load carrying bogies of the electric train, prior to moving into the ring building for trials.



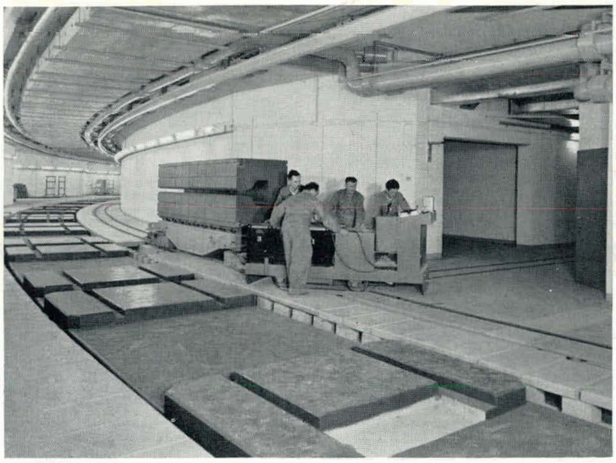


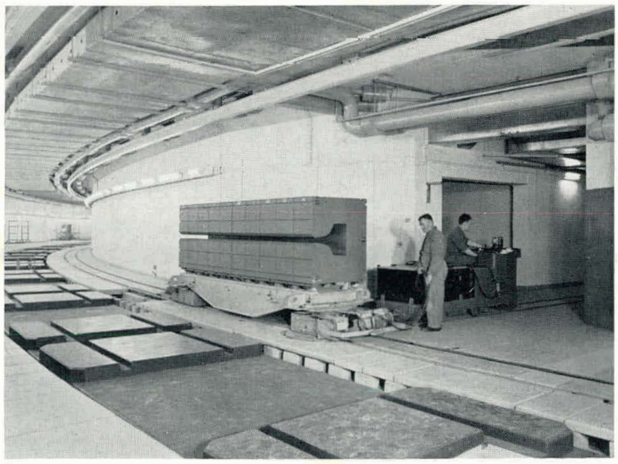


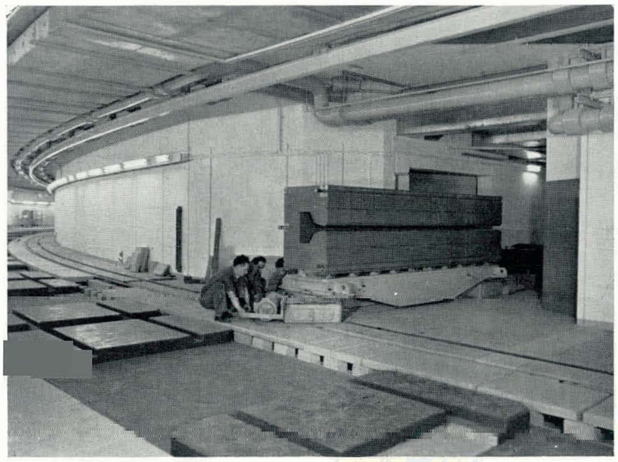
Positioning of the unit on the ring girder.

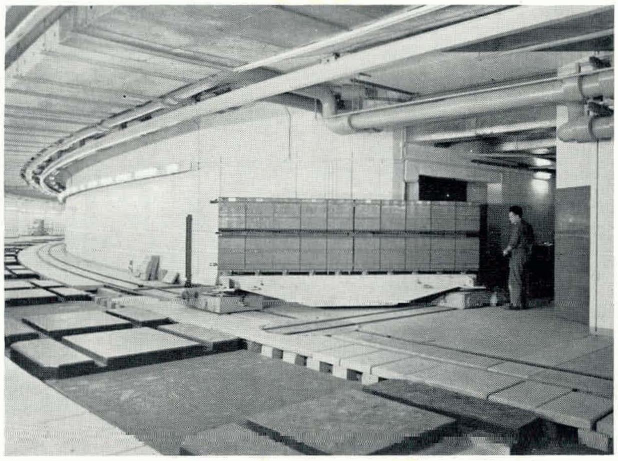


Transport of the unit inside the ring building.

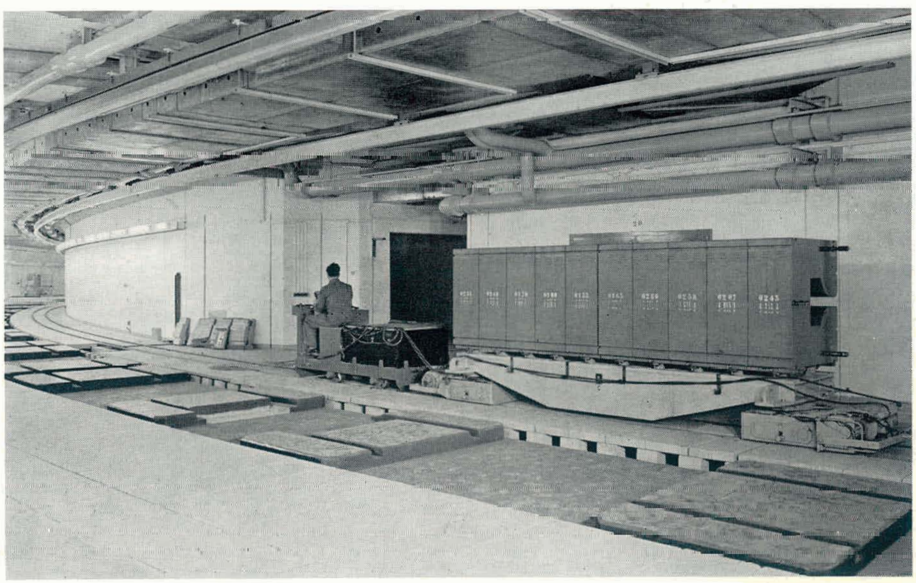


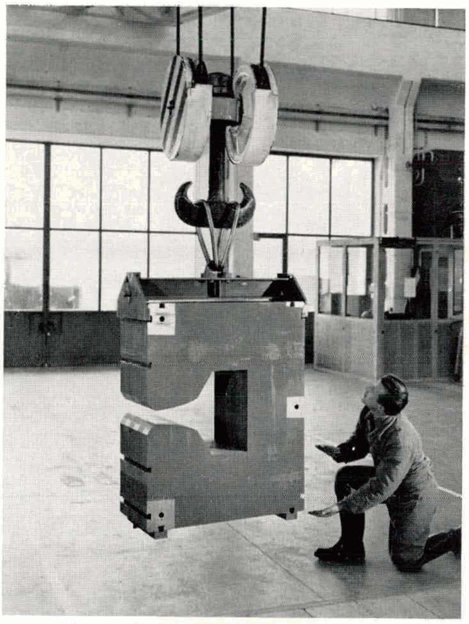






Turning a magnet block alignment test unit about by successively pivoting the two bogies on a turn-table inside the ring building.





Unloading of a magnet block on delivery and placing it in position for storing.

quency-voltage converter, based on the measurement of the charging current of a fixed capacitor, proved to be encouraging. A first servo oscillator was built and operated successfully, using a frequency-voltage converter with about ± 1 part per thousand linearity and a reproducibility over 8 hours of approximately one part per thousand.

(d) *Beam control*

The design of the beam control system was begun. It will be of the phase-locked, preprogrammed type and very probably will employ a special heterodyne arrangement to permit the transmission of information at a constant frequency carrier to the phase discriminator in the servo system. Preliminary experiments on phase-locking two oscillators by means of a servo system were encouraging, and further experiments, including in the servo loop the present experimental high power amplifier and cavity model, are in progress.

Experimental work for the development of transverse and phase pick-up electrodes is being carried out. The prototype for the pick-up electrode structure was designed. In addition, wideband high gain amplifiers with small and stable phase shift have been built and successfully tested.

e) *Phase oscillation analogue*

The construction of an electronic analogue computer for the phase motion of particles in the proton synchrotron has been completed and the computer is now in its final testing stage.

Subsequently the original analogue was improved and used to measure the anisochronism of large amplitude phase oscillations. The results obtained for the static case (no acceleration) agreed with theoretical values.

The measurements of the effect of hum resonances are being carried out at present, and preparations have been made for the studies of transition phenomena.

Some changes in the arrangement of the computer will make it possible to simulate the conditions of phase-locked beam control, and corresponding experiments are being prepared.

6. Injection linear accelerator

(a) *Installation of equipment*

During 1957 work was mostly concentrated on the installation of equipment in the wing of the linear accelerator, as follows:

— Faraday cage, erected complete (see page 35);
— pumping system of 500 kV column, installed and working;
— high tension generator (500 kV), installed;
— tank I vacuum envelope and pumping system, installed and working;
— tank II vacuum envelope and pumping system, 80% installed;
— power distribution system, installed and working.

The liner and most of the drift-tubes of tank 1 were delivered and some damage suffered in transit by the liner was repaired. The tank is ready for the assembly of drift-tubes. (See page 35).

(b) *R.F. equipment*

A considerable amount of work has also gone into modifying the 2 MW radio frequency generators, which were not very reliable when delivered by the firm. Trials were subsequently made up to 2.5 MW and the generators now appear to be satisfactory. Parts of the radio frequency system of the linear accelerator are now ready for installation in the wing.

Tests on the prototype modulator were satisfactory, and the components for all final modulators have been ordered.

Development and testing work on such items as high-power phase-shifters, attenuators and loads, servo-tuners for the accelerating cavities, R.F. monitoring equipment, has reached the point where final designs are being established.

(c) *Ion source and accelerating column*

Work with the experimental set-up of the vertical accelerating column and ion source ended when the transfer of the 500 kV set to the wing of the linear accelerator began. At that time the pulsed beam intensity was 40 mA at the bottom of the column and the measurements suggested that more current would be available by further improvements to the lens system. Some difficulties were experienced in making the horizontal accelerating column, and several vacuum leaks in it had to be repaired. It is now vacuum tight and has been tested for mechanical strength and is being installed.

(d) *Pulsed focusing magnets*

The design of the pulsed quadrupoles for tank 1 has been fixed, and a few have been made to verify construction techniques and magnetic properties. Measuring equipment for locating the axis and symmetry planes with precisions of 0.05 mm and 0.1° has been constructed. Quadrupole magnets for the first cavity are now being constructed. Final prototypes of the electronic pulsing circuits have been made and tested.

The new drift-tubes to contain these quadrupoles will have removable ends : tests on models of them have been made in a resonant cavity, and show that the joints and fixing screws do not cause R.F. breakdown at the operating electric fields strengths. Consequently the manufacture of these drift-tubes has been started.

(e) *Inflection equipment*

The two bending magnets and their stabilized power supplies have been ordered. The quadrupole lenses to be located between the linear accelerator and the synchrotron have also been ordered.

7. Electrical engineering

(a) *Power engineering*

The detailed planning of the proton synchrotron substation has been completed and part of the equipment for the substation has already been delivered by the manufacturers. Installation has started.

A detailed scheme for the remote control of the substation and other parts of the Power House has been completed and an order for the required additional equipment will soon be placed.

The power distribution system is nearly completed in the south experimental hall and in the wing of the linear accelerator. In the ring building the distribution systems for the services are completed, and the 380/220 V cables are already laid for supplying the vacuum and the R.F. systems. Power distribution equipment is also being installed in the north experimental hall and in the central building. An order has been placed for distribution boards and panels in the proton synchrotron Power House.

The detailed design of the magnet supply equipment has been completed and manufacturing is proceeding apace. The magnet power supply is nearly completed at the manufacturers. The M.G. set, including the Scherbius regulator, will be erected and tested at the manufacturers. Problems concerning the special foundation requirements for the M.G. set have been solved.

Possible methods for achieving a slow rate of rise of magnet current at the start of the pulses have been investigated.

(b) *Cabling and controls*

A standard system of cable trunking was designed and is in production. Details of installation in the ring and the radial tunnels are being prepared. Basic types of signalling cables have been decided upon, and some quantities ordered; wiring in the wing of the linear accelerator is practically completed.

Planning of the control system in general and detailed designing of control devices for the various components of the synchrotron continued. Specifications for the intercommunication and public address systems in the wing of the linear accelerator and the proton synchrotron Power House were drafted and sent off to possible tenderers.

Specifications of many different types of relays were studied, and exhaustive tests made on a few types from which a range of standard types has been selected.

8. Mechanical engineering

(a) *Cooling system*

Contracts for the magnet cooling system and for the pipework have been placed. This system is made entirely of aluminium to match the coils of the magnet and the water is demineralized. The system is designed to hold the temperature of the magnet coils to within ± 2° C. The delivery is arranged so that the system will be installed, tested and ready for use by April 1958.

The general cooling system has been simplified to a well water supply with the necessary pipe work in the ring building.

The installation of the aluminium pipes for the magnet cooling system is about to start, and the manufacture of the heat exchangers and other parts of the system is progressing satisfactorily.

(b) *Vacuum system*

Four types of vacuum chamber were investigated in detail with respect to their material, mechanical, magnetic and vacuum characteristics.

Finally the so-called thick-walled (2 mm) type was chosen and a contract was placed. The Ni-Cr stainless steel called Fluginox 130 for the chamber is being manufactured with very tight tolerances on the permeability and overall resistivity. Half the total quantity of sheet steel has already been rolled and is about to be measured.

Experimental work with oil diffusion pumps and their auxiliary safety systems continued. A getter-ionization pump was investigated with respect to its potentialities in connection with linear and synchrotron accelerators. Very poor results were obtained during the first few months of operation, but now, after many small modifications have been made, much more promising results are coming along. However this new type of pump, which presents many advantages in principle over the conventional oil pump, does not seem sufficiently developed to be of use in the synchrotron vacuum system.

Consequently tenders were for complete pumping stations using oil diffusion pumps.

9. Survey

The general study of the ground deformations continued. Comparisons of recordings of water levels on different points of the Léman's shores confirmed the periodical tilting of the ground discovered by levelling methods.

It was found that the maximum deformations to be expected are about 1 mm/100 m/month, corresponding to a maximum rate of about 0.1 mm/100 m/day. A method for setting up the magnets on the beam was evolved accordingly, consisting in executing all important operations in periods of 4 hours, within which a constancy in lengths of 0.01 mm is assured, and resetting the basic elements after each set of measurements.

A great deal of work has gone into the development of combined supports for the theodolites and microscopes to permit simultaneous readings of angles and lengths during the positioning of the magnet units. It is important that these quantities should be measured in the shortest possible time to limit the errors due to the concrete beam deformations. These supports are being designed and manufactured and the tolerance between the axes of the theodolite, the microscope and the support must remain within 0.01 mm.

Special pulleys using knife-edge bearings instead of roller bearings have been developed by the proton synchrotron workshop to stretch the invar wires used for the length measurements. The first model that has been completed has a sensitivity of 0.5 g under a 20 kg charge, which is about 100 times better than the usual metrology pulleys.

An " electric eye " is being developed for our theodolites. This device will allow the taking of a great number of angular bearings in a short time and increase the present accuracy of the theodolites. They could also be used later on if required as automatic controls of stability when the machine is working.

Studies of the optical refraction in the ring building are being carried out and it has been found that the temperature corrections are very hard to compute correctly for long sight paths. It seems easier, in most cases, to stir the air at random along the sight line and to rely on a statistical compensation. Other methods are also being tried.

Some of the 30 m long concrete ring girder sections were surveyed with invar tapes during the construction of the complete ring. Simultaneously, measurements of the temperature inside these ring sections using thermocaps were made, to obtain the temperature corrections. The shrinkage was found to reach 10^{-4} of the length in the first 36 hours of the setting of the concrete, $1.3 \cdot 10^{-4}$ after a month, and probably $2 \cdot 10^{-4}$ after a year.

It was decided to put thermocaps into the 20 joints between concrete sections to allow the constant checking of temperatures around the ring.

Dynamical measurements of the complete annular beam have given very satisfactory results. Vibrations were induced at a given point and the consequent amplitudes of oscillation recorded in several places around the beam. The period of oscillation (~ 1 s) and the wave lengths fell within 10% of theoretical computations.

The invar wires between the eight geodetic monuments and the central monument have been installed and a record is now being kept of the changes of dimensions of the foundations. These changes are periodic ($T \sim 15$ days) and reach up to now a maximum of about 0.5 mm across the diameter. This is in good agreement with the results of the survey on the underlying rock which have been obtained by surface triangulations and depth pendulums. (See page 36).

10. Building work

The offices, laboratories, experimental halls and the ring complex are all completed and occupied by the Proton Synchrotron Division. There remain several small installations, mainly services, to finish. In the ring complex the annular concrete girder is now floating free on the foundations and is complete with the dampers and water circulating system. The air conditioning system is now in full operation and accurate measurements are already being carried out on the stability of the whole structure.

Apart from some road work yet to be finished, the last major building to be completed is the Power House, which will contain the magnet generators, water cooling apparatus and electrical substation for the whole machine. Although the substation of this building is not yet finished, it has been possible to start installing the equipment in order to replace the present temporary electric distribution system. (See page 37).

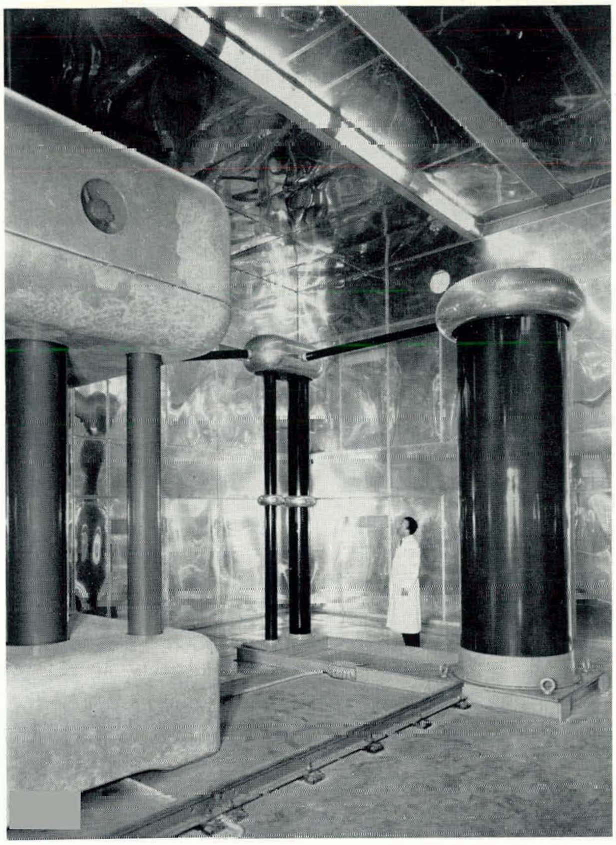
11. Nuclear Physics Group

During 1957 the problem of using the proton synchrotron for nuclear physics experiments was given some consideration. If the machine comes into operation in 1960 as at present planned, then there remain two or three years to design and construct the major components of the experimental apparatus. At an energy of 25 GeV the usual methods of particle analysis and detection break down, and not only is the experimental apparatus large and expensive, but it needs a preliminary period of study and development before the design and construction can even start.

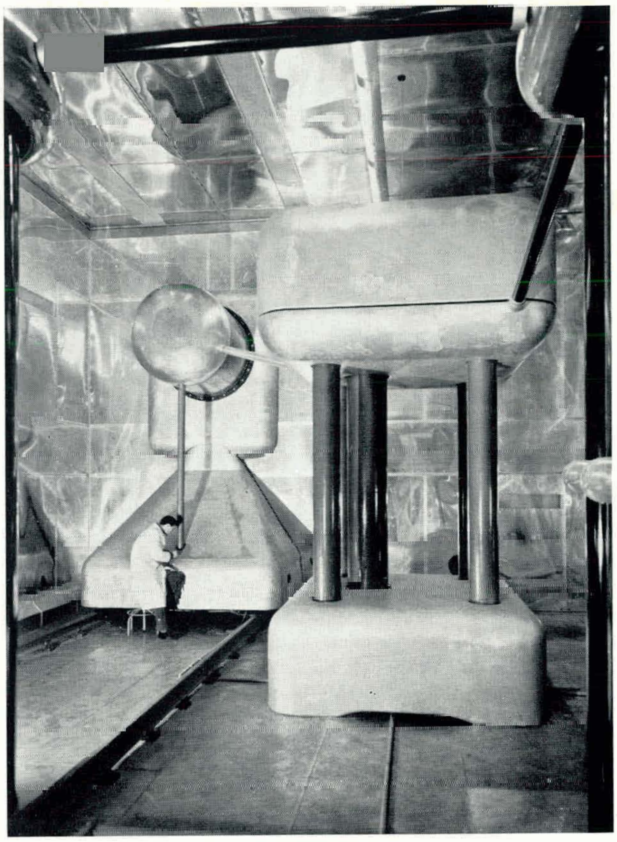
In order to make an initial selection in the vast field of possible experiments and to gain some idea of the nuclear physics apparatus involved in these experiments, a Nuclear Physics Group has been set up inside the Proton Synchrotron Division in 1957. The close co-operation of this group with the Theoretical Study Division, the Synchro-cyclotron Division and the Scientific and Technical Services Division should allow a judicious distribution of tasks and an efficient co-ordination of the efforts of the various Divisions.

A short list of 9 typical experiments, summarized in the following table, has been drawn up and serves now as a basis for forthcoming studies.

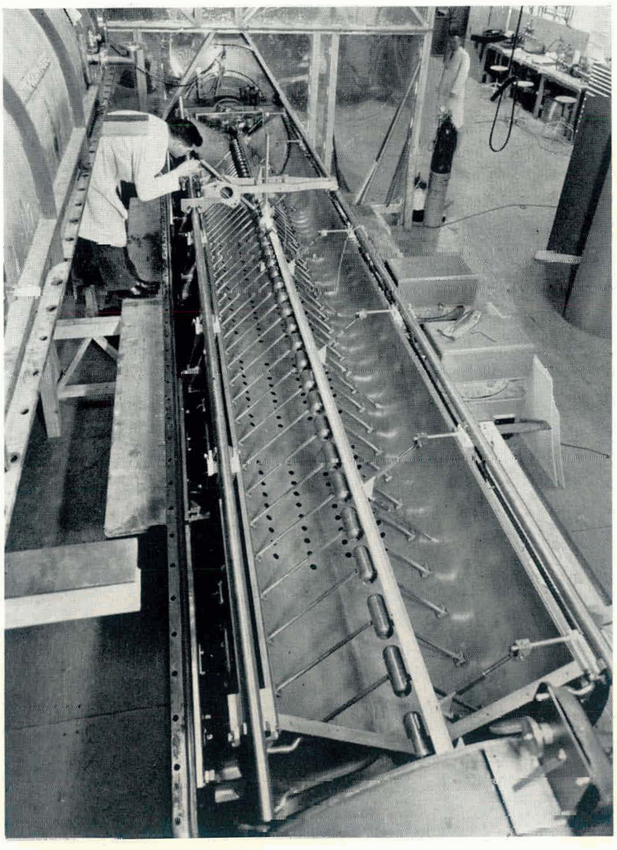
No.	*Experiment*	*Detector*	*Special problems*
1	p-p-scattering, total and differential cross sections	Counters	
2	π-p-scattering, total and differential cross sections	Counters	Discrimination against p
3	π-p- interactions: *(a)* Total and differential cross section *(b)* Production of hyperon pairs *(c)* Decay modes of anti-hyperons	Bubble chambers	Separation of π from p
4	Scattering of K^+-mesons against protons	Counters	Discrimination against p and π
5	Scattering of K^+-mesons against protons	Bubble chambers	Separation of K^+ from p and π
6	Diffractive production of π by protons on nuclei	Bubble chambers	
7	Proton-antiproton, total and differential cross sections	Counters	Identification of antiprotons
8	Proton-antiproton interactions	Bubble chambers	Separated beam of antiprotons
9	Interactions of high-energy γ-rays	Counters	



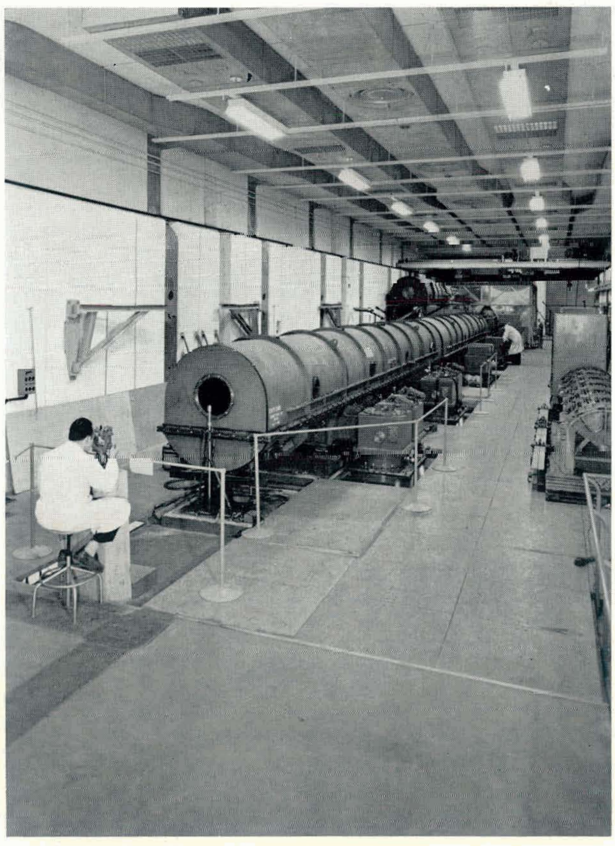
View inside Faraday cage with the 500 kV set (right) and part of ion source control platform (left).



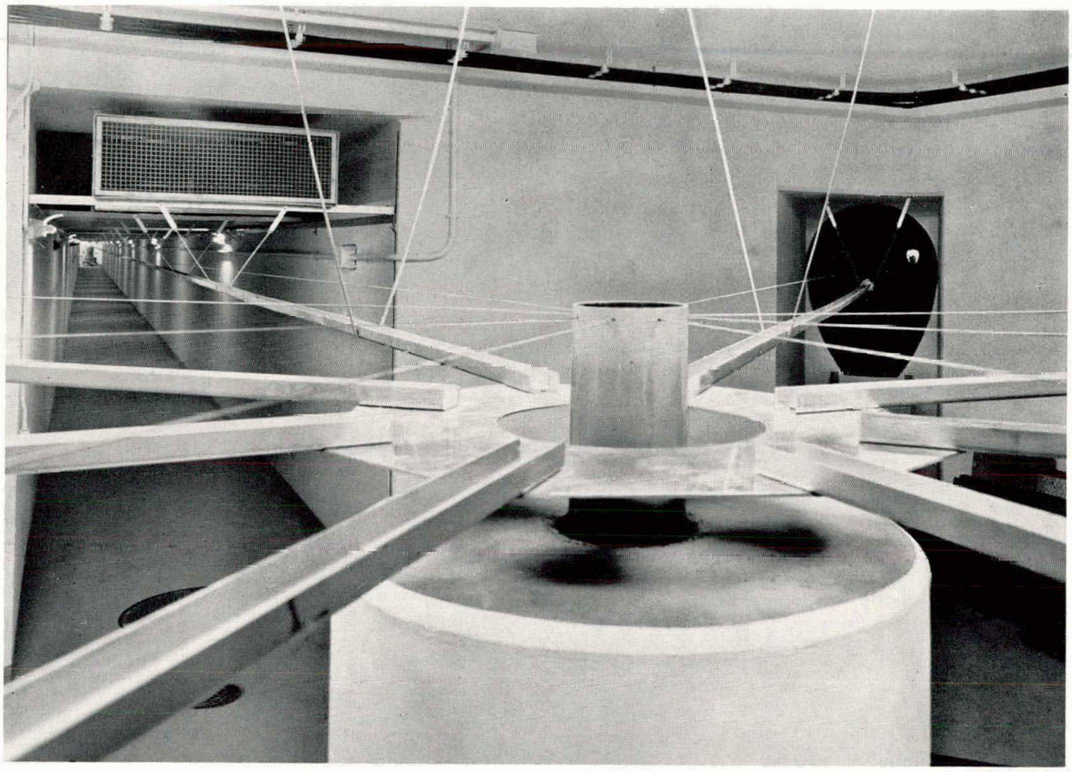
View inside Faraday cage. Horizontal accelerating column and ion source (left), and ion source control platform (right).



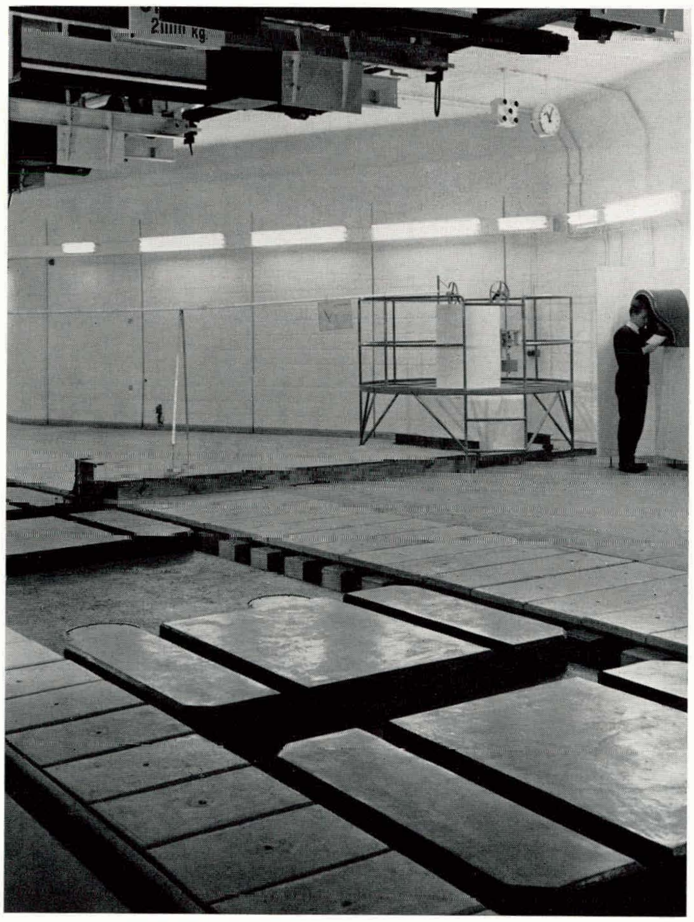
Alignment of drift tubes, tank I. View looking towards 500 kV input.

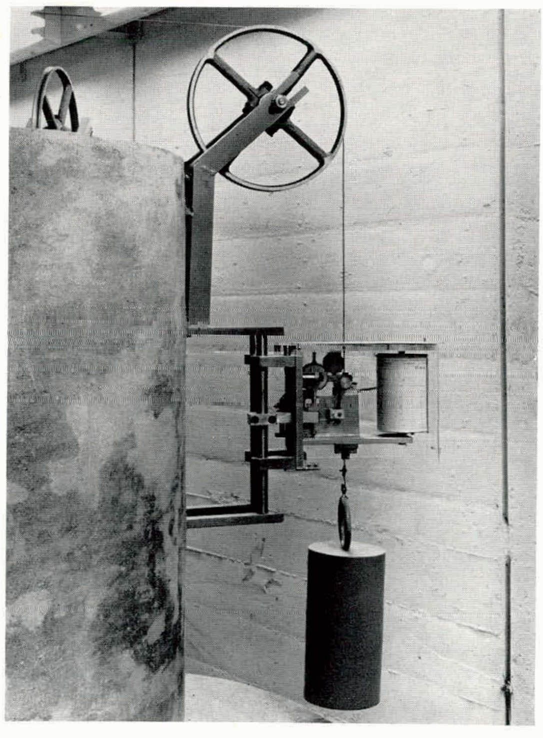


General view of Linac wing, looking from output end towards the Faraday cage.



Central geodetic monument with, in the background, a radial tunnel and a radial channel, along which the invar wires are set. Two outer geodetic monuments, 100 m away from the centre at the end of both tunnel and channel.





One of the eight outer geodetic monuments.

1 MAIN SUBSTATION
a 18kV switchgear
b 3kV switchgear
c 380/220V switchgear
d Transformer 800kVA, 18/3kV
e Transformers 800kVA, 18kV/380-220V
f Subdistribution board

2 BATTERY ROOM
a Battery charger
b Batteries

3 STORE

4 COMPRESSOR ROOM
a Air compressor unit
b Compressed air tanks

(2–4: installed in the basement of the main substation)

5 AIR CONDITIONING COMPRESSOR ROOM
a Condensing units
b Control panels
c Power distribution and control board
d Pumps
e Expansion tank
f Compressed air plant
g Subdistribution board

6 COOLING ROOM
a Heat exchangers
b Main pumps
c Slow-circulating pump
d Filter
e Demineraliser
f Header-tank with remote level indicator
g Control desk
h Power distribution board
i Subdistribution board

7 MAIN GENERATOR ROOM
a Main driving motor
b Main alternator
c Flywheel
d Frequency changer
e Tacho-dynamo
f Auxiliary alternator
g Liquid starting resistor
h Control panel
i Foundation for motor-alternator set
k 6kV switchgear for main driving motor
l Rectifier for electric brake
m 6kV switchgear for main alternator
n Alternator field breaker
o Drain pumps
p CO_2 - fire extinguisher
q Flywheel cooling air ducts
r Pit for transformer dismounting
s Oil lubricating tank
t Subdistribution boards

(h–t: installed in the basement of the main generator room)

8 POWER CONVERTER ROOM
a Mercury-arc power converters
b Power converter control panels
c Electronic exciter sets
d Control panel for electronic exciter
e Subdistribution board

9 FILTER ROOM
a Filter reactor
b Filter condensers
c Filter control panel

10 DEGASSING ROOM
a Shorting contactor
b Spare rectifier tanks
c Control panel

11 P.H. CONTROL ROOM
a Control desk
b Main control board
c Auxiliary control boards
d Main distribution board
e Main distribution board (emergency)
f Subdistribution board

12 SUBSIDIARY GENERATOR ROOM
a Scherbius cascade
b Synchronous - synchronous converter
c M.G. set for input power computer
d Subdistribution board

13 COMPUTER ROOM
a Standard magnet unit
b Subdistribution board

14 ROOM FOR PERSONNEL
a Subdistribution board

15 TRANSFORMER CELLS
a Intermediate transformer
b Transformer for main driving motor 18/6kV
c Formation transformer and commutating reactors
d Grounding resistor

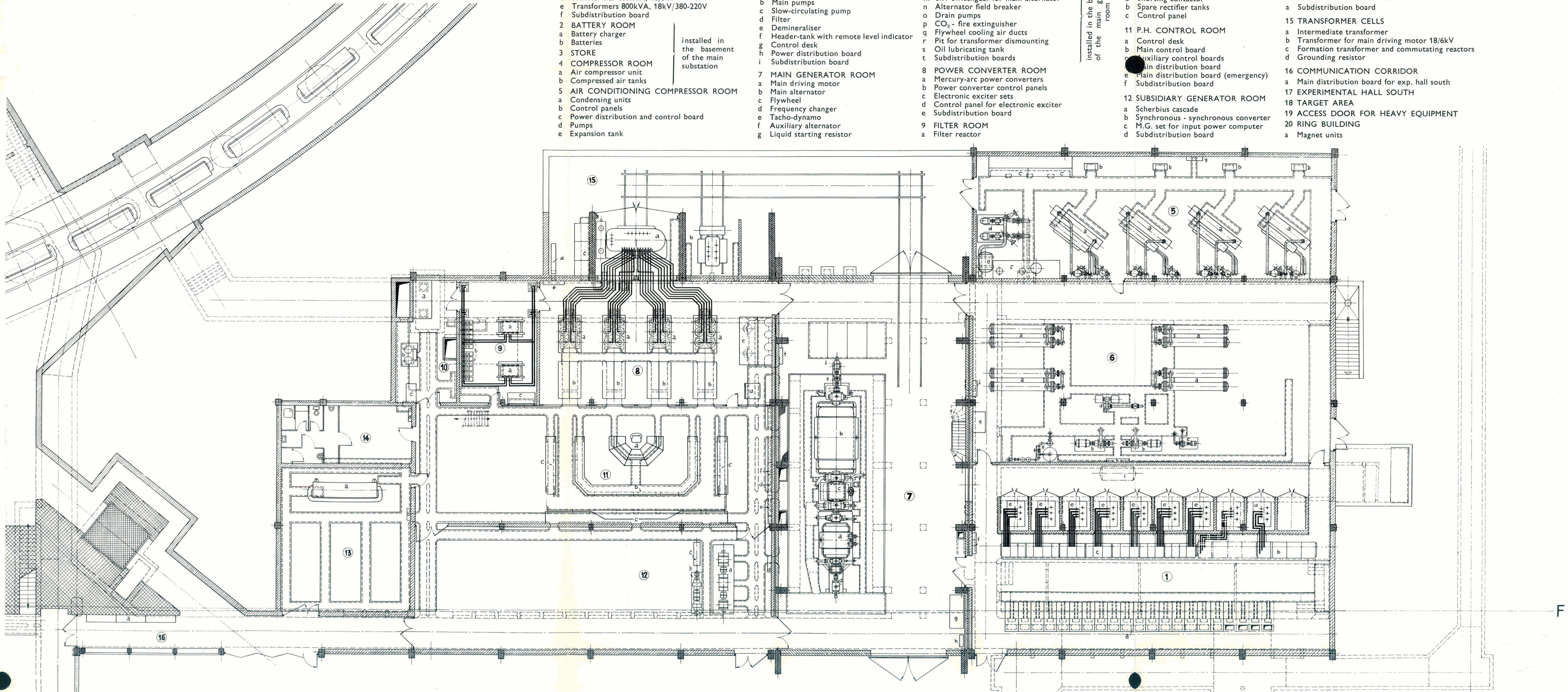
16 COMMUNICATION CORRIDOR
a Main distribution board for exp. hall south

17 EXPERIMENTAL HALL SOUTH

18 TARGET AREA

19 ACCESS DOOR FOR HEAVY EQUIPMENT

20 RING BUILDING
a Magnet units



P.S. POWER HOUSE. Main floor

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Preliminary studies undertaken in connection with these experiments on targets, the ejection system, the beam transport system, the particle analysing and particle discriminating systems and the particle detection equipment itself are only in their initial stage, and no idea can yet be given of the lines it will be decided to pursue.

As a start, the pion-proton experiments (No. 2 and 3) have been selected for a study. Various aspects of these experiments have been considered, namely the production of pions using an internal target in the machine, the yield of impurities in the pion beams, the analysis of the pion beam including the focusing channels, particle detection and identification.

The theoretical studies of pion production using the Fermi statistical model have aimed at calculating the yield of pions per steradian and MeV/c as a function of pion momentum and angle over a range of incoming proton energies. Some estimates have also been made of impurities in terms of the same variables and attempts have been made to compare the results with experimental data from accelerators and cosmic ray work.

A study has been made of the problem of the targets themselves, and particularly the use of multiple traversal targets to give long output pulses from the machine. Also calculations have been made on swinging the circulating beam onto an internal target to give short bursts (100 millimicro-second duration) of low intensity, for bubble chamber work.

Another study has been made of focusing channals and analysing systems using magnetic and electric fields. Optimum parameters for focusing systems have been established.

Considerations on time of flight methods for particle identification have shown that flight paths of 40 m and resolution times of 1 millimicro-second (which is rather optimistic) do not lead to identification at very high momentum. For example, discrimination is just possible between a pion and a proton using a flight path of 40 m and 1 millimicro-second at 7.5 GeV/c.

The use of large gas-filled Čerenkov counters for particle identification has given more encouraging results and a study on a 10 m long, 40 cm diameter chamber is under way.

A tentative layout of a typical experiment on the total cross section of pions using Čerenkov detectors, complete with analysing system, etc., showed that the proton synchrotron experimental hall is only just large enough to contain such an experiment. Due to the length limitation of the hall ($\sim$ 100 m) a flight path of 600 m is being considered on the north side of the machine. Such a flight path may be useful for antiproton experiments where the long length may be essential to remove the pions from the antiproton beam using crossed electric and magnetic fields.

The problems involved in building and using a large bubble chamber have also been given some consideration. There seems to be no upper limit on the desirable length from a nuclear physics point of view and the limitation is one of technology, man-power and cost. At present an attempt is being made to determine as realistically as possible how big a chamber can be built in CERN by 1960.

A balanced effort is necessary to insure that bubble chambers and instruments for the evaluation of photographs shall all be ready when experimental research begins. With regard to the latter instruments, it may prove necessary to put into service several semi-automatic machines and more than one fast digital computer.

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SYNCHRO-CYCLOTRON

I. GENERAL

The Synchro-cyclotron Division is the first Division which has had to deal with all the aspects of experimental research with accelerators.

The synchro-cyclotron produced its first beam at full energy on 1st August 1957, almost exactly on the date laid down several years ago, and experimental research is due to start at the beginning of 1958.

During 1957, the work of the Division therefore included not only the completion and subsequently the testing of the machine itself, but also the assembly of beam extraction devices and the preparation of the experiments of the initial programme. Co-operation for this purpose between experimental teams and theoreticians was excellent.

The recruitment of physicists and technicians continued in 1957, and, taking into account the transfer of the Electronics Group from the Scientific and Technical Services Division to the Synchro-cyclotron Division, the total complement of the Division reached a figure of 109 at 31st December 1957. 26 physicists, 19 fellows and research associates are included in this figure.

II. CONSTRUCTION AND TESTING

All the components of the accelerator were assembled and tested separately, and on 1st August, the first proton beam was accelerated and immediately reached full energy. (See pages 8 and 43).

1. Radio frequency

(a) *Delivery*

The various components of the radio frequency system were delivered 2 months later than originally expected. The delay was mainly due to difficulties with the tuning fork modulator. It was practically impossible to reproduce actual operational conditions for the modulator at the works, since it could not be mounted on an actual accelerator. It was therefore decided to have the modulator and various ancillary parts delivered before they were fully completed and to carry out adjustments at CERN.

(b) *Assembly*

Assembly began with the fitting of the dee-liner and it continued as deliveries took place. Once the dee had been put in position, assembly work proceeded on the R.F. cubicle, which houses the main rectifier and parts of the servo-systems and other control and supply apparatus. Subsequently, it was possible to fit the stub-tank and the oscillator cubicle on the machine, and to install provisionally the ancillary electronic equipment and the tuning fork control system in the cyclotron hall. After preliminary trials without a magnetic field, the ancillary electronic equipment and the control system were moved into the proton room so that the machine could be tested with a magnetic field.

(c) *Trials and adjustments*

A large number of adjustments had to be made before the installation was in full working order. A variety of problems which are normal in the construction of such a large installation and which the manufacturers had been unable to solve, had to be dealt with.

i) *Tuning fork modulator*

The tuning fork assembly is now working adequately, despite early difficulties : magnetic damping and heating of the tuning fork were both found to have more serious effects than expected, and the original auxiliary R.F. pick up system was too sensitive to spark discharge. The tuning fork drive was modified and full amplitude can now be reached in spite of magnetic damping. Heating is kept down within acceptable limits by operating the oscillator only during the length of the duty cycle. Finally an optical pick up system was developed to replace the auxiliary R.F. pick up system. (See page 52).

ii) *Oscillator*

When the R.F. system was tested without a magnetic field, it was noted that the oscillator went out of oscillation at various points of the frequency range. A number of tests were carried out to detect the reasons for these occurrences. Finally, it has been possible to track them down to resonances generated in the oscillator's ceramic condenser banks. They were eliminated through slight modifications to the layout and the size of the condensers. When pulsed tests were carried out on the radio frequency system with the magnetic field on, a similar phenomenon was noted at low frequencies; it was due to the influence of the magnetic field on the behaviour of the grid blocking valves and of the oscillator valves. The magnetic shielding of the oscillator proved too weak. Its dimensions had been determined as a result of measurements of the fringing field carried out on the model of the magnet. The fringing field was in fact much higher than could be expected from measurements taken on the model, as these had to be carried out before the stub-tank was designed. A great deal of time would have been required to improve the shielding; accordingly, the frequency response of the oscillator feedback was altered by placing a two-terminal reactance network in an appropriate position, and the feedback ratio was so increased that full excitation could be reached over the whole frequency range, despite the alterations in the behaviour of the valves caused by the magnetic field. (See page 52).

iii) *Short-circuit condenser*

Spark discharges often occurred in the condenser and a number of plates thus came to be damaged. These discharges were found to be mostly due to an inadequate vacuum in the individual condenser cavities, owing to the slow pumping speed inside the plates. The condenser was modified and now gives entire satisfaction.

(d) *Trials*

Installation trials were conducted for 6 months and came to an end in December. A reliability test was conducted under the following operational conditions :

— magnet current 1700 A;
— maximum pressure in the tank above the diffusion pump $5 \cdot 10^{-6}$ mm Hg;
— frequency range 28.89 to 16.5 MHz;
— modulation frequency 55 Hz;
— anode d.c. voltage 5 kV;
— anode input 11.5 kW;
— efficiency 60%;
— mean voltage over frequency range at dees 9 kV_{rms}.

(e) *Rotating condenser*

Although the main difficulties connected with the tuning fork seem to have been solved, construction of the rotating condenser as a stand-by is nevertheless proceeding.

2. Ion sources

The two ion sources, namely the arc source and the cold cathode source have been thoroughly tested and both of them produce currents of suitable quality; however, the current produced by the cold cathode source is more intense.

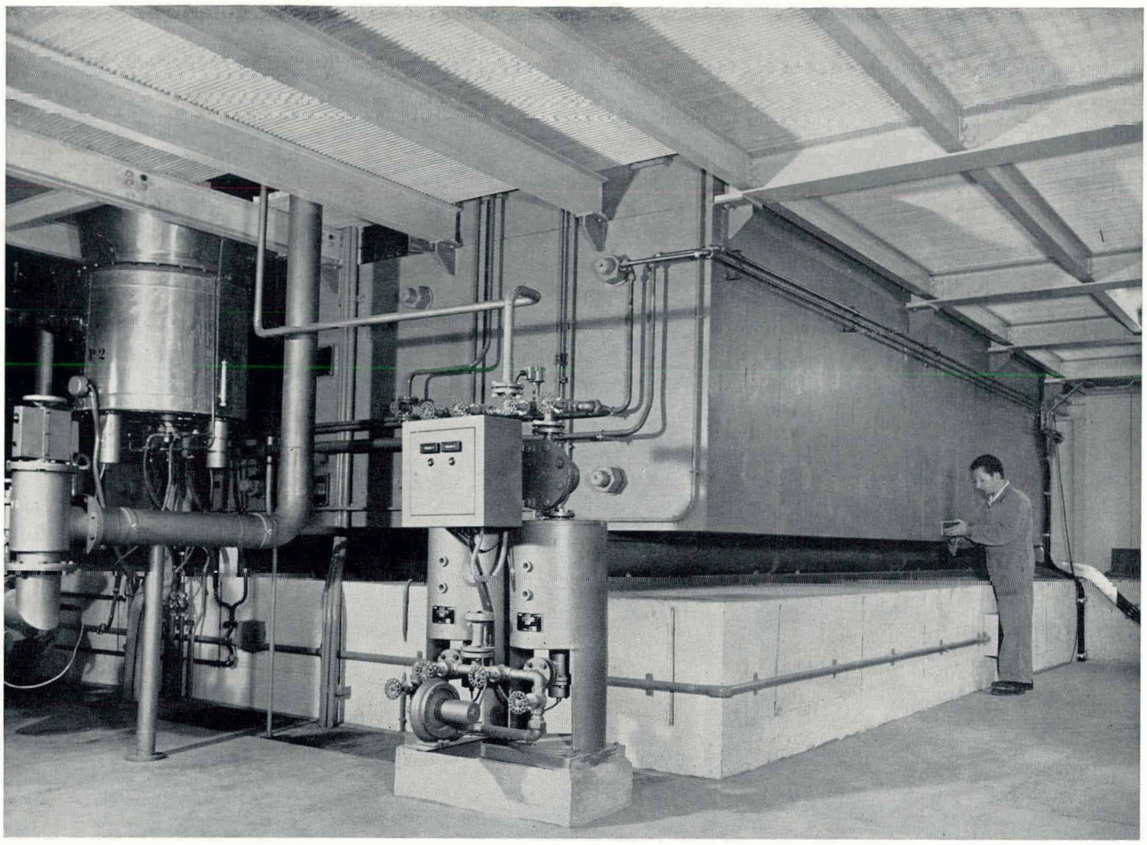
This source shows no sign of wear. Its power supply is pulsed and its power dissipation is very low, i.e. only 1 watt. Unlike the arc source, it does not require water cooling nor does the filament need to be replaced at regular intervals. The intensity of the accelerated beam is greater and can be regulated within wide limits.

The final version of the cold cathode source can be substituted for the arc source as required. There still remains to find by means of a mobile support the optimum position, where intensity is at a maximum and radial oscillations are at the minimum. (CERN Publication 57-45.)

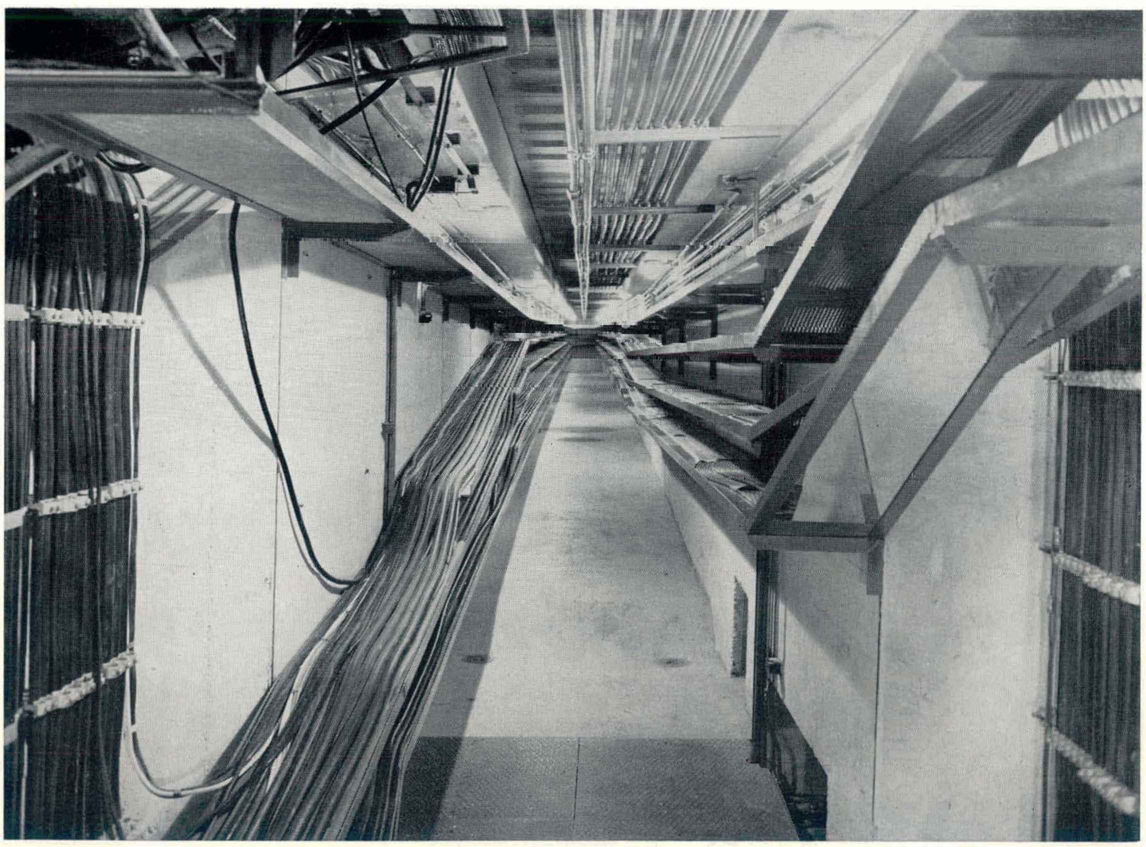
3. Internal proton beam measurements

Investigations of the properties of the internal proton beam have been started during the year under review.

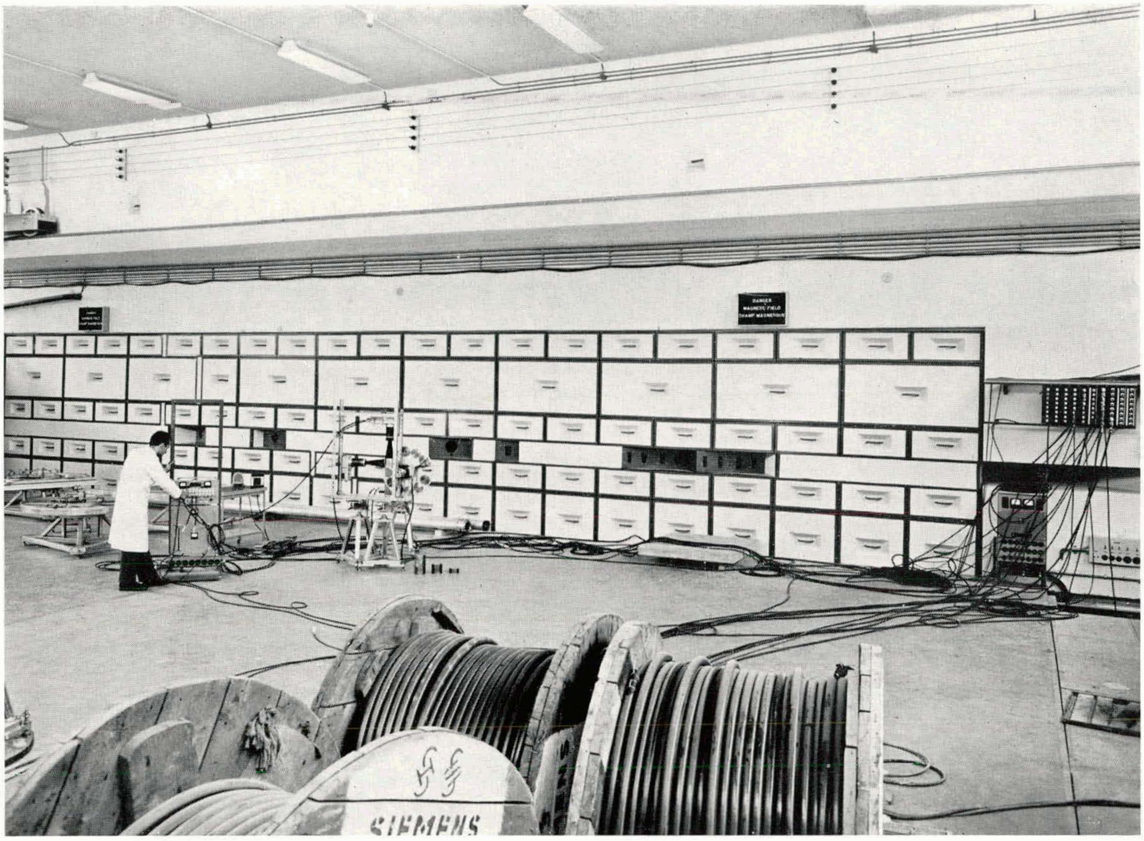
A copper constantan thermocouple mounted on the probe target was placed on different radii and gave a reading proportional to the beam current. As the energy increases the number of multiple



Synchro-cyclotron basement with part of the vacuum equipment.

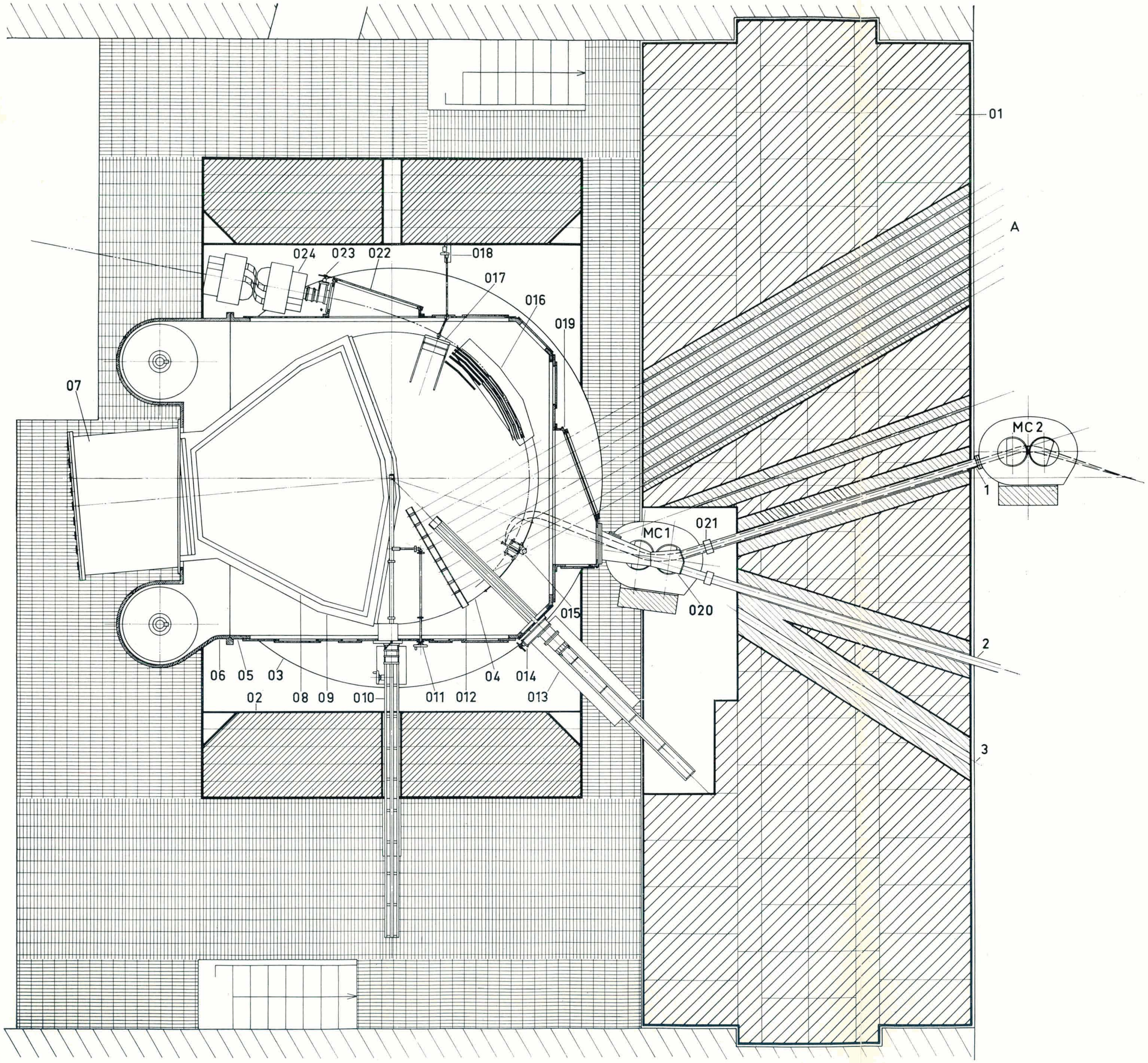


Cable passage between the synchro-cyclotron and the control station.



Experimental hall where beams of neutrons and mesons from internal targets emerge through channels in the wall.

The neutron shielding wall in lowered position.



A	Neutron Channel
MC1	Meson Deflection Magnets
MC2	
1, 2, 3	Meson Channels
01	Lifting Platform
02	Magnet Steel
03	Magnet Coil
04	Magnet Pole
05	Vacuum Tank
06	Pump Manifold
07	Stub Tank
08	Dee
09	Dummy Dee
010	Ion Source
011	Ion Source Adjustment Mechanism
012	Flip Target
013	Probe Target
014	Probe Target Air Lock
015	Universal Target
016	Magnetic Channel
017	Beam Regenerator
018	Beam Regenerator Drive
019	Neutron Blister
020	Junction Box
021	Universal Joints
022	Proton Blister
023	Vacuum Valve
024	Strong Focusing Lens

General layout showing the beam extraction channels in the neutron shielding wall.

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traversals increases and the ionization loss decreases. Therefore the thermocouple electromotive force was proportional to beam current within 20% between a radius of 1.5 m and almost maximum radius, and was approximately 0.5 mV for 0.1 μA. No loss of beam was noticed in this range of radius. The outer limit of the beam is dependent on the minimum frequency of the oscillator. No blowing up of the beam at $R = 2.27$ m, where $n = 0.2$, was noticed, probably owing to the fact that the height of the beam at this radius is only about 3 cm compared with a free height inside the dee of 12 cm.

The vertical height and position of the beam was determined by radiographs from aluminium plates with a sloping inside edge. Protons with zero vertical amplitude will first hit the target in the magnetic median plane. Because of the focusing properties of the magnetic field the subsequent passages through the target will take place mainly on the same radius, in spite of any horizontal scattering that may occur. By taking two target plates, one with the long side down, the other with the long side up, the magnetic median plane and the beam height were determined. More than 90% of the protons were found to have less than 15 mm amplitude, corresponding to 30 mm beam height. The magnetic median plane was 12.5 mm below the geometric one. This value is expected to change when the regenerator and magnetic channel for beam extraction is in position. (See page 54).

In order to enable an easy adjustment of the median plane a diverter has been installed, which can divert current from one of the cyclotron magnet coils into the other. For this purpose two d.c. machines on the same shaft are operated in series with the main generator. By a potentiometer, that is motor-operated from the control desk, the voltage can be made slightly different on the two machines, and current is diverted from one coil to the other. The total number of ampere-turns and the field strength in the magnet is very little affected as the losses in the two machines are less than 3 kW compared with about 700 kW power in the magnet at 1700 A. The diverter current produces a field in the radial direction that penetrates into the gap. The effect is necessarily stronger near the edge than further in. It is therefore only possible to get the beam exactly right on one radius. On 2.25 m radius the beam is in the geometric median plane for + 17 A diverter current, whereas on 2.00 m radius + 27 A are required. Rated current from the diverter is ± 80 A.

In order to determine the magnetic center of the cyclotron in the horizontal direction, a target was placed in the dee on a radius of 2211 m exactly opposite the probe target. If the probe with the thermocouple target was placed on a smaller radius it caught the full beam, if on a larger radius none at all. About 6 mm movement was sufficient to change the thermocouple voltage from 20 to 80% of maximum. When 50% is caught on each target they can be assumed to be on the same radius in relation to the magnetic center. In this way it was found that the magnetic center was displaced 6 mm towards the probe. A third target was placed on the universal target holder 90° from the two others and adjusted until it caught ⅓ of the beam, indicated by ⅓ loss of the beam hitting the thermocouple probe target. The corresponding radius was 2.211 m or exactly the same as that of the target in the dee. Accordingly the magnetic center, for this radius, seems to be right in direction north-south and 8.5 mm west of the geometric center. Again, one can expect this value to change when the regenerator and the magnetic channel are in position.

The internal beam current was measured using a 2 mm graphite target (0.318 g/cm^2) comparing the C^{11} annihilation radiation with that of a 100 mC Na^{22} standard source. Assuming 29 mb cross section and with a multiple traversal number of 30 at 1700 A on 2 m radius the beam current was found to be 0.08 μA. Little effort has been made so far to maximize the beam current; one can therefore expect somewhat higher beam currents when optimum conditions have been found.

The regenerator and magnetic channel have been placed in the gap. Floating wire measurements have been started to determine the proton trajectories.

4. Beam bending magnets

A number of bending magnets have been delivered and their field strength and field homogeneity have been measured. The pole edges can be turned 60° to get various degrees of vertical focusing. The coils have watercooled aluminium windings. (See page 54).

One magnet is to be used to focus the proton beam; it has a field strength of 1.4 Wb/m^2 in a gap of 11 cm at 360 A (resistance 0.11 ohm/coil) and an effective length of 1.33 m. The bending angle for 600 MeV protons is 26°.

Another magnet will be used for the externally produced mesons and has a field strength of

1.2 Wb/m^2 in a gap of 16 cm. at 360 A (resistance 0.11 ohm/coil) and an effective length of 1.53 m. The bending angle is 60° for 400 MeV pions and is made possible with the low power mentioned and a magnet weight under 20 tons by making the poles convex on one side. To improve the focusing properties the turning edges have been shaped by adding wedge shaped shims.

As to the three other magnets, one has been installed for the first selection of internally produced mesons and is in a fixed position between the cyclotron and the neutron side wall. The others are intended for various uses. They have C-shaped cores enabling a vacuum tank to be introduced from the side. The field strength is 1.0 Wb/m^2 at 400 A in a gap of 15 cm. The resistance is 0.12 ohm/coil and the effective length 0.96 m.

5. Protection

The final shielding wall against neutrons was constructed and fitted with appropriate channels for mesons and neutrons; the big lifting platform is working satisfactorily and saves a great deal of time in stacking the shielding blocks. It looks as if the shielding of the machine will be very good. (See pages 44 and 51).

III. RESEARCH

1. Beam monitoring

Two beam monitors are being assembled. One is a seven-plate ionization chamber which will be filled with argon at almost atmospheric pressure. The path length in the chamber is 13 cm and the multiplication factor will be about 1700. The chamber is expected to saturate for beam intensities up to 10^8 protons/cm²/s. For higher beam intensities a secondary emission chamber is being built of a type developed at Stanford. This instrument is essentially an evacuated multiplate ionization chamber. Instead of gas ions, charged particles are collected that have been knocked out of the foils.

To measure the charge collected in each of these chambers, a current integrator has been developed which, in continuous operation, can integrate currents between 10^{-6} and 10^{-12} A with an accuracy of 0.3 %.

The absolute proton beam intensity will be determined in two steps. First, with a proton beam intensity of about 2000 protons per second, an ion chamber and two counters will be placed in the beam. The charge that will be measured corresponds to a definite number of protons passing the chamber as counted by the two counters in coincidence. To count 2000 protons/s without appreciable loss a 25 MHz scaler has been built and tested. After this, at much higher beam intensities the ratio of the multiplication factors of ionization chamber and secondary emission chamber will be determined by passing the proton beam through both chambers simultaneously.

The energy of the beam and the energy spread will be determined by range measurement. For more accurate values an apparatus for measuring the angle of emission of the Čerenkov light emitted by the protons of the external beam is being designed.

2. Internal meson beams

Depending on experimental conditions the π and μ meson beams from the synchro-cyclotron can be produced either from an internal target and deflected out into the experimental area, or by an external proton beam. During the initial operation of the machine, some preliminary measurements were done on internally produced meson beams.

The internal meson beams are produced by allowing the proton beam to strike a target mounted either at the end of a probe or on a " trolley ". The " trolley " can move azimuthally along the pole tip rim, and it has also provision for moving the target radially. (See page 53).

The negative π mesons produced in the forward direction from the internal target are deflected by the fringing field of the cyclotron and escape from the machine if their energy is larger than about 100 MeV. The same is the case for positive mesons emitted backwards with respect to the protons striking the target.

In order to collect and deflect the mesons emerging from the cyclotron a deflection magnet has been placed close to the machine inside the shielding wall. (See page 53).

The energy of the mesons of highest intensity accepted by the deflection magnet varies according to the position of the internal target. The closer the target is to the bending magnet the lower is the energy of mesons with maximum intensity. For energies between 150-250 MeV the flux of negative pions at the entrance of the deflection magnet has been found to be of the order of 10^3 cm^{-2} s^{-1} for an energy band of the order of 50 MeV. The flux decreases for lower and higher energies, being very small below 100 MeV and above 350 MeV. Since the positive pions have to be selected from the backward direction with respect to the motion of the protons their intensity is generally lower by a factor of 10 or even more at the higher energies.

At the entrance to the deflection magnet inside the shield the pions with maximum intensity are roughly parallel in the horizontal plane and slightly divergent in the vertical plane. The pole piece edges of the magnet can be rotated and therefore entrance and exit angles of the pions set for optimum focusing in the experimental area.

The layout of the channels in the shield shows some of them (see page 45) pointing towards the center of the machine. Pions of about 200 MeV entering this channel are neither focused nor defocused in the fringing field of the cyclotron. One can therefore obtain a reasonably strong beam of negative pions through this channel without using the inside deflection magnet. The protons circulate in this case anticlockwise in the cyclotron and strike the target which is located far away from the proton deflection system. For π^+ the sense of rotation of the proton is changed.

With the deflection magnet in use low energy pions ($\sim$ 100 MeV) have to be deflected 40°-50° in order to pass through the channel, high energy (300 MeV) about 25° with the protons circulating anticlockwise. With protons moving clockwise the low energy pions would have to be deflected about 20°-30°.

A second deflection magnet with mobile pole edges has been placed at the exit of the channels in the shield.

3. Pi meson experiments

All the general electronic equipment necessary to do experiments has been built up and has been used to measure range curves for negative pions from the cyclotron. The equipment, which has already been thoroughly tested with cosmic ray muons, behaved as expected. A particularly valuable piece of test equipment, designed and built in the group, has been a " cyclotron simulator " which gives trains of pulses similar in pattern to those to be expected from the cyclotron.

Two hydrogen targets have been designed. The first is intended for general purposes and is now ready to be tested with liquid hydrogen. The second, which is a long (60 cm) cylindrical target, has been designed for transmission experiments with pions and is being made.

All components necessary for a large lead glass Čerenkov detector are now ready and this will shortly be assembled.

Experiments were carried out on the cyclotron to extract and investigate a negative pion beam of about 200 MeV from an internal target. This gave a very satisfactory intensity of $7 \cdot 10^4$ pions/s over an area of 100 cm^2. The final beam will have a considerably smaller area and will perhaps be more intense. The momentum acceptance of the magnet system was, however, large, and it may be necessary to reduce this. The nuclear absorption in copper of these pions corresponded to a geometrical cross section. (See page 53).

4. Mu meson experiments

The design of the focusing channel for μ meson scattering experiments has now been completed and firms have been invited to submit tenders. An alternating gradient focused momentum selection system to be put at the end of the channel is being studied. In order to collect data needed to get a better idea about the intensity and purity of the μ meson beam, a programme has been started to investigate the pion beams produced at an internal target. Counter and emulsion methods will be employed. At the same time apparatus intended for the selection of μ mesons against π mesons is being prepared and will be tested in the existing π beams.

5. Polarized proton source

A source of protons that are polarized before being accelerated was designed during the year.

The apparatus essentially consists of 4 parts, namely a hydrogen dissociation tube, a collimator, a magnetic separator and an ionizer. This set calls for a powerful pumping system consisting of about ten vacuum pumps of very different types. The process of polarization itself takes place in the magnetic separator which consists of a long permanent quadrupole magnet, 7 m in length, 20 cm in external diameter and with a gap of a few centimeters.

Pumps were appropriately selected, and two separate magnet prototypes, 25 cm long, were constructed in order to study the field and to select a suitable material for the magnet. Magnetization was carried out with a movable coil at 15000 ampere-turns for a few seconds.

The hydrogen dissociation tube which produces the atoms and injects them through the collimator into the magnetic separator, has been successfully tested. It is fitted in its proper place on the pipes of the pumping system. Its efficiency for the production of atoms is 80%. (CERN Publication 57-30.) (See page 53).

6. Experiments on non-conservation of parity

The most striking effect of non-conservation of parity in weak interactions is that most particles arising from such interactions are polarized. Following the first announcement of the successful experiments in U.S.A. with polarized nuclei and the polarization of μ mesons, some experiments were done at CERN to show the circular polarization of γ rays following β decay.

The circular polarization of the γ rays was measured by transmission through magnetized iron. The results on a number of allowed Gamow-Teller transitions were found to agree with the two-component theory of the neutrino. In a mixed Fermi and Gamow-Teller transition a large interference effect was found. The neutrinos emitted in such decays must therefore be of the same helicity (orientation of the spin with respect to the direction of motion). (CERN Publication 57-47.)

7. Spallation experiments

(a) *Installation*

The Spallation Group constructed equipment needed for the tritium measurements in targets and meteorites. The general parts of this set of apparatus consist of a high frequency generator to degas the targets under vacuum, a vacuum system and a low level counting arrangement for low activities. The generator had already been purchased in 1956, the vacuum system was finished towards the end of 1956, and in Spring 1957 a second vacuum line was built up. To avoid exchanges of tritium and stopcock grease and to lower the memory effect this second line was completely closed with mercury.

The first low level arrangement consists of a common anticoincidence ring of GM counters in a 20 cm steel shield. It could be improved by using a plastic scintillator as anti-coincidence detector instead of using the counter ring and by selecting the material of the inner low level counter. The trials to improve this low level arrangement are not finished yet; different new apparatus is in construction. However all target measurements can be carried out with the already existing counter, and even tritium measurements of meteorites are possible in favourable cases.

(b) *Measurements*

During the second half of last year tritium measurements were made in iron targets irradiated with 50-177 MeV protons. The irradiations were carried out in Uppsala. The results are in agreement with those obtained in similar experiments.

At the end of the year two irradiations could be made with the internal beam of the CERN synchro-cyclotron. It turned out that the beam was not yet in the centre plane so that it was not possible to make exact monitor measurements. From the values of the proton current which were obtained from an internal beam monitor a preliminary tritium production cross section has been found to be about 50 mb at 400 MeV.

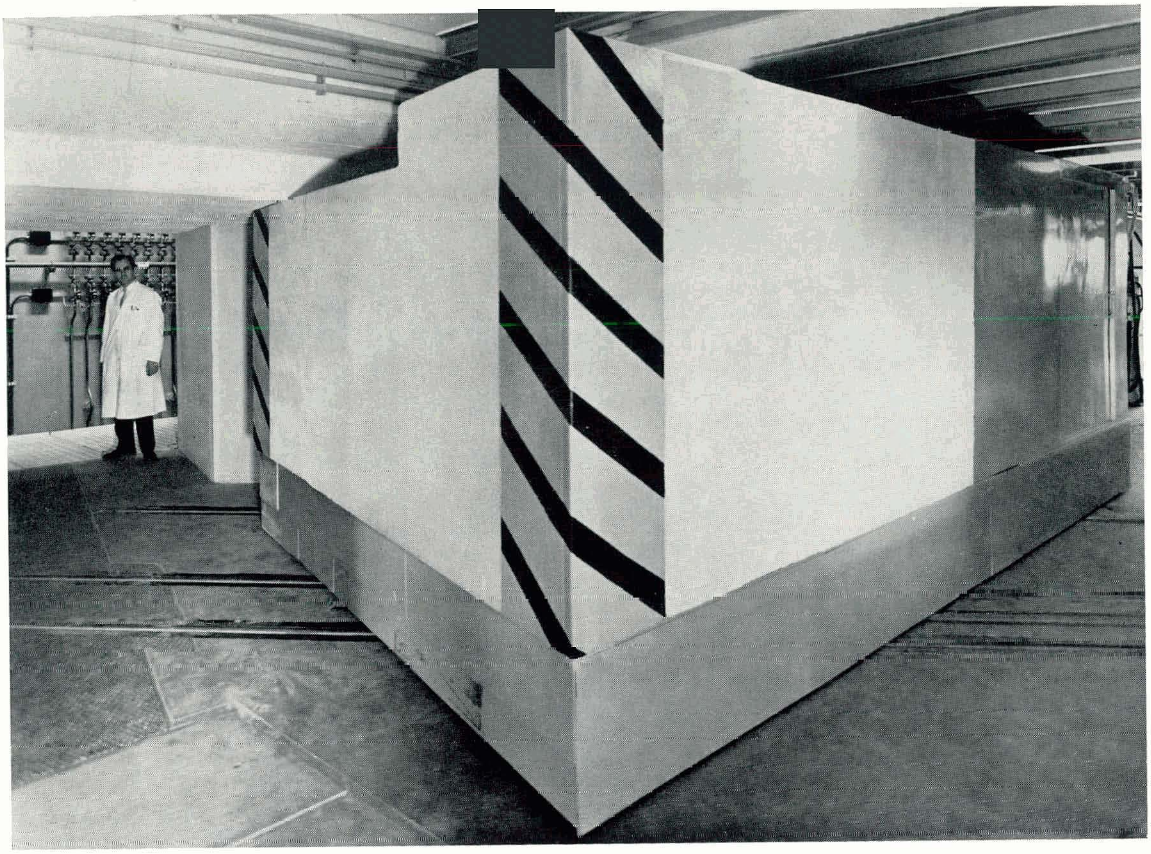
It is planned to measure the tritium production cross section in different materials up to 600 MeV proton energy. As the CERN synchro-cyclotron gives very intensive meson beams, an attempt will be made to determine also the tritium production rate in meson irradiations. The comparison between the production rates of protons and mesons might be especially interesting for small nuclear fragments, such as, for example, tritium.

8. Emulsion techniques

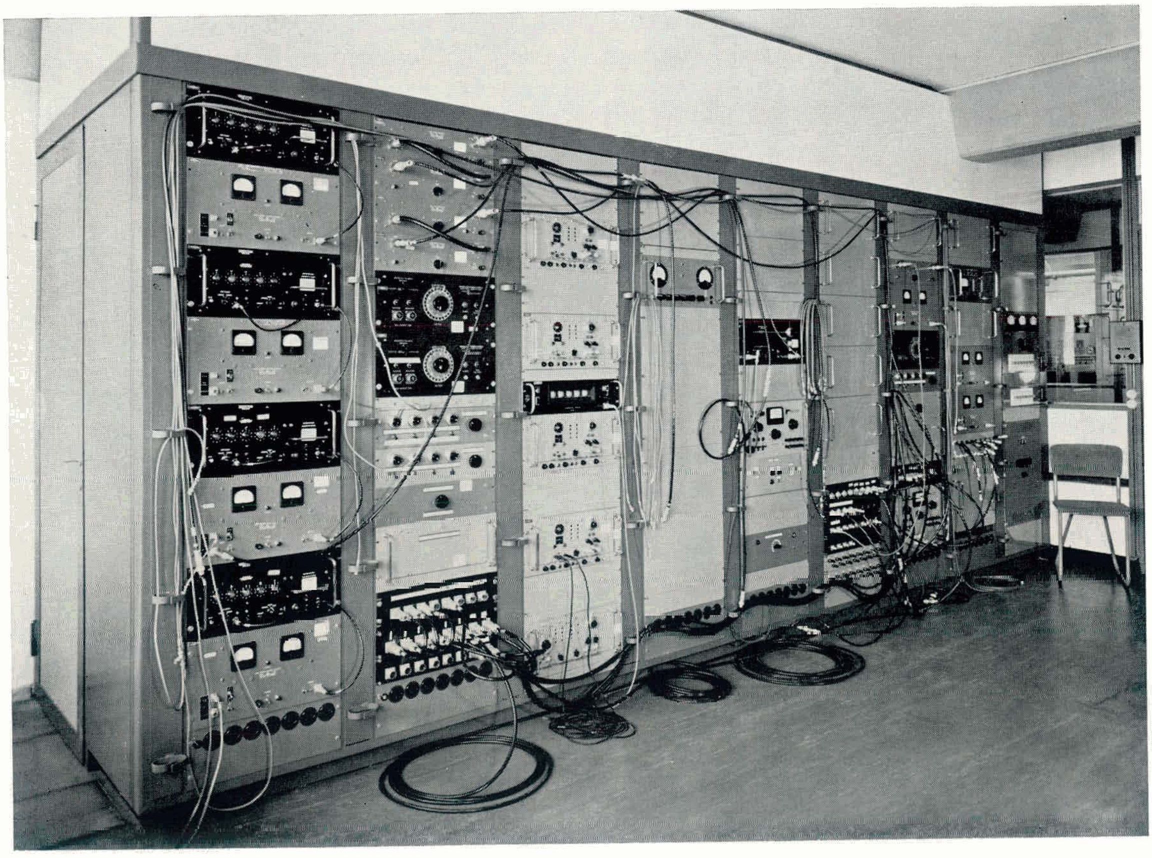
The Emulsion Group started work in October 1957 and prepared a programme in connection with proposed experiments. A set of dark rooms to develop thick nuclear research emulsions of total area up to 2 m^2 is being completed. These dark rooms will be available for physicists who bring plates to be irradiated by the synchro-cyclotron beams.

9. Electronics

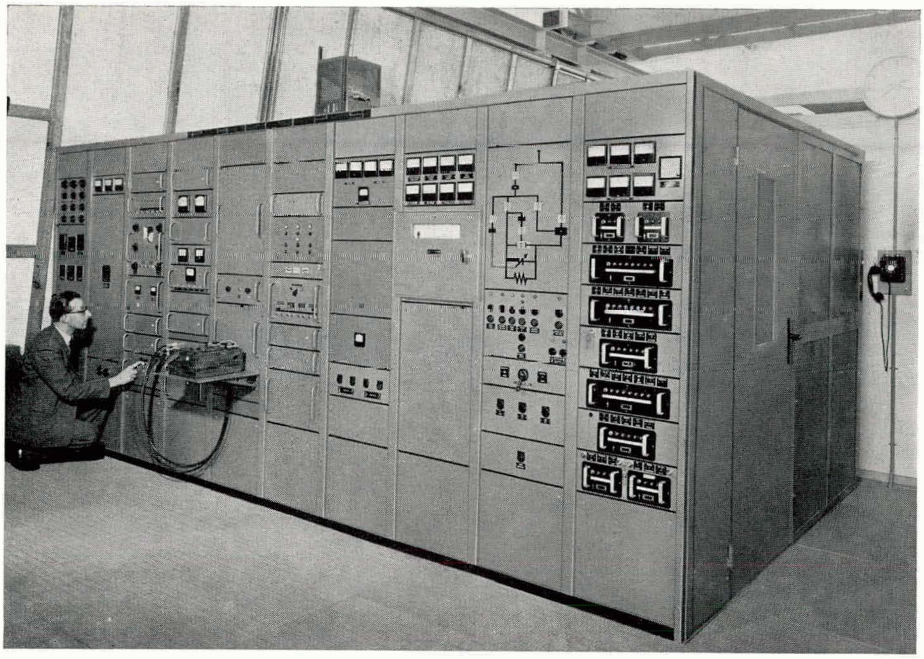
The Electronics Group emerged in its present form as a result of an amalgamation of the Scientific and Technical Services Division's Electronics Group with the existing nucleus in the Synchrocyclotron Division.



The passage into the synchro-cyclotron hall with the shielding door open.

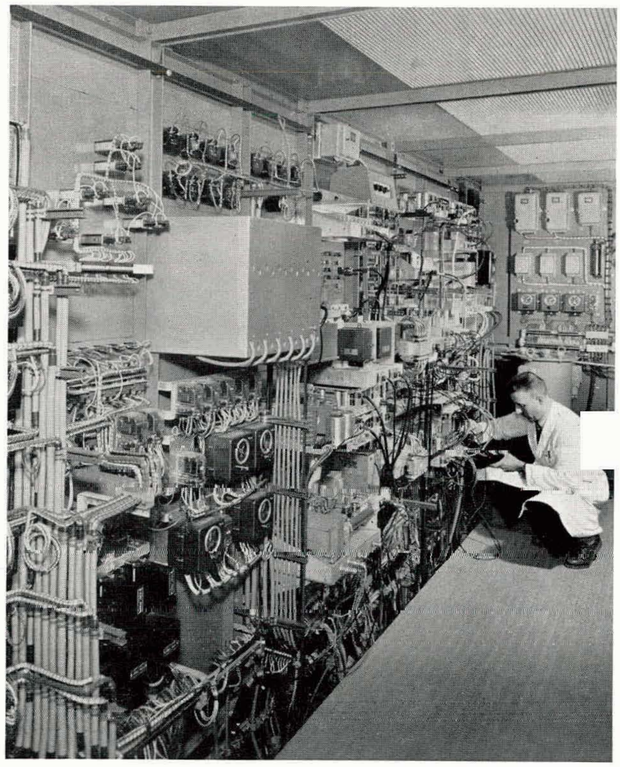


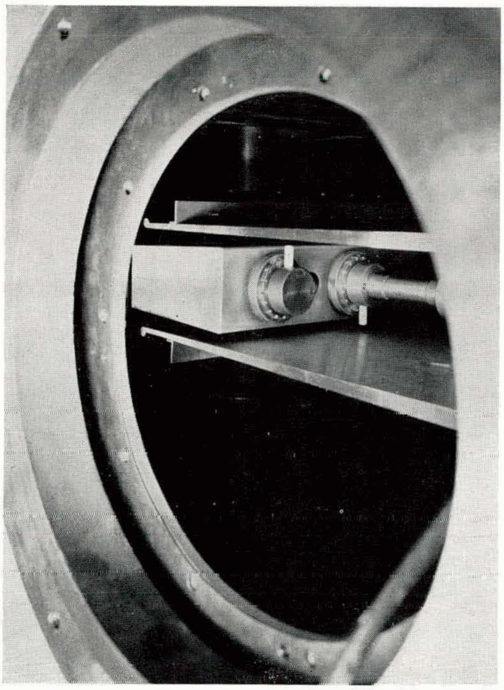
A counting room.



Control equipment for high frequency system.

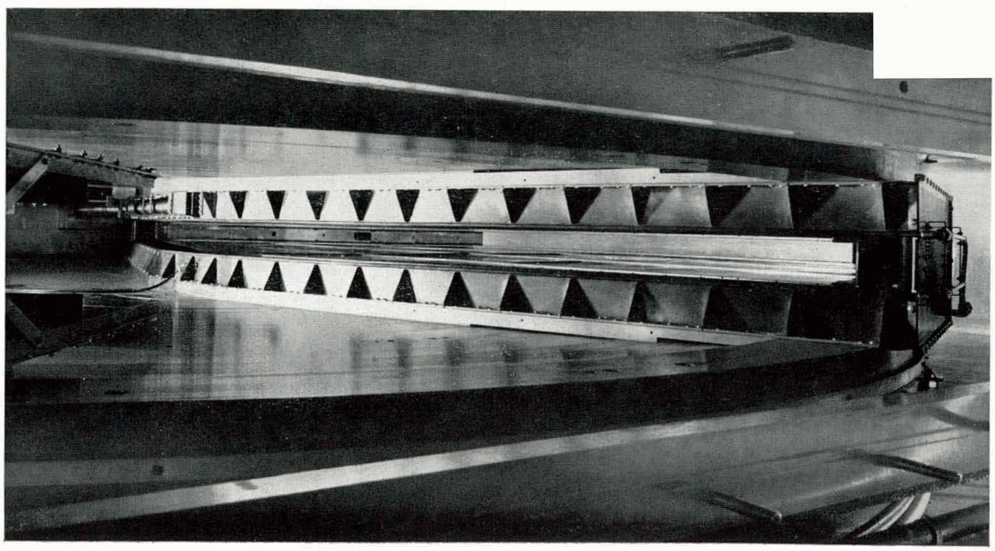
Back view of high frequency control equipment.

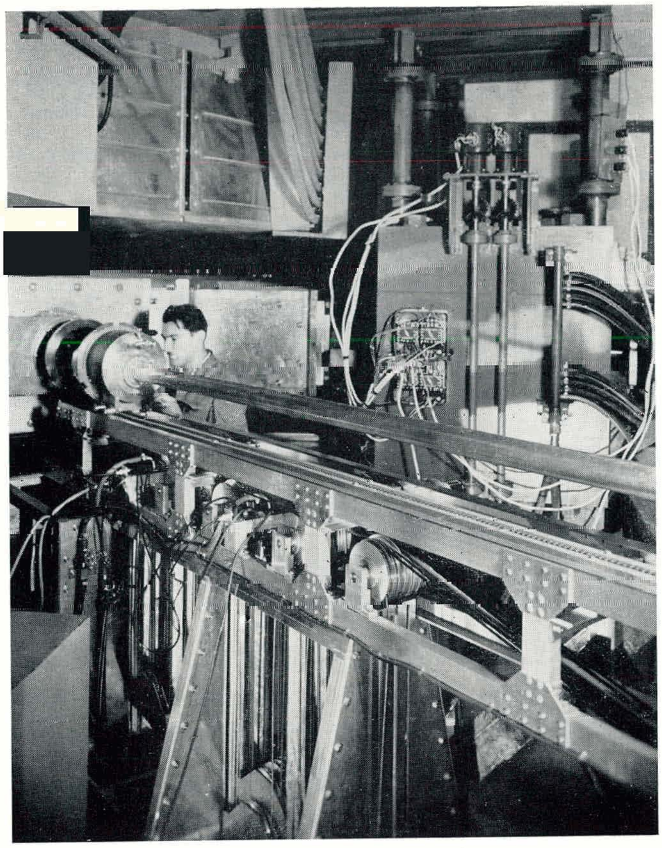




Tuning fork modulator.

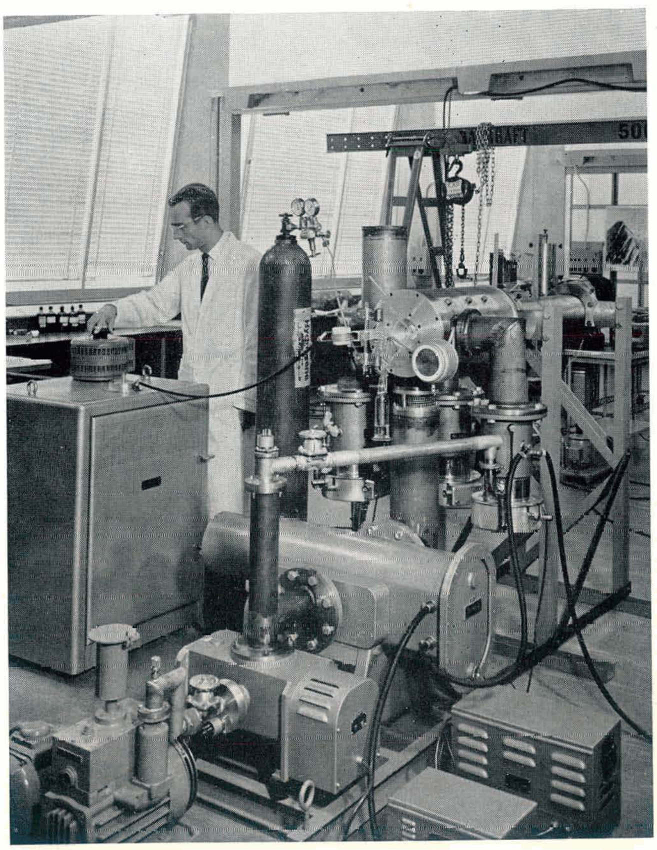
The inside of the vacuum tank showing dees.



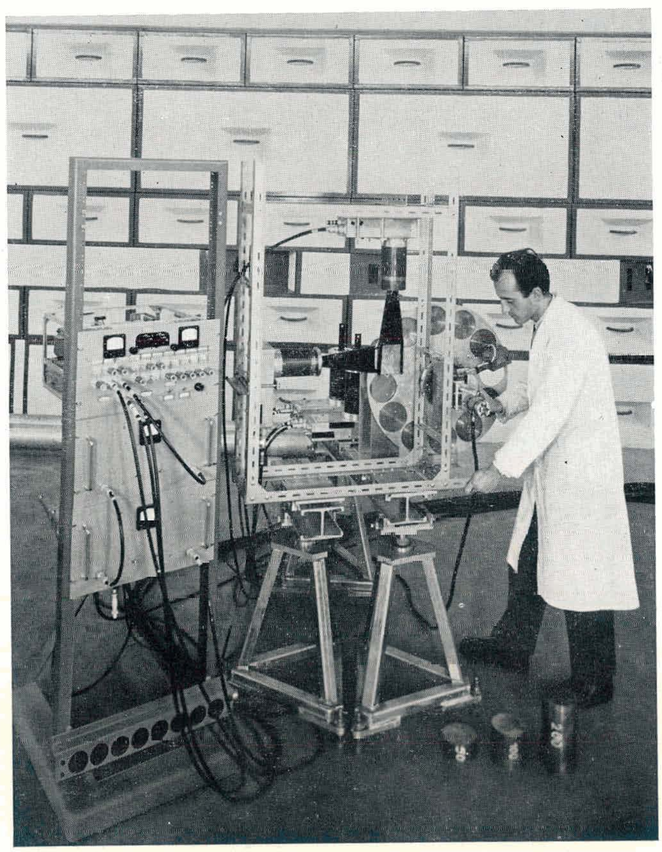


Probe target mechanism.

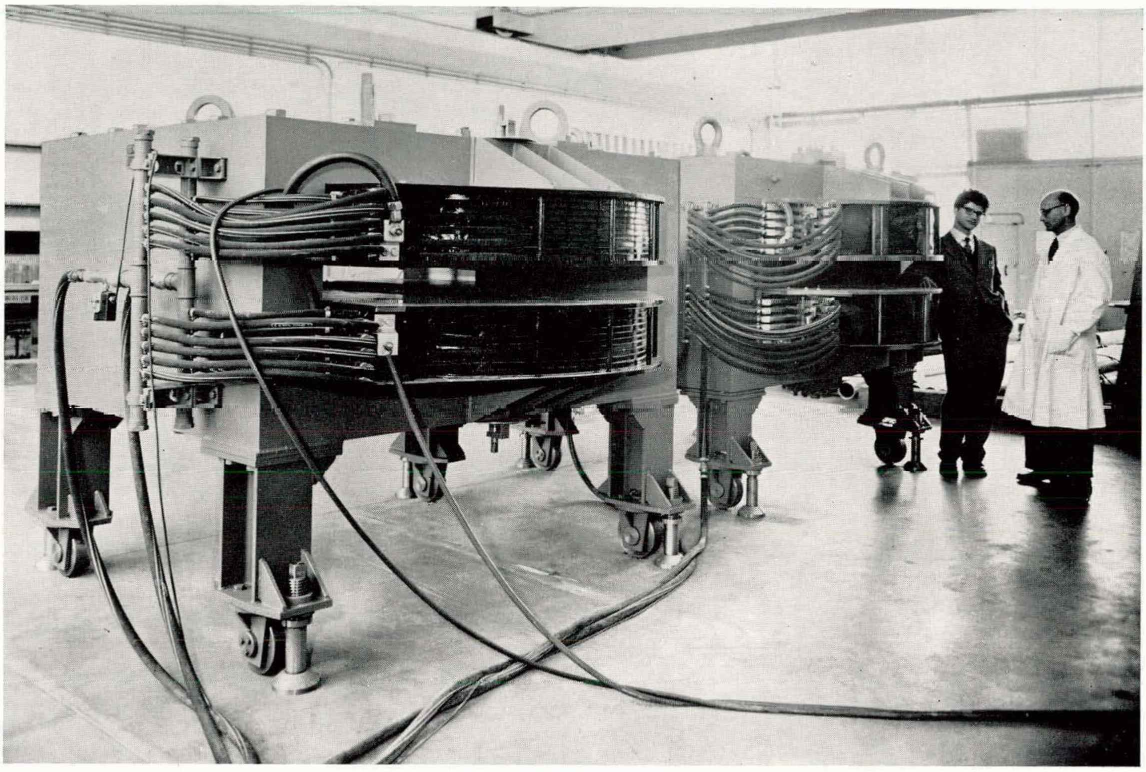
π^- bending magnet.



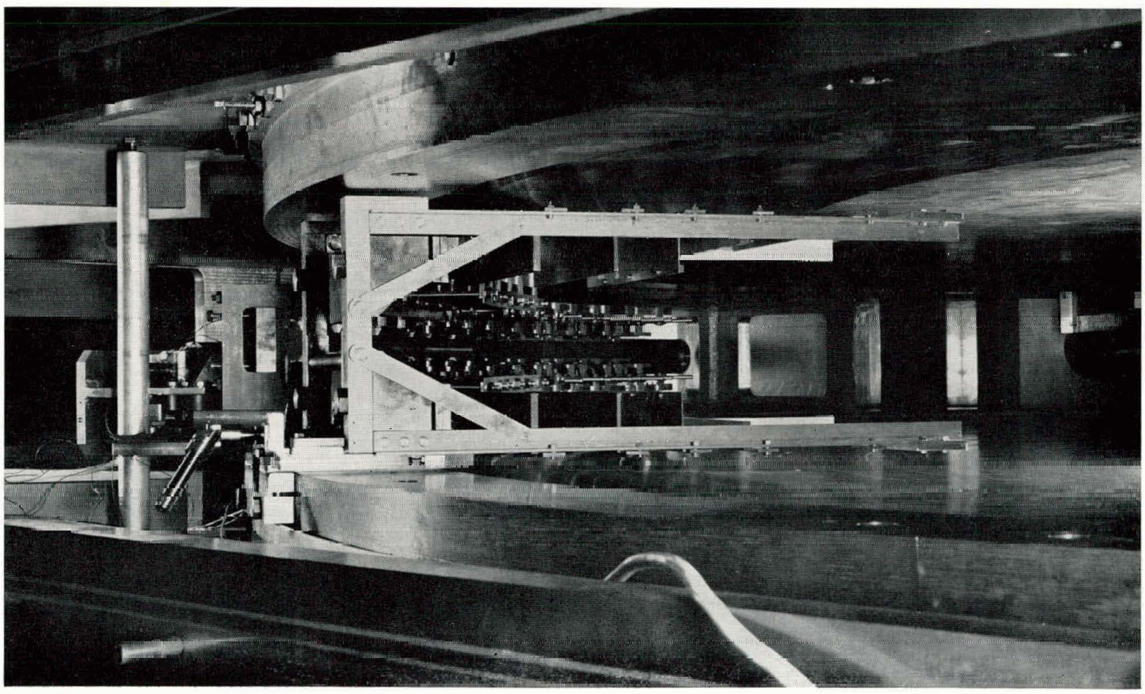
Proton polarisation apparatus.



Scintillation telescope with absorbers for meson range determination.



Proton and π^+ bending magnets.



Regenerator for the external proton beam.

The main object of the Electronics Group has been to supply the experimental teams with the necessary electronic instrumentation either by buying or developing and manufacturing the necessary equipment.

The group has in addition continued to provide for the electronics needs of the Scientific and Technical Services Division which, after the transfer, lacked an electronics workshop of its own.

Some of the equipment which was developed during the year by these teams is listed below :

— 100 channel " Hutchinson-Scarrot " pulse height analyser with nickel wire memory;

— trochotron scalers (1 MHz region);

— various millimicro-second coincidence circuits with discriminators;

— fast pulse generators (1 mμs rise time);

— regulated power supplies;

— prototype of photograph evaluation instrument for the Scientific and Technical Services Division;

— delay boxes, both hand operated and remote controlled;

— robot printer for printing out from scalers;

— current integrators;

— various control circuits and flash equipment for the bubble chamber (Scientific and Technical Services Division).

The electronics development teams and the research groups are supported by an electronics construction section called the wiring pool. The pool was formed in 1957 and is now the backbone of the electronics output.

In September a conference was organized at CERN on electronic instrumentation for nuclear research.

SCIENTIFIC AND TECHNICAL SERVICES

1. General

During the course of 1957, CERN went through a period of transition towards the initial phase of its scientific activities. In the Scientific and Technical Services Division this tendency took the shape of an intensification of activities connected with the development of new experimental techniques; in particular, the bubble chamber staff, part of whom belonged to the Synchro-cyclotron Division, were concentrated in the Scientific and Technical Services Division. Other activities of a more current nature were transferred to other Divisions (main mechanical workshop to the Site and Buildings Division; electronics workshop to the Synchro-cyclotron Division). Apart from the two main spheres of development of experimental techniques (liquid hydrogen chambers and electronic evaluation of track photographs) and their general basic techniques (gas liquefaction and electronic computation respectively), the Division started a health physics section and continued to administer the Scientific Information Service and the Cosmic Ray Research Group.

2. Cryogenics

The hydrogen liquefying plant was finally installed during the first half of Summer 1957.

The liquefier itself was built by the Leyden cryogenics laboratory. It is of standard design. The hydrogen is compressed to a pressure of about 100 atmospheres and cooled through a heat exchanger with two baths of liquid nitrogen boiling under low pressure and is finally exchanged with cold expanded hydrogen. It goes through an expansion valve in which it cools down and becomes partly liquid.

All the remainder of the plant was constructed at CERN to the specifications of the Leyden experts. Commercially available hydrogen of 99.99% guaranteed purity is put in contact with palladium catalysts where the last traces of oxygen turn into water and it subsequently fills two gasometers of 5 m^3 each.

The compressor is supplied with pure hydrogen through these gasometers; after being compressed, the hydrogen is purified once more of the water and oil it might contain and introduced into the liquefier. The expanded hydrogen which has not become liquid is returned to the gasometers. Thanks to a special circuit, it is possible to use the compressor to fill hydrogen bottles with hydrogen from the gasometers. Hydrogen which has passed through the liquefier is very pure. The hydrogen that evaporates from the dewars is taken back to the gasometers through a recovery line.

The liquid hydrogen plant building was constructed in accordance with the principle of safety through ventilation which is applied in all large plants of this kind such as Leyden, Boulder, etc. The ventilation is such that the air is entirely renewed every three minutes. Owing to this system it is possible to use standard electrical equipment, which is kept below a maximum height of 2 metres throughout the building.

In addition to the room for the liquefying plant itself the building includes a room for the gasometers and an experimental laboratory equipped with a movable crane. This laboratory is equipped with the same safety system as the room for the liquefying plant. This will enable tests on bubble chambers and liquid H_2 targets to be carried out in the easiest and safest conditions.

Liquid hydrogen was produced for the first time in July 1957 by Leyden experts. It was produced again on several occasions by CERN staff initially under the supervision of a Leyden expert and subsequently without any outside help. Samples of air were taken during production in various parts of the laboratory and analysed; everywhere the hydrogen content is well below the danger point.

The plant produces about 32 litres of liquid hydrogen per hour; its output could be doubled or trebled by adding another compressor. (See page 61).

3. Bubble chamber

The 10 cm bubble chamber, mention of which was made in the previous Report, was constructed during 1957. Our purpose is not limited to producing a working instrument but is rather to have a handy piece of equipment on which systematic tests can be carried out with a view to constructing larger chambers. The liquid hydrogen bubble chamber technique is still in its early stages and there are no unanimously accepted solutions to all the problems raised. For the same reasons, in anticipation of larger scale operations, it was necessary to train staff to work with bubble chambers and liquid hydrogen by handling comparatively small and thus less dangerous quantities.

In these circumstances, the problem did not consist in obtaining tracks in liquid hydrogen as quickly as possible, but it involved, on the contrary, the construction of an instrument that would be up-to-date and as easily altered as possible.

Accordingly the chamber was made of stainless steel rather than copper. The temperature is controlled by means of a hydrogen bath under pressure and not by the " heat leak " system which is simpler but more limited in its applications. The pressure bath apparatus itself operates in a closed circuit, the reliquefaction of hydrogen being regulated through a heat exchanger. This is an original CERN project which was first tested at Leyden and subsequently at CERN. All the cooling circuits include removable cold joints and cold valves. The expansion system is of the liquid expansion type and not of the gas expansion type.

Many of the difficulties raised could have been overcome for a small chamber but could not be eliminated in large chambers.

The construction of the chamber began about January 1957. At the beginning of the summer most of the essential components—vacuum tank, chamber, expansion mechanism, liquid nitrogen jacket—were ready. The summer was devoted first to pressure tests and subsequently to vacuum tests. These sometimes took rather long, as the technical staff had to solve new problems. The end of the year was taken up with assembling the various cooling and vacuum circuits, the control and measurement instruments (gas thermometers), and in testing pneumatically-operated low temperature valves. (See pages 59 and 62).

In the meantime the design of a 30 cm chamber was completed; it will be placed in a 15 000 gauss magnetic field produced by a magnet and generator, which have already been ordered. Tests on various types of stainless steel have been carried out at Grenoble University to ensure the steel does not become magnetic at low temperature. The experience gained in the construction of the smaller chamber and the tests carried out on it will certainly be profitable for the building of the new chamber.

4. Instruments for the evaluation of photographs

The track instruments such as cloud or bubble chambers, particularly when used in a magnetic field, give detailed and relatively complete information on the high energy events they are made to record. When used in the beams of high energy accelerators, they accumulate rapidly large numbers of photographs of interesting events (about 600 photographs per hour, 10 % of which may show interesting events). A typical photograph shows, on a background of random droplets or bubbles, a number of rays, some belonging to the beam under study, others to stray radiation. Significant events are picked out by careful inspection; they are recognized by certain salient features such as a sharp bend in a track, or a number of rays diverging from an apex. The event can sometimes be identified immediately, but a number of measurements and calculations must usually be performed to extract all the available information from the picture. Yet, the information required on high energy events is usually statistical in nature (angular distributions, excitation curves, etc.) i.e., obtainable only from the detailed analysis of a large number of events. The rather slow methods which, up to now, have been in use, for instance in cosmic ray physics, cannot deal with the accelerator requirements.

If, in the succession of operations used in these " classical " methods (measurements performed on selected tracks, spatial reconstruction, calculation of physical magnitudes), we try to locate the bottlenecks, we notice that these do not reside in the visual scanning of the photographs, nor in the operation of bringing the cross-wire of a measuring microscope in coincidence with a visually selected point of the track. The really laborious part begins with the reading of the co-ordinates thus obtained, and the subsequent data processing, leading to such results as true co-ordinates in space, angles between tracks, curvatures, etc.

It is precisely in this domain that digital computers will prove most helpful, giving us a reasonable hope of catching up with the present day's high speed of production of significant photographic data. The information contained in the photographs will have to be translated into the computer code, and recorded on the punched tapes, which are fed into the computer. The translation will be performed by an observer using a specially designed measuring instrument. Several proposals, mostly unpublished, for such instruments have recently been put forward in various high energy laboratories.

A first prototype instrument is nearly completed in CERN, and is being subjected to preliminary tests. The CERN instrument consists of a projection microscope, giving to the observer an enlarged image of the track chamber photographs. By manual control of the mechanical stage of the microscope, the observer obtains a coincidence between relevant points of the event under study and a fixed pointer. An optical device translates the motion of the stage into interference fringes, which are in turn counted by an electronic circuit. The fringes counted give a measurement of the position of the stage, thus of the co-ordinates of the point studied, which are coded and punched when the observer presses a pedal. A key-board enables the operator to punch identification numbers and auxiliary instructions. The electronic circuit is built with transistors and printed circuits. Several improvements of the instrument, such as a servo-motor drive, are under development. (See pages 60 and 61).

Design and procurement are in progress for another prototype instrument intended to record line directions rather than point co-ordinates. This instrument, less precise than the first, will use the eye's faculty to fit promptly a line through a set of points; it will provide a means of rapid analysis of simpler events such as elastic collisions.

Preparatory work has been done on the operations which have to be performed after the tape has been punched. A computational method was sought which would yield the required geometrical quantities (angles, lengths, curvatures). A satisfactory solution has been worked out for straight tracks. Pending the delivery of the CERN computer, arrangements have been made with IBM to be granted time (under the IBM Endowment Plan for Europe) on the Paris 704, in order to test the computational methods. (CERN Publication 57-29.)

5. Electronic computation

The " Mercury " electronic computer ordered by CERN will probably not be installed until the summer of 1958. Collaboration with other purchasers of similar computers (particularly Harwell, Saclay and Manchester University) has continued, and CERN's proposals for the efficient use of computer storage in matrix calculations formed the subject of one of several meetings of " Mercury " purchasers which have been held in England during 1957 and attended by CERN staff.

The problem of calculating numerically the orbits of protons in the CERN proton synchrotron has been investigated in some detail, and trial calculations have been carried out. It is hoped to have a computer programme for the solution of this problem in use on one of the earlier " Mercury " computers early in 1958, some months before the CERN computer is available. Another important computational problem, the processing of digital information produced by the electronic instrument for the measurement of photographs, has been investigated by a CERN fellow.

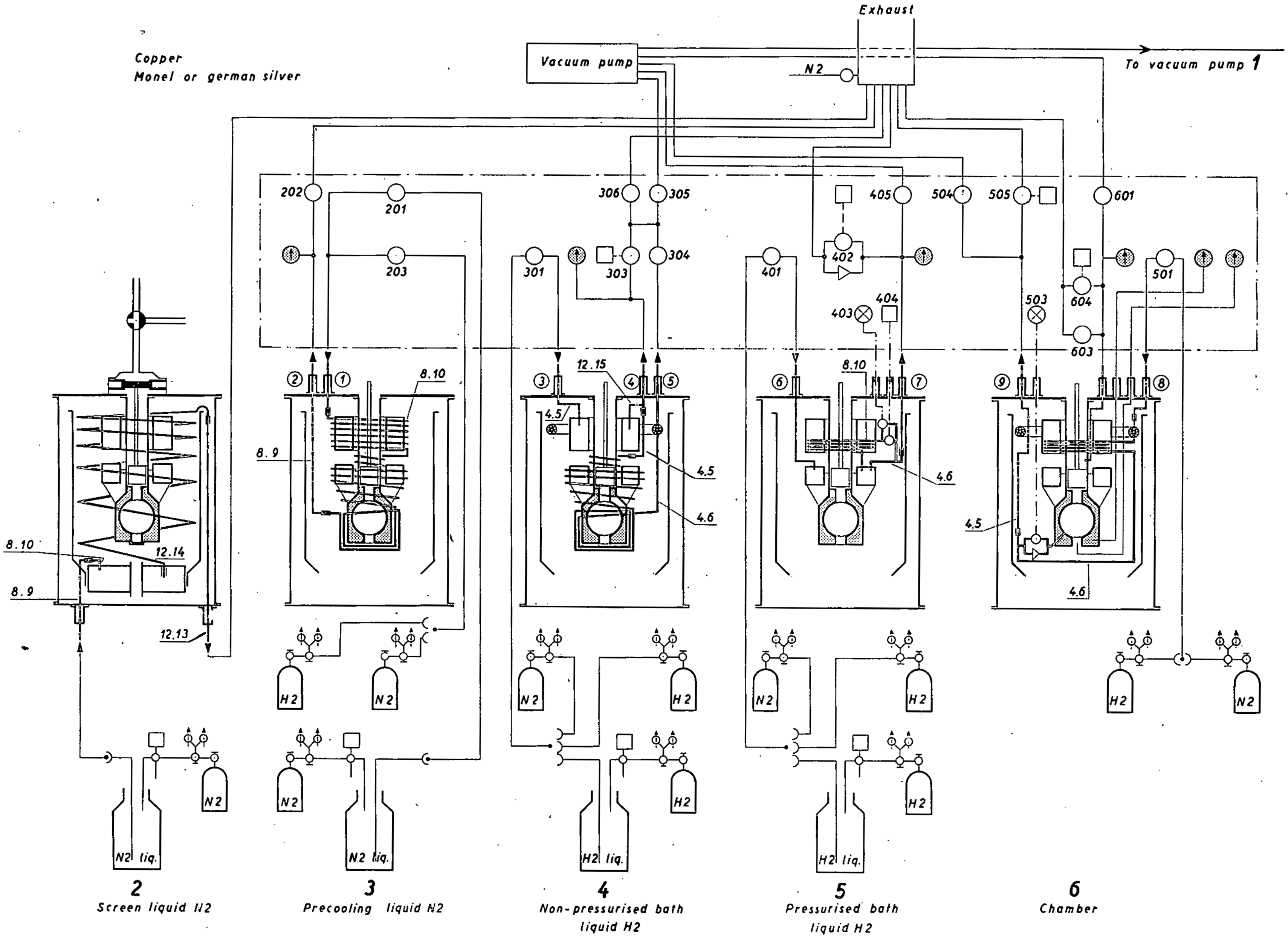
The computer section has been able to help staff from other Divisions of CERN to prepare programmes for use on the English Electric " Deuce ", and the IBM 704 computer in Paris; and a 704 programme has been prepared for calculating sets of dynamical tables relating to two-body nuclear reactions.

By the end of 1957, there were 3 staff in the Computer Section (including 1 fellow), and further staff were being recruited to start work during 1958. When the CERN computer has been installed, the principal function of the permanent programming staff will be to help members of CERN who are preparing and running computer programmes. It is hoped to make programming easier to learn by making available to all CERN staff one of the two simplified programming systems called " Autocode ", developed at Manchester University and the Norwegian Defence Research Establishment.

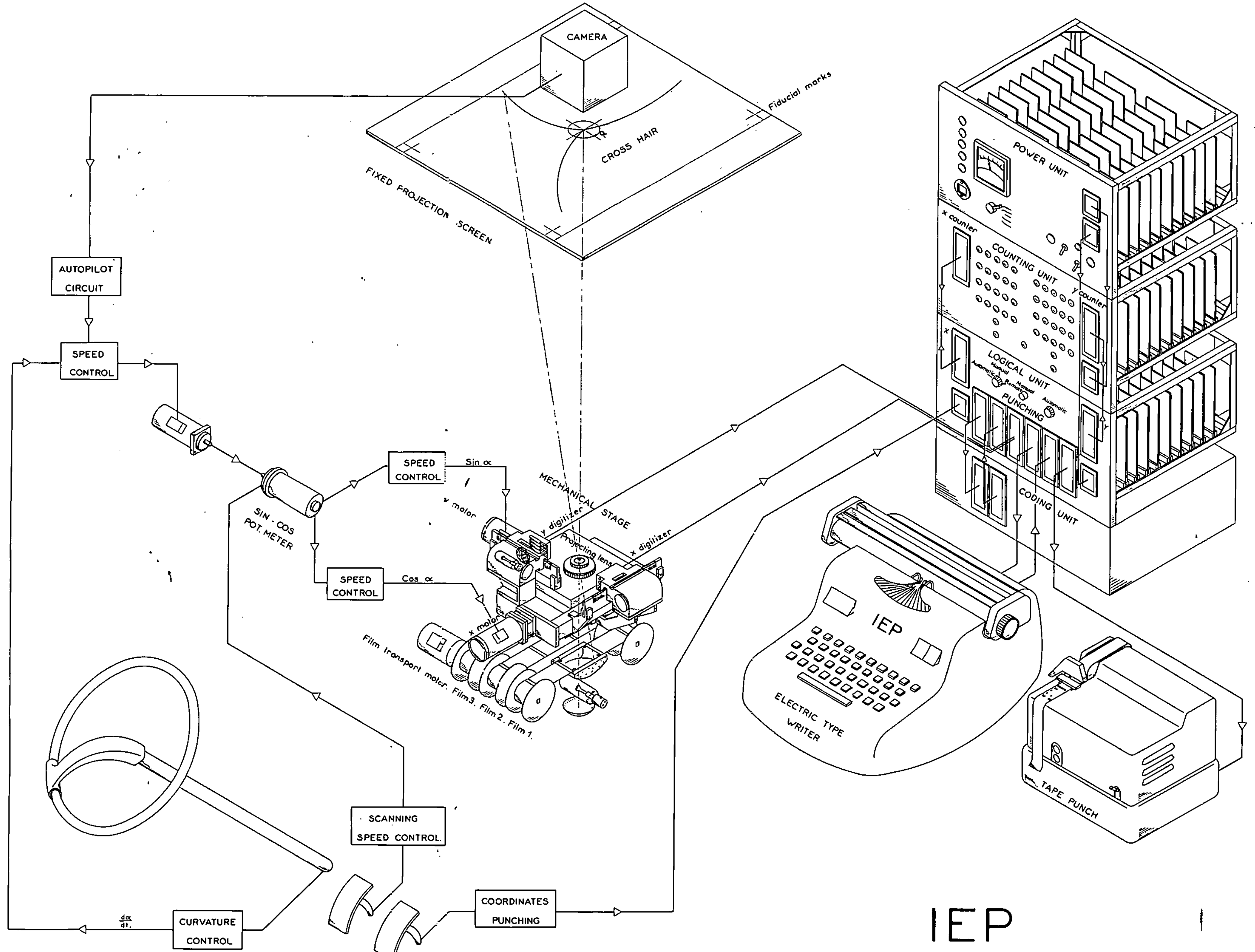
6. Health physics

The health physics section was formed in February 1957 by the appointment of an experienced radiation physicist, with a half time technical assistant.

During the year a study was made of the present and future radiological hazards in the Organization's laboratories, and of ways of measuring and controlling them. Advice was given to the Administration on insurance problems, and co-operation with the Safety Committee produced the first parts of a radiation safety code to be issued in 1958. Advice was also given on the health aspects of various radio-chemical services, including waste disposal. A film badge service, operated



Scheme for precooling and filling of liquid hydrogen bubble chamber



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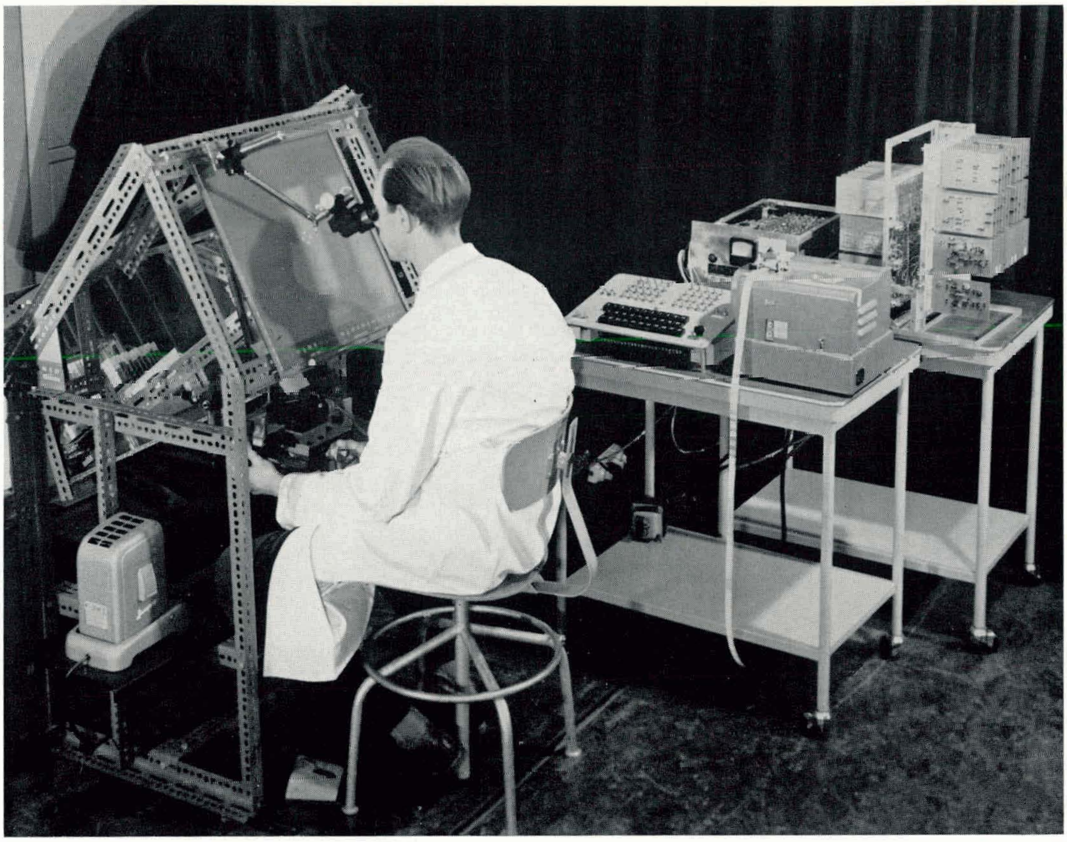
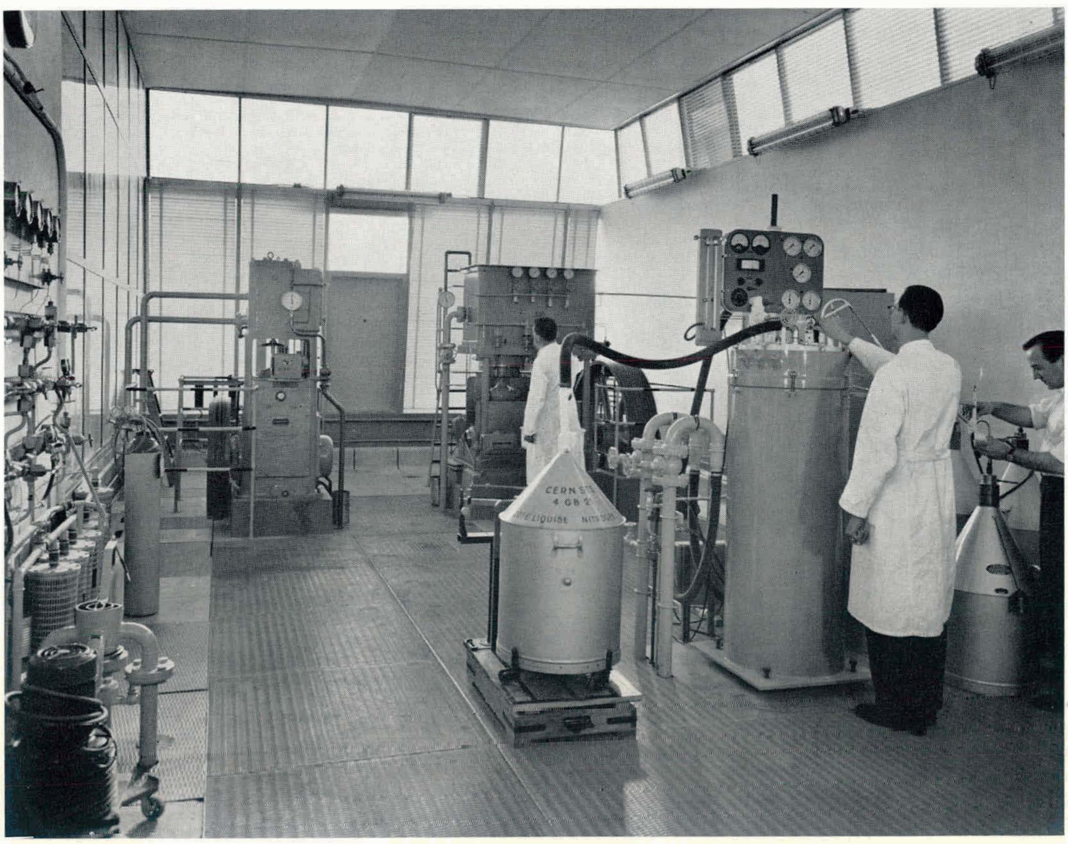
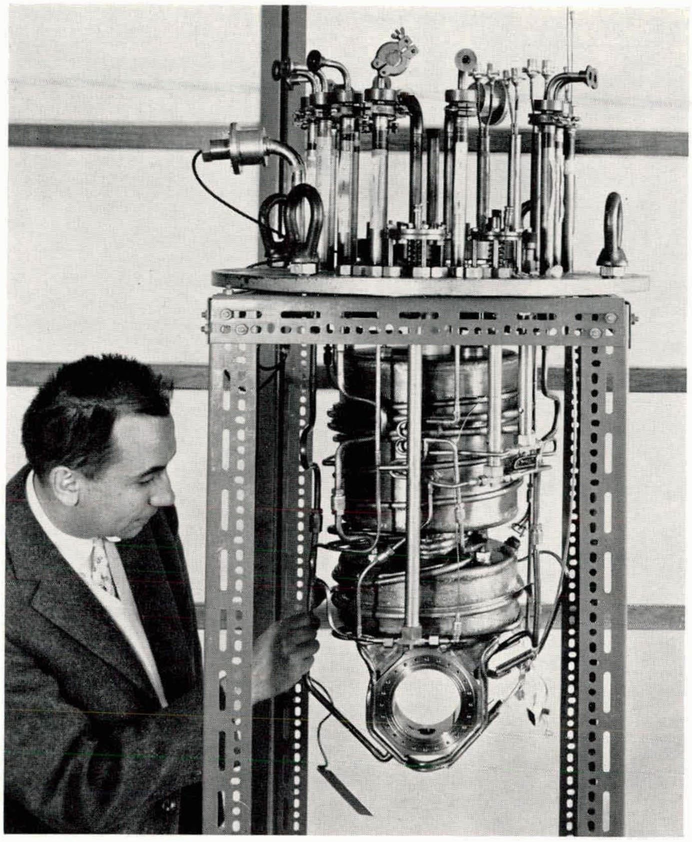
INSTRUMENT FOR EVALUATION OF PH(GRAPHS



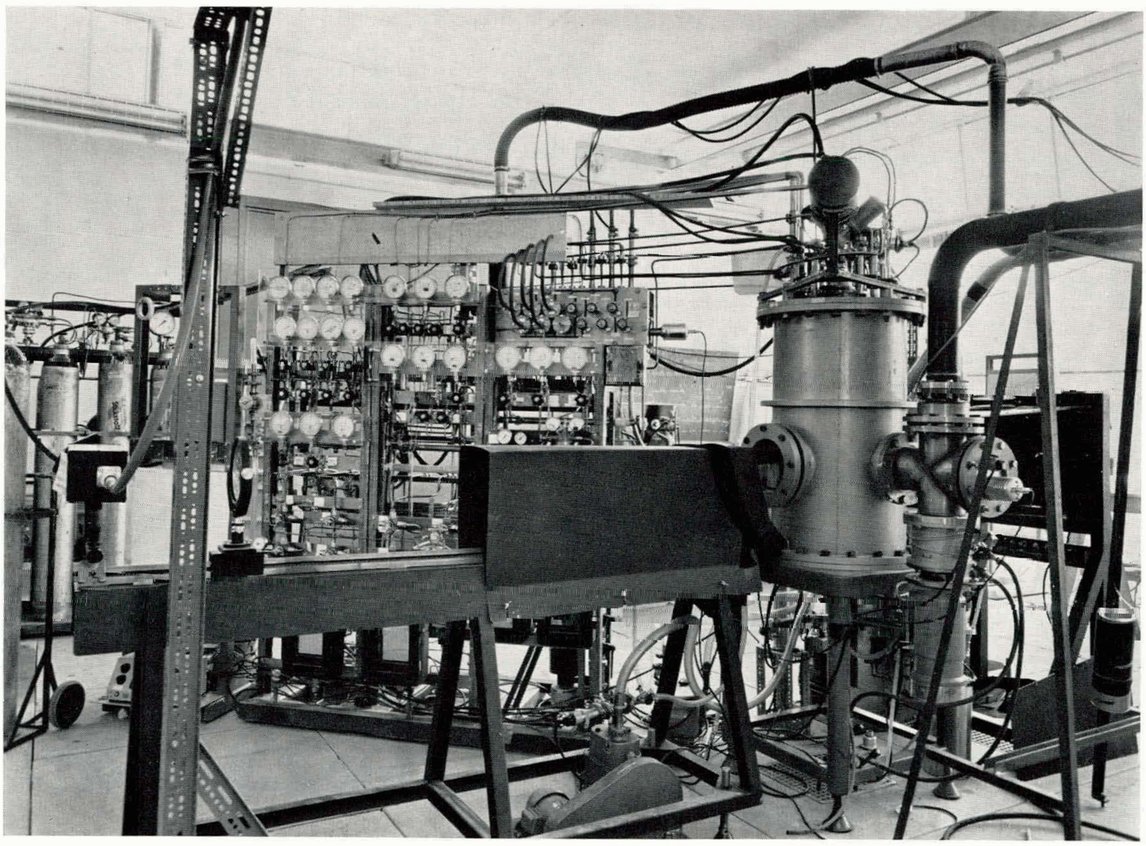
Prototype instrument for the evaluation of photographs.



Hydrogen liquefaction plant.



10 cm bubble chamber.



Bubble chamber together with its cooling and vacuum circuits, control and measurement instruments, etc.

with the help of the Genevese Service de Contrôle des Irradiations, was instituted in April, and the number of films used grew steadily to approximately forty per week. A card index of all personal exposures was kept.

As the relevant literature is widely scattered as reports, and short papers published in a wide range of journals, a collection of reference and documents was started. Contacts with workers in other establishments were made, and in this way a further collection of unpublished papers and data was obtained.

The unusually high energy of the radiation produced by the accelerators introduces theoretical and experimental difficulties not encountered in conventional health physics, and some effort was spent on the problems. Through informal co-operation with a British committee, the maximum permissible fluxes of high energy neutrons and protons was studied, and estimates were made for particles with energies up to 1 000 MeV. The instrumental problems of measuring such particles were also studied. It appeared that, at present, tissue equivalent ionization chambers are the only instruments with a known energy response throughout the entire energy range of interest. As such chambers are unavailable commercially, two were made for CERN through the kindness of Professor Failla of Columbia University. The necessary auxiliary equipment for them was obtained, and they will be in service in the first half of 1958. Other instruments for the measurement of high energy radiation were obtained, and calibrated by means of standard sources. Much work remains to be done before fully satisfactory measuring instruments are available. Research with this object was commenced on a small scale during the year, and contacts were made with other interested laboratories.

Such development work, coupled with the growing routine demands made on the health physics section as the experimental programme of the accelerators comes into force, will involve additional staff in the future.

7. Scientific Information

(1) Library

During 1957 the library settled its long-term programme and elaborated practices suited to the needs of CERN, which is now entirely concentrated at Meyrin. It moved into its permanent quarters in September.

These consist of a reading room capable of accommodating 44 readers (308 m^2), an adjoining work room and four sound proof cubicles. Specially designed stands allow for the display of 360 periodicals and the filing of approximately 15 000 reports. The shelving can accommodate around 10000 volumes. It is hoped that this space will suffice for the first ten years of CERN's existence.

In June the library of the Proton Synchrotron Division moved to Meyrin. It can accommodate about a thousand volumes and seat six readers.

There has been a rise in the rate of growth and in the use of the library, especially in the intake of reports and in loans to readers.

Much effort has been devoted to procuring in good time pre-prints of special interest: some 600 scientists in 28 countries were approached. As a result 40 pre-prints have been received on an average each month since July and they are brought to the notice of users by the distribution of a weekly list.

The Service is now producing the following regular publications :

a) select accessions list (appears every 2 weeks, classified by subject);

b) list of pre-prints received in the library (weekly);

c) list of forthcoming conferences (6 per year).

(2) Publications and exchange

Future policy for the CERN report series is based on the following principles :

— CERN has the duty of maintaining an open policy for the dissemination of the results of its scientific and technical work;

— communications of academic standard should be published in existing scientific periodicals;

— reports should be considered as a means of recording and distributing information auxiliary to publications in periodicals, with utility as one of the main criteria;

— reports might well have a less " official " and more preliminary character and thus preference should be given to speedy communication rather than presentation in definitive form.

A total of 56 publications were announced in the CERN series. Of these 9 were reports and 47 notifications of reprints of papers by CERN staff members. On the average the reports are printed in editions of 600 copies.

Exchange arrangements have been established with 251 institutions in 35 countries. Thus broadly speaking we cover a fair proportion of the laboratories and universities all over the world, where work in nuclear physics and its related fields is being done.

The proceedings of the 1956 Symposium have sold fairly steadily throughout the year. To date 16 reviews in the scientific press have come to our notice.

(3) Photography and offset

The move to Meyrin into specially designed work rooms made possible a more rational planning of the work load. Equipment is available for the following: technical photographs, enlargements, slides, photo-offset, photo-copying and contact copying (dye-line and copy rapid).

Towards the end of the year the staff consisted of 14 persons, 2 of whom worked on a half-time basis.

SITE AND BUILDINGS

1. General

Activity on the Meyrin site reached its peak in 1957. With the exception of the Main Building for the Directorate-General and the Administration, all the buildings shown on the general lay-out included in the Annual Report for 1955 are about to be completed. The number of workmen employed on the site varied between 500 and 932.

Technical and common services expanded again during 1957. These services will gradually form the bulk of the Division's activities.

The Division dealt with the move of services that were still accommodated provisionally at Cointrin and at the Institute of Physics, and with their installation at Meyrin. In conjunction with specialized services in other Divisions, it proceeded with the installation of electrical and mechanical equipment, particularly for the Proton Synchrotron Division.

At the end of the year, the total complement of the Division was 163, including 39 employed in the Main Workshop.

2. Buildings and installations

Proton synchrotron buildings

(a) *Ring building*

In July, the joints between the 30 sections of the ring girder were cast, thus making the girder one solid whole. Once this had been done, a civil engineer from the architect's office compared the behaviour of the girder with theoretical figures, particularly in respect of the distortion of the girder under pressure applied at a given spot and under the effect of vibrations. There is a remarkably good agreement between the measurements and the theoretical figures. (See page 67).

The air conditioning system, which is intended to keep a constant temperature inside the ring, was installed and put into operation. There is a flow of air on either side of the girder. The air is kept at 18° C with a tolerance of less than ± 1° C and a dew point of 9° C. The treatment of the air is effected at each of 8 ventilation sub-stations, which make it possible to deal with temperature fluctuations section by section. The total quantity of air treated is 154 000 m³/h, of which 40 000 m³/h, i.e. 5 000 m³/h in each of the 8 sub-stations is normally fresh air. An " over dense " pressure is thus maintained in the ring. The air is first filtered by means of rotating oil filters and heated or cooled to give the required conditions using hot water supplied at a constant temperature of 50° C and cold water at a temperature of 4° C supplied from separate installations located in the proton synchrotron buildings outside the ring. The air after entry into the ring building is drawn out at roof level by exhaust ducts and returned to ventilation equipment for retreatment and recirculation. Water is pumped through a network of pipes cast in the girder in order to increase the thermal conductivity of the girder and to ensure that its temperature reaches equilibrium. The water temperature is not controlled but provision has been made to control it at a later date, if necessary. (See page 73).

Similar air conditioning equipment has been installed in the linear accelerator wing and is already in operation.

(b) *Power house and sub-station*

This is the last unfinished building of the proton synchrotron complex. Great efforts have been made to complete this in the very limited time allowed. Very fast progress was made in the concrete work, and finishing work is proceeding apace. It has been possible to begin installing the proton synchrotron control equipment on delivery.

(c) *Experimental halls and laboratories*

All the staff of the Proton Synchrotron Division with their equipment are now accommodated in their permanent laboratories and offices at Meyrin. This Division is using the experimental halls and installations to test and assemble the magnet blocks. (See pages 68 and 69). Baryte blocks, to be placed underneath the shielding bridge in the experimental hall, are being manufactured, and the system which will be used to place them under the horizontal girders was installedand tested. (See page 74).

Synchro-cyclotron buildings

This building is completed and the two hydraulic lifting platforms were put into operation. (See page 74).

Laboratory wings

Laboratories in wings I and II are now occupied by the Synchro-cyclotron and Scientific and Technical Services Divisions. The library and the Theoretical Study Division have also been moved into their permanent accommodation. The telephone exchange is ready. Concrete work for laboratory wing III is practically complete and internal work is proceeding. Construction is also in hand of the radioactive effluent delay tank necessary for use with the radio-chemical laboratories being equipped in wing III.

Main Building for the Directorate-General and the Administration

Work is proceeding on the basis of the reduced programme from which the canteen in particular was excluded. The foundations are practically completed.

Main Workshop building

As the building was ready, most of the machines were installed and are operating. (See page 69).

Liquid hydrogen building

This building was handed over to the Scientific and Technical Services Division. (See page 68).

Power house

The electrical sub-station was finally energized using the new 18 kV feeders from " La Renfile " station. The emergency Diesel generator and two air compressors were installed. Two oil storage tanks were placed in position.

The office part of the building is now completed and occupied by the Site and Buildings Division staff, part of which is also accommodated in the store-rooms and garages. (See page 72).

Water pump house and sewage work

The sewage treatment plant is operating and all cooling water pumps have been installed.

Surroundings

Following completion of the major part of the building programme, it has been possible to begin levelling the ground, sowing with grass the areas that had been levelled, and building roads.

3. General works and maintenance services

This has been a particularly difficult transition period, owing to the coincidence of divisional movements into new premises with the putting into service of new installations. To cause the minimum of inconvenience to staff and research generally, a certain degree of improvisation has been necessary. Nevertheless, with minor exceptions, it has been possible to provide the Divisions with good and uninterrupted services. The maintenance service operates in accordance with a clearly laid down periodical control schedule.

The maintenance of existing buildings and plant still represents only a minor part of the duties assigned to the Site and Buildings Division. The Division continues to receive numerous requests from other Divisions for special installations and works.

The total consumption of electric power has trebled since 1956 and it reached a figure of 3 million kWh in 1957; maximum demand was 2200 kVA. Cooling water consumption amounted to about 200000 m^3.

4. Common services

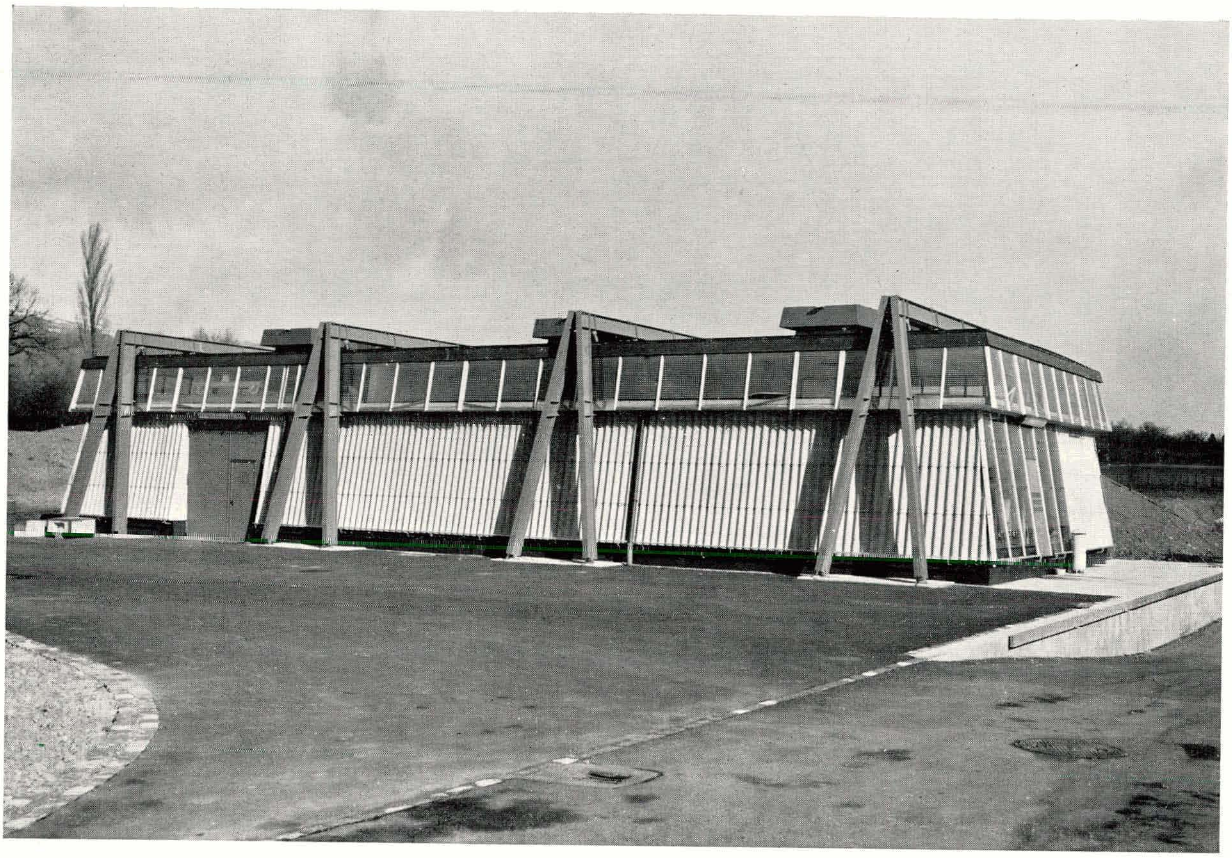
(a) *Transport section*

During the period under review, this section was kept extremely busy as, apart from routine duties, it had to deal with the removal of the various Divisions to Meyrin. Over 20000 tons of equipment were brought on to the site and 7287 passengers were carried. A total distance of 220660 km was covered. A particularly intensive transport programme has had to be arranged to deal with the delivery of equipment for the proton synchrotron.

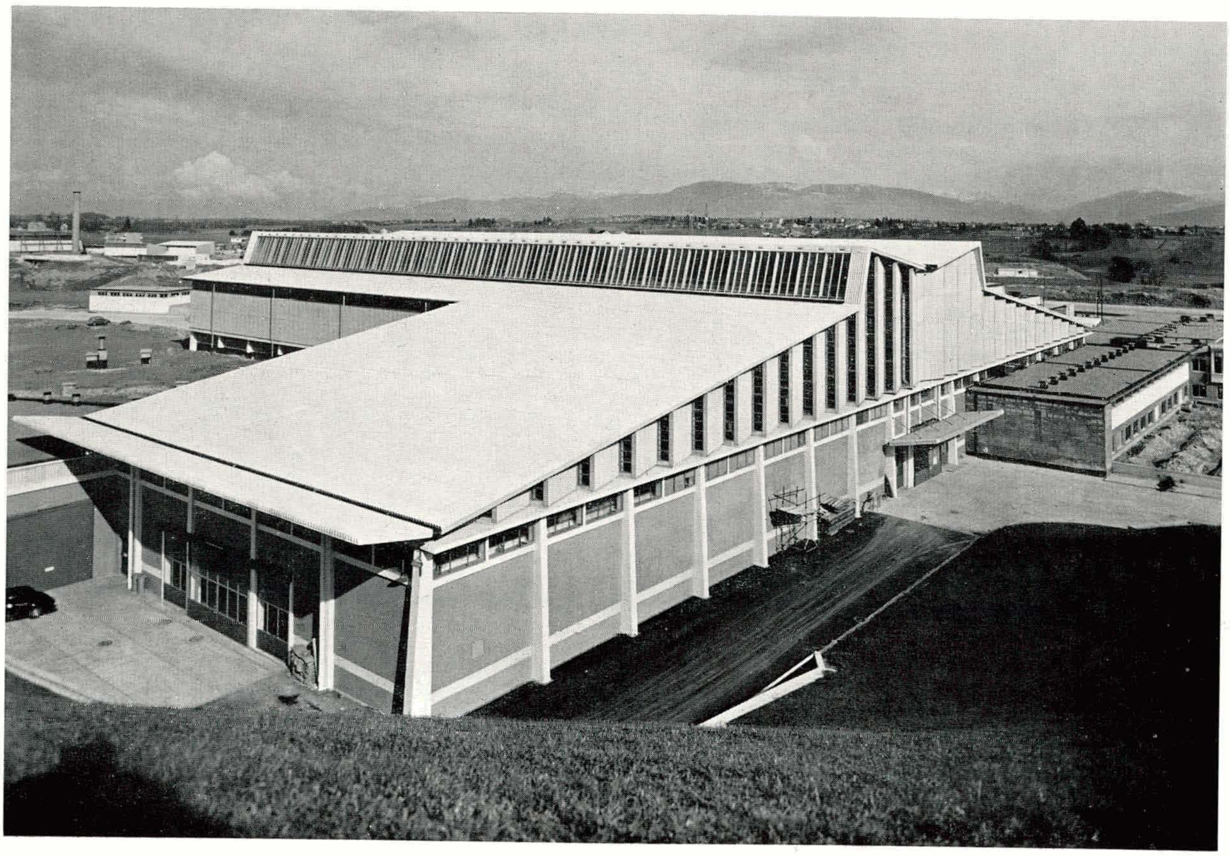
(b) *Fire services, first aid and site security*

The organization of this section has been planned to provide a continuous cover throughout the 24 hours. Under the leadership of a chief fire officer, a small team of experienced firemen has been recruited and has, in turn, trained many of the scientific and technical staff, so that in an emergency the permanent team should receive adequate help. Suitable fire fighting equipment has been provided and exercises are frequently being held. Instruction in the rudiments of first aid has been given to several members of the other Divisions. The first aid station is now up in its permanent accommodation. It is equipped with an ambulance for the transport of casualties to hospital.

Interior of the ring building of the Eurotron, 25 GeV proton synchrotron.



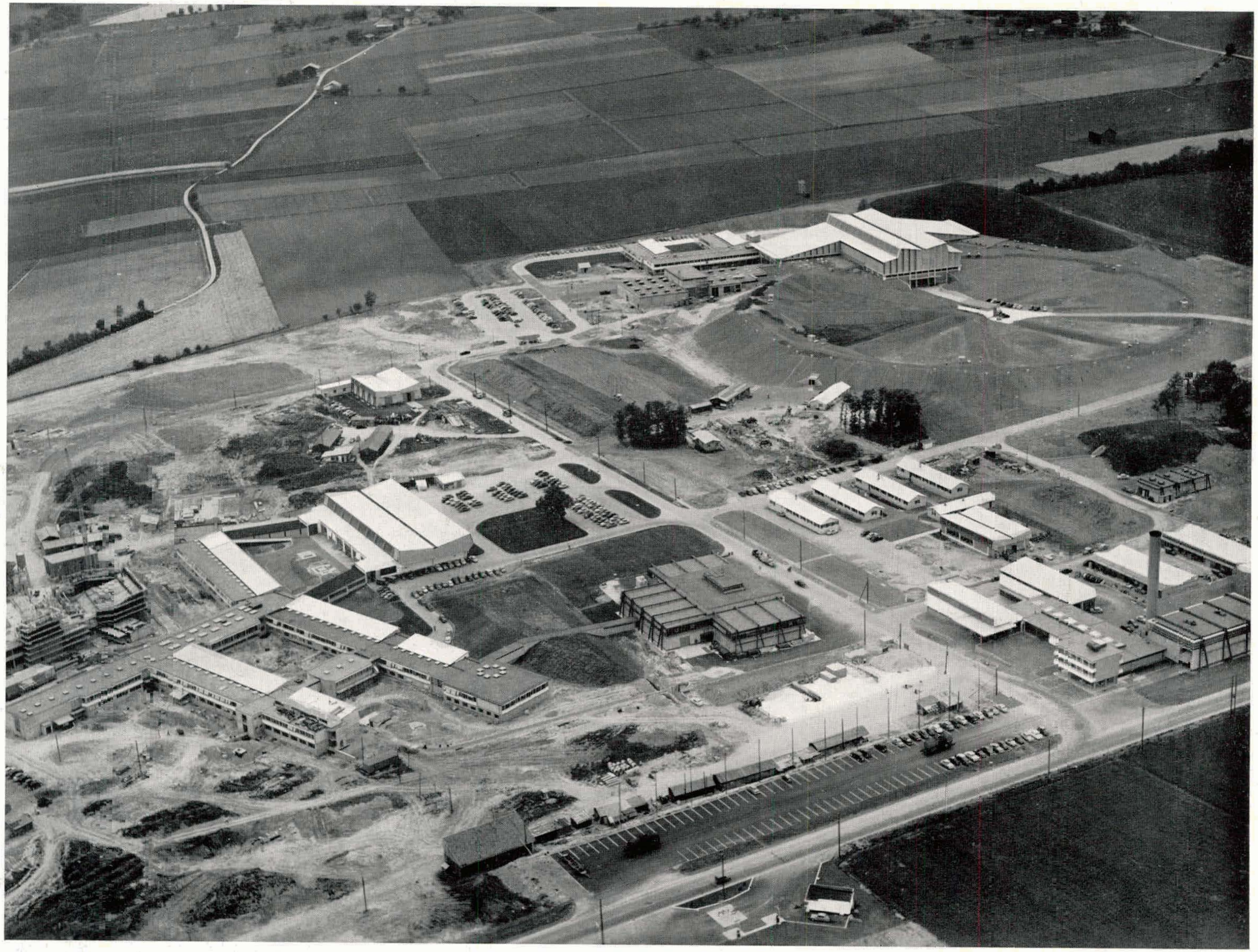
Hydrogen liquefactor building.



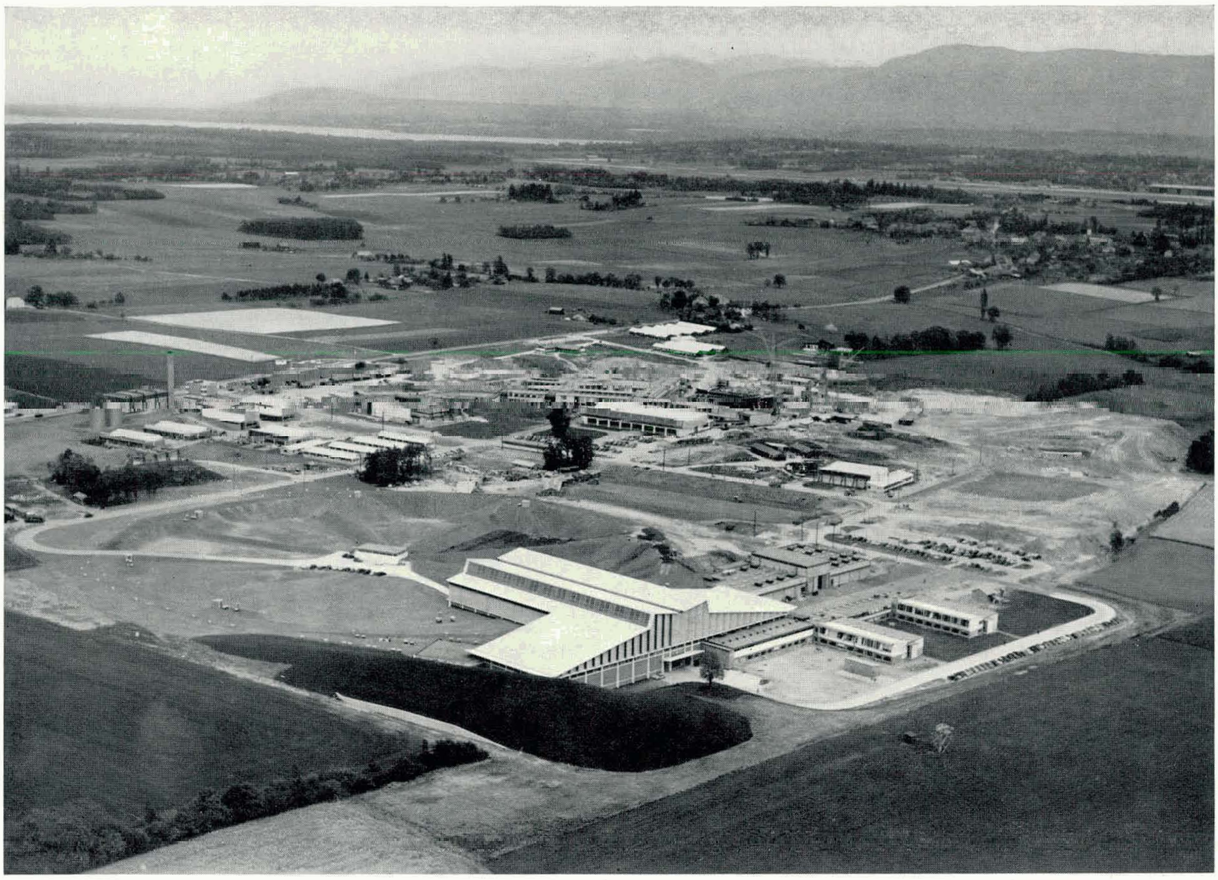
Proton synchrotron experimental hall building.

Main workshop.

Proton synchrotron experimental hall building.



Aerial view of the site May 1958.



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May 1958.

Aerial view of the site with the 25 GeV proton synchrotron in the foreground.

February 1957.

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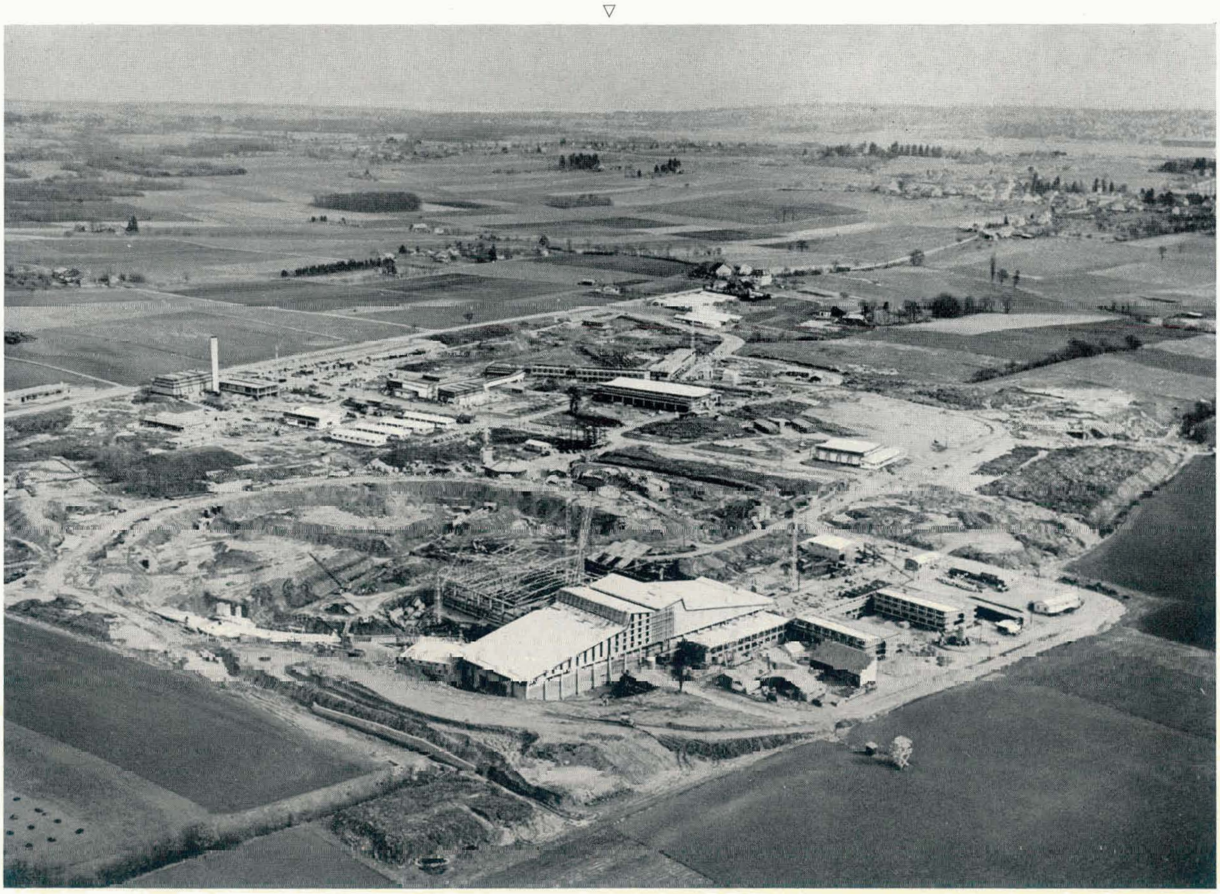
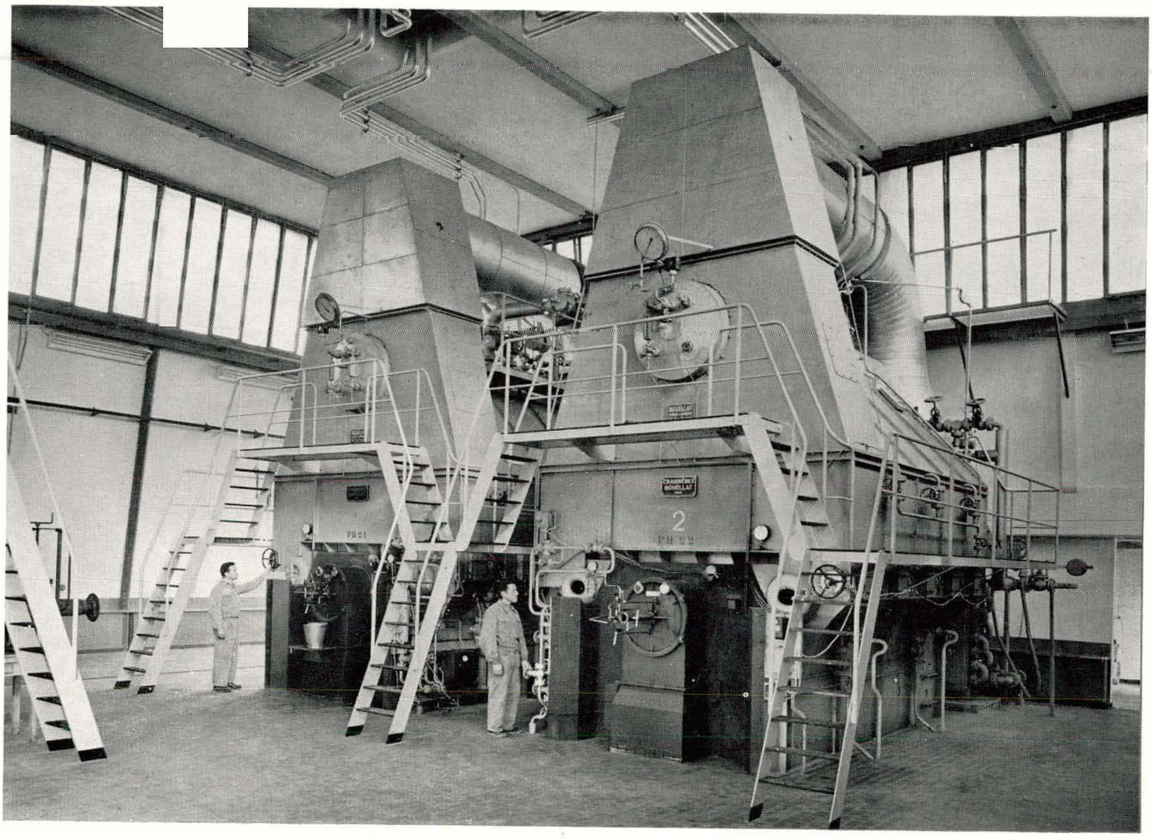
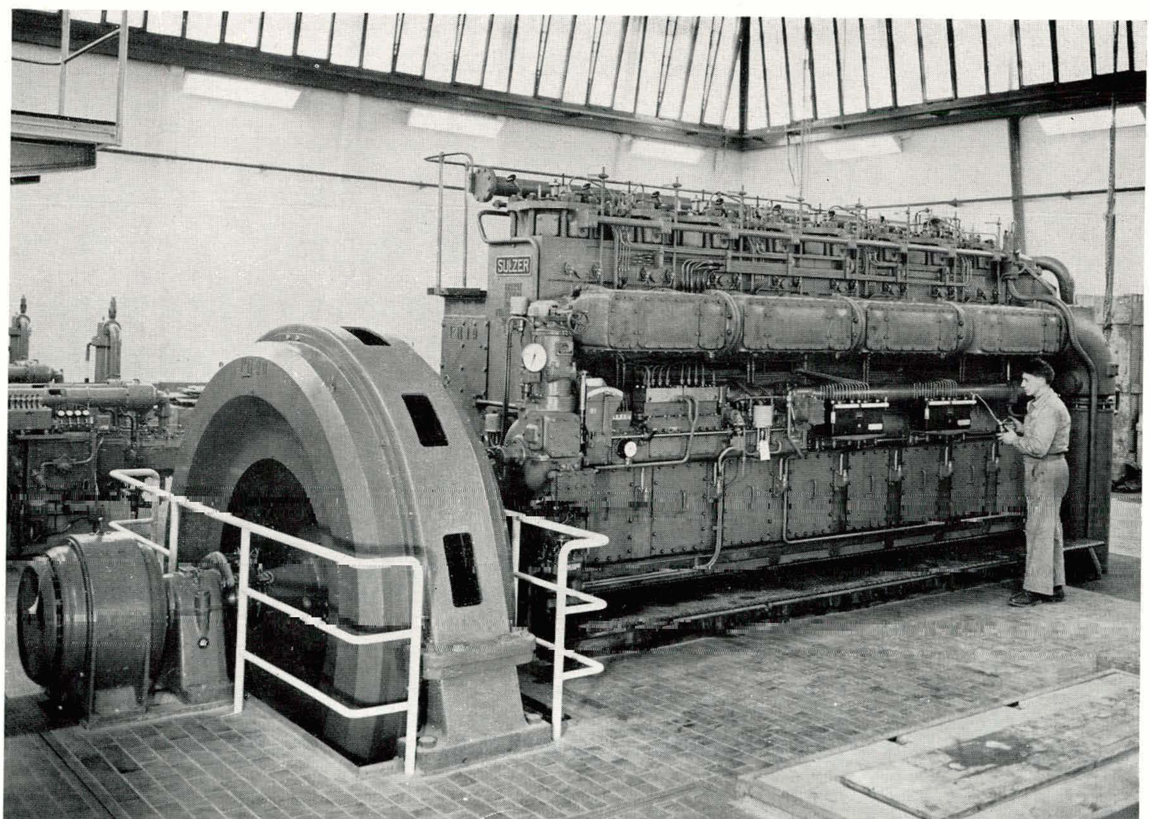
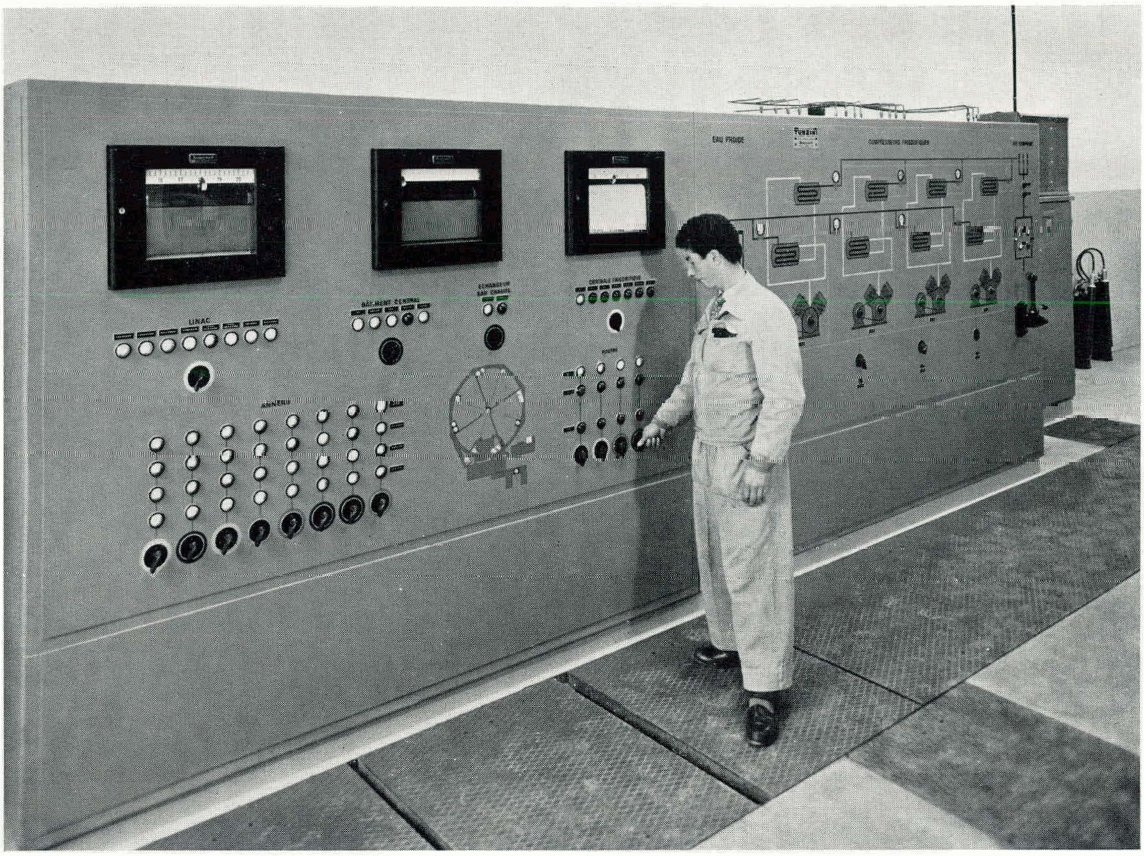




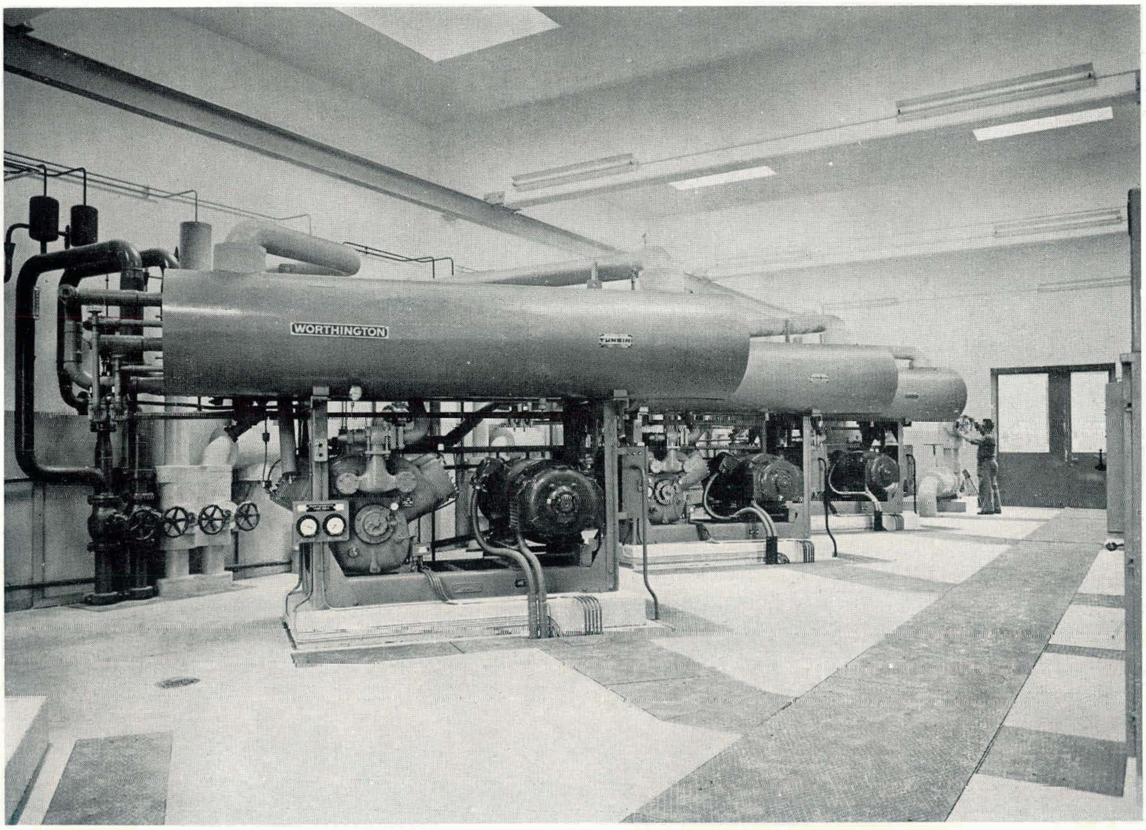
Power house: boilers for superheated water.



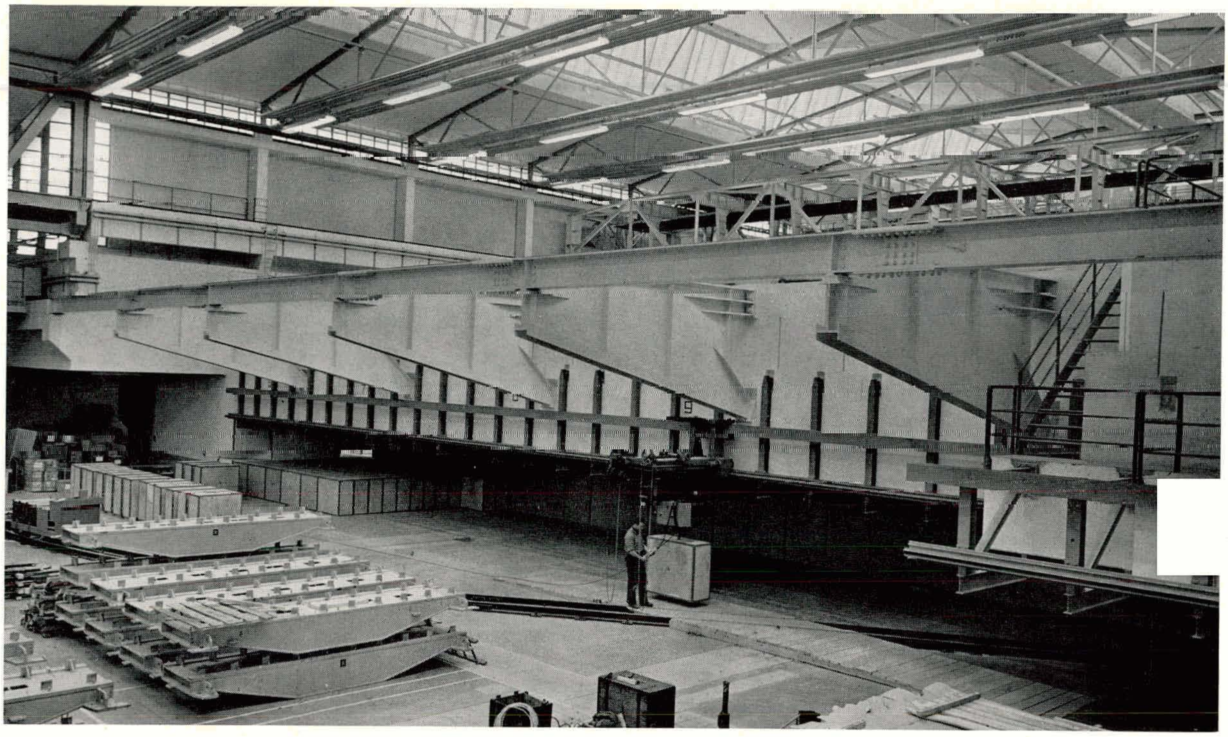
Power house: emergency Diesel plant.



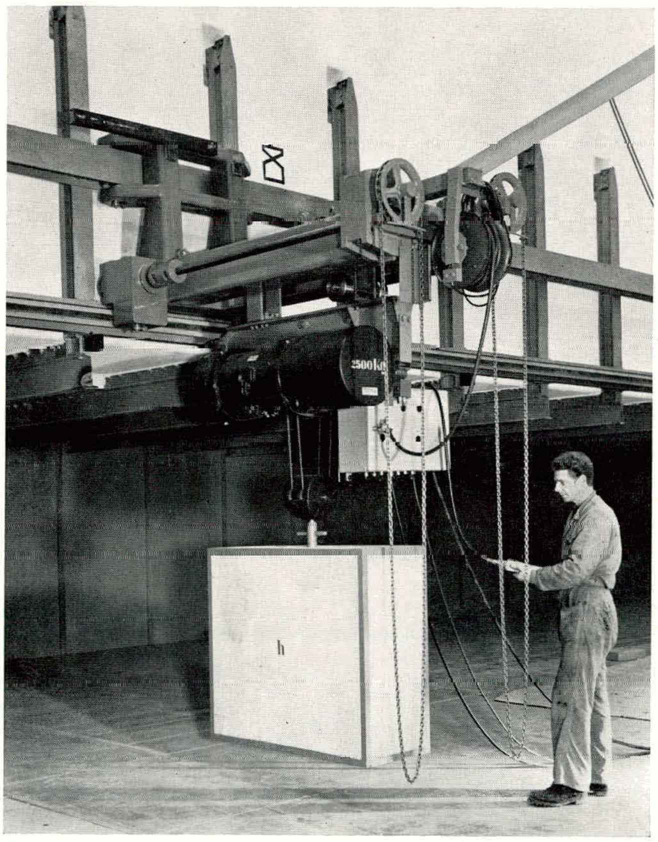
Control panel of air conditioning for the proton synchrotron ring building.



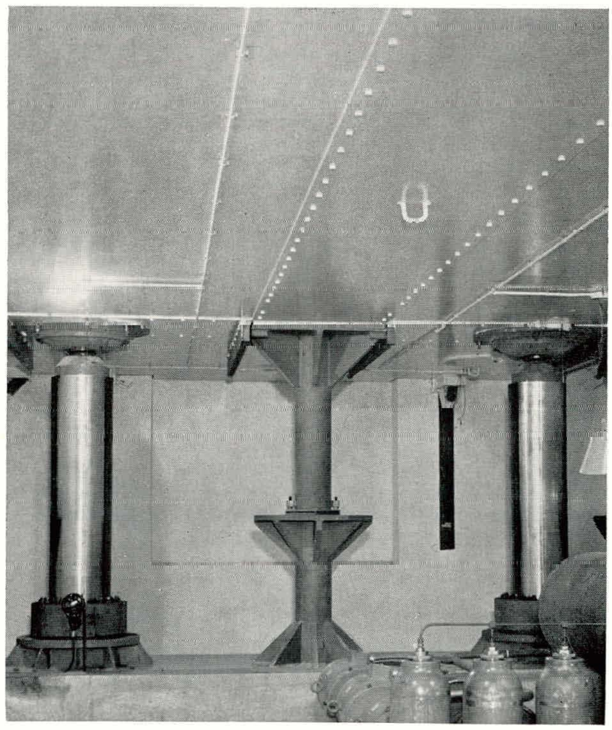
Refrigeration system for air conditioning of proton synchrotron ring building.



Partial view of the main proton synchrotron laboratory.
In the background crane for placing the shielding blocks of baryte concrete.



Wall crane, equipped with electric pulley block, for the handling of shielding blocks of baryte concrete.



Two of the four hydraulic jacks of the 2220 ton lifting platform of the synchro-cyclotron.

5. Staff facilities

With the influx of staff to Meyrin, the number of users of the temporary canteen has risen a great deal and the average daily attendance at lunch time is now approximately 310.

A hut has been made available to the Staff Association for recreational purposes.

6. Safety on the site

A safety engineer was appointed to watch working conditions and give advice to staff on the prevention of accidents. This system accounts for the fact that the number of accidents in 1957 was very small.

A Safety Committee sits under the chairmanship of the site engineer and includes representatives of every Division. It meets at regular intervals to examine all problems connected with accident prevention and reports direct to the Director-General.

A safety manual is being prepared. Safety codes have already been issued on the following subjects :

— procedure in case of accidents;
— storage of chemicals;
— safety rules concerning the use of hydrogen;
— electrical safety code;
— mechanical lifting apparatus and pressure vessels.

7. Main Workshop

The management of the Main Workshop which works for all the Divisions, was transferred from the Scientific and Technical Services Division to the Site and Buildings Division in July. At the same time, the workshop was moved with all its equipment from Cointrin to Meyrin and completed its tooling.

Amongst the major items of work performed in the workshop, mention should be made of the 10 cm bubble chamber, the rotating condensor for the synchro-cyclotron and the polarized ion source. Routine work includes the manufacture of a large amount of ancillary equipment for the large machines, such as mobile supports for magnets, and laboratory equipment, attachments for vacuum chambers and many spare parts.

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ADMINISTRATION

1. General

In 1957, practically all CERN's activities have been concentrated at Meyrin and the Administration Division has had to adapt the operations of its various services to deal with the changed situation, while bearing in mind the general development of the Organization which is about to switch from the constructional to the experimental stage.

This development is influencing the internal structure of CERN. The Division has taken part in the study of the modifications that will be called for in this structure when research with the two accelerators makes up the bulk of the Organization's work.

Though it could be expected that the completion of construction work would result in a levelling off or a decrease in the Division's activities, its tasks have not in fact ceased to grow and the small increase in its staff which has gone up from 60 in 1956 to 73 in 1957 bears no relation to the increase in its volume of work.

On the whole, the percentage of administrative expenses compared with total expenditure has remained very low.

2. Finance Office

The plan of accounts and the layout of the budget already reflect to some extent the need to follow the new activities in detail, whereas hitherto only the cost of construction had to be known: all types of expenditure were in fact directed towards construction and could therefore be regarded as capital expenditure.

Henceforth, an increasingly detailed distinction will have to be drawn between construction expenditure, operational expenditure and research expenditure. It will also be useful to be in a position to know at any time the cost of each of the main experiments and of the research work of any type conducted by the various groups.

When the budget for 1958 was prepared, difficulties in estimating long-term expenditure with a reasonable degree of accuracy proved particularly acute. In fact, the estimates for 1958, which had been made at the end of 1956 in the Capital Investment programme extending until the end of 1960, turned out to be definitely inadequate.

Owing to these difficulties which are inherent in all research work, where basic or detailed programmes and techniques may change very quickly, the Council gave up the idea of preparing reliable forecasts of expenditure for several years ahead.

The Council decided at its 9th session in December 1957, that the contributions of the Member States for 1958 should total 56 million francs and that they should not exceed 100 million for the years 1958 and 1959 taken together.

During the course of the financial year, CERN experienced financial difficulties on account of delays in the payment of contributions and of the inadequacy of its working balance.

3. Personnel Office

Besides its ordinary tasks, the personnel office worked out two major changes in 1957, one of which concerned the appointment policy and the other the general grade structure.

Hitherto, only fixed term contracts (maximum three years) could be granted to CERN staff members.

It has appeared necessary as a result of experience to set up a stable cadre of scientists and engineers as well as of administrative and technical staff. While it maintains the possibility of renewing scientific staff at frequent intervals, the new appointment policy meets CERN's special requirements in this respect.

A comprehensive review of the grade structure has taken place. Whereas staff members were

CERN STAFF AS AT 31st DECEMBER 1957
Distribution by functions and Divisions

Division	Leading and Scientific	Technical	Administrative	Ancillary	Fellows	*Total*
Directorate-General	1	—	7	—	—	8
Proton Synchrotron	48	91	7	19	3	168
Synchro-cyclotron	26	53	3	8	19	109
Scientific and Technical Services	26	20	6	3	3	58
Site and Buildings	4	76	4	79	—	163
Theory	6	—	1	—	11	18
Administration	4	1	49	19	—	73
TOTAL	115	241	77	128	36	597

previously divided into four classes which emphasized the difference in their original background, (university, administrative, industrial) the new system provides for the sub-division of the staff into fourteen grades without the previous distinctions. There are grounds to think this new classification will facilitate co-operation between people with very different backgrounds and avoid certain anomalies.

The increase in the cost of living and in wages in Switzerland and in the Member States had led the Council to vote a five per cent increase in basic salaries with effect from 1st January 1958.

The Division is proceeding with its preliminary studies for an eventual linking of salaries to indices.

4. Purchasing Office

Like the other two Offices, the Purchasing Office had to face a considerable increase in its work load in 1957. The number of orders and contracts placed in 1957 amounted to 11 500 (7 900 in 1956), and some of them, which were of special importance, gave rise to lengthy negotiations.

The Council decided that CERN should not cover its own fire and radiation risks. A contract was therefore negotiated and concluded, whereby companies from several Member States jointly took a share in covering these risks.

BREAKDOWN OF 1957 EXPENDITURE

	Budget 1957	Expenditure 1957	Differences	EXPENDITURE 1957							
				Office of the Director General	Proton Synchrotron	Synchro-cyclotron	Scientific and Technical Services	Site and Buildings	Theoretical Study Division	Administration	TOTAL
TOTAL	**61'825'800.—**	**60'478'260.95**	**–1'347'539.05**	**306'912.76**	**17'935'448.31**	**5'186'012.35**	**3'035'645.54**	**31'734'908.61**	**673'796.77**	**1'605'536.61**	**60'478'260.95**
1. **Staff expenses**	**9'943'200.—**	**10'100'974.15**	**+ 157'774.15**	**222'582.78**	**3'093'920.35**	**1'850'159.05**	**1'448'489.40**	**1'641'416.45**	**615'262.53**	**1'229'143.59**	**10'100'974.15**
10) Salaries	8'068'800.—	8'275'547.40	+ 206'747.40	143'099.15	2'566'956.15	1'494'466.75	1'168'759.55	1'414'930.—	506'412.90	980'922.90	8'275'547.40
11) Social insurance	1'142'400.—	1'104'297.73	– 38'102.27	19'567.50	334'525.70	180'216.70	146'204.20	159'583.20	52'855.54	211'344.89	1'104'297.73
12) Travelling expenses	288'000.—	285'091.81	– 2'908.19	13'174.30	117'854.80	53'173.95	57'457.10	7'058.90	27'957.21	8'415.55	285'091.81
13) Other expenses	406'000.—	397'084.16	– 8'915.84	7'788.78	74'583.70	122'301.65	76'068.55	59'844.35	28'036.88	28'460.25	397'084.16
14) Guest professors	38'000.—	38'953.05	+ 953.05	38'953.05	—	—	—	—	—	—	38'953.05
2. **General expenses**	**3'743'100.—**	**2'461'684.19**	**–1'281'415.81**	**64'369.63**	**346'320.32**	**384'292.43**	**260'740.02**	**1'040'750.31**	**38'815.96**	**326'395.52**	**2'461'684.19**
20) Adminis. expenses	353'900.—	358'493.65	+ 4'593.65	1'802.20	18'615.89	14'012.30	47'775.09	11'647.25	7'746.69	256'894.23	358'493.65
21) Committees a. experts	191'500.—	182'989.02	– 8'510.98	42'541.45	39'401.30	57'132.74	14'227.65	875.—	24'714.38	4'096.50	182'989.02
22) Interest payments	2'000.—	7'198.35	+ 5'198.35	—	—	—	—	—	—	7'198.35	7'198.35
23) Servicing premises and furniture	932'000.—	813'928.81	– 118'071.19	—	4'653.—	775.14	3'644.85	798'780.51	74.41	6'000.90	813'928.81
24) Expendable stores	2'163'000.—	1'018'260.36	–1'144'739.64	—	283'650.13	312'372.25	195'092.43	224'303.25	—	2'842.30	1'018'260.36
29) Miscellaneous	100'700.—	80'814.—	– 19'886.—	20'025.98	—	—	—	5'144.30	6'280.48	49'363.24	80'814.—
3. **Capital expenses**	**48'139'500.—**	**47'915'602.61**	**– 223'897.39**	**19'960.35**	**14'495'207.64**	**2'951'560.87**	**1'326'416.12**	**29'052'741.85**	**19'718.28**	**49'997.50**	**47'915'602.61**
30) Site and buildings	25'600'000.—	28'064'444.10	+2'464'444.10	—	—	—	—	28'064'444.10	—	—	28'064'444.10
31) Equipment	3'709'500.—	3'177'837.28	– 531'662.72	19'960.35	1'259'309.53	310'299.50	599'455.97	919'096.15	19'718.28	49'997.50	3'177'837.28
32) Accelerators	15'920'000.—	13'684'981.11	–2'235'018.89	—	12'598'736.66	1'086'244.45	—	—	—	—	13'684'981.11
33) Experimental equipment	2'910'000.—	1'486'490.16	–1'423'509.84	—	38'939.70	1'033'716.81	413'833.65	—	—	—	1'486'490.16
38) Raw materials and spares	—	1'501'849.96	+1'501'849.96	—	598'221.75	521'300.11	313'126.50	69'201.60	—	—	1'501'849.96

BUDGET 1958

	Office of the Director-General	Proton Synchrotron	Synchro-cyclotron	Scientific and Techn. Services	Site and Buildings	Theoretical Study Division	Admi-stration	Total
TOTAL	**550'000**	**17'827'800**	**5'512'000**	**4'278'100**	**25'686'800**	**678'000**	**1'920'700**	**56'453'400**
1. **Staff expenses** .	**305'000**	**3'868'800**	**2'682'000**	**1'610'100**	**3'003'800**	**629'000**	**1'498'700**	**13'597'400**
10) Salaries . .	184'000	3'273'000	2'265'000	1'310'000	2'670'000	539'000	1'172'700	11'413'700
11) Social insurance	25'300	418'800	280'000	174'100	290'000	57'000	282'000	1'527'200
12) Travelling expenses . .	21'500	100'000	63'000	60'000	10'000	20'000	14'000	288'500
13) Other expenses . . .	24'200	77'000	74'000	66'000	33'800	13'000	30'000	318'000
14) Guest professors	50'000	—	—	—	—	—	—	50'000
2. **General expenses**	**229'000**	**238'000**	**362'000**	**277'000**	**1'403'000**	**41'000**	**354'000**	**2'904'000**
20) Administration expenses	7'000	24'000	12'000	62'000	10'000	1'000	265'000	381'000
21) Committees and experts .	172'000	30'000	50'000	24'000	1'000	40'000	10'000	327'000
22) Interest payments . . .	—	—	—	—	—	—	5'000	5'000
23) Servicing premises and furniture .	—	14'000	100'000	6'000	792'000	—	7'000	919'000
24) Expendable stores . . .	—	170'000	200'000	185'000	593'000	—	4'000	1'152'000
29) Miscellaneous . . .	50'000	—	—	—	7'000	—	63'000	120'000
3. **Capital expenses**	**16'000**	**13'721'000**	**2'468'000**	**2'391'000**	**21'280'000**	**8'000**	**68'000**	**39'952'000**
30) Site and buildings . .	—	—	—	—	19'846'000	—	—	19'846'000
31) Equipment .	16'000	1'134'000	430'000	150'000	918'000	8'000	68'000	2'724'000
32) Accelerators	—	11'677'000	688'000	—	—	—	—	12'365'000
33) Experimental equipment .	—	190'000	750'000	1'820'000	—	—	—	2'570'000
38) Raw materials and spares .	—	720'000	600'000	421'000	516'000	—	—	2'257'000

APPENDIX A

CERN PUBLICATIONS

CERN 57-1 HAGEDORN, R. Stability and amplitude ranges of two dimensional non-linear oscillations with periodical Hamiltonian applied to betatron oscillations in circular particle accelerators (Part I & II).

CERN 57-2 BUDDE, R., CHRETIEN, M., LEITNER, J., SAMIOS, N. P., SCHWARTZ, M. and STEINBERGER, J. Properties of heavy unstable particles produced by 1.3-GeV π^- mesons.
Repr. from Physical Review, *103*, (6), p. 1828-1836, 1956.

CERN 57-3 Espe, I. Electronic motion in the rotating H_2 molecule.
Repr. from Physical Review, *103*, (5), p. 1254-1257, 1956.

CERN 57-4 ALSTON, M. H., CREWE, A. V., EVANS, W. H. and von GIERKE, G. A study of positive pion production in p-p collisions at 383 MeV.
Repr. from Proceedings of the Physical Society, A, *69*, p. 691-704, 1956.

CERN 57-5 COOPER, W. A., FILTHUTH, H., NEWTH, J. A., PETRUCCI, G., SALMERON, R. A. and ZICHICHI, A. A probable example of the production and decay of a neutral tau-meson.
Repr. from Nuovo Cimento, ser. 10, *4*, p. 1433-1444, 1956.

CERN 57-6 D'ESPAGNAT, B. et PRENTKI, J. Interactions faibles directes bosons-leptons et désintégrations des mésons K.
Repr. from Nuovo Cimento, ser. 10, *4*, p. 1572-1574, 1956,

CERN 57-7 ALSTON, M. H., EVANS, W. H., FIDECARO, M., NEWPORT, R. W., VON GIERKE, G. and WILLIAMS, P. R. π^+-p scattering at 10-35 MeV in a diffusion cloud chamber.
Repr. from Proceedings of the Physical Society, A, *69*, p. 798-803, 1956.

CERN 57-8 MØLLER, C. The ideal standard clocks in the general theory of relativity.
Repr. from Fünfzig Jahre Relativitätstheorie/Cinquantenaire de la Théorie de la Relativité. Bern, 11-16 Juli, 1955. Verhandlungen/Actes. Basel, Birkhauser, 1956.

CERN 57-9 ADAMS, J. B. La construction des accélérateurs. Introduction à la 1re semaine du Symposium du CERN. (Traduction de CERN 57-10).
Extr. de Industries atomiques, No. 4, p. 9-22, 1957,

CERN 57-10 ADAMS, J. B. The CERN Symposium 1956. (I. High energy accelerators.)
Repr. from Nuclear Instruments, *1*, p. 2-9, 1957.

CERN 57-11 VON DARDEL, G. F. The CERN Symposium 1956 (II. Nuclear instrumentation and sessions on anti-proton physics and nuclear scattering).
Repr. from Nuclear Instruments, *1*, p. 10-16, 1957.

CERN 57-12 LUNDBY, A. The CERN Symposium 1956 (III. Pion physics).
Repr. from Nuclear Instruments, *1*, p. 17-20, 1957.

CERN 57-13 JOUVET, B. L'exclusion des « fantômes ».
Repr. from Nuovo Cimento, Supplemento, ser. 10, *4* (2), p. 813-816, 1956.

CERN 57-14 HAGEDORN, R. and SCHOCH, A. Stability and amplitude ranges of two dimensional nonlinear oscillations with periodical Hamiltonian applied to betatron oscillations in circular particle accelerators. (Part III)

CERN 57-15 JOUVET, B. Les couplages de Fermi et la théorie des bosons.
Repr. from Nuovo Cimento, Supplemento, ser. 10, *4*, p. 738-742, 1956.

CERN 57-16 JOUVET, B. Fermi coupling and mass and charge spectra of bosons.
Repr. from Nuovo Cimento, ser. 10, *5*, p. 1-20, 1957.

CERN 57-17 GLASER, V., and KÄLLÉN, G. A model of an unstable particle.
Repr. from Nuclear Physics, *2*, p. 706-722, 1956/57.

CERN 57-18 FRÖMAN, P. O. Alpha decay of deformed nuclei.
Repr. from K. Danske Videnskabernes Selskab. Matematisk-fysiske Skrifter, *1* (3), p. 1-76, 1957.

CERN 57-19 VILLARS, F. A note on rotational energy levels in nuclei.
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CERN 57-23 VISCONTI, A. and UMEZAWA, H. Scattering problems in field theory.
Repr. from Nuovo Cimento, Supplemento, ser. 10, *4* (2), p. 829-831, 1956.

CERN 57-24 NAGEL, B. A remark on quantum electrodynamics with non-vanishing photon mass and Lamb shift calculation.
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Repr. from Nuclear Physics, *3*, p. 446-455, 1957.

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Repr. from Nuclear Physics, *3*, p. 471-475, 1957.

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Repr. from Physical Review, *105* (6), p. 1931, 1957.

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CERN 57-29 GOLDSCHMIDT-CLERMONT, Y. The analysis of nuclear particle tracks by digital computer.

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Repr. from Reviews of Modern Physics, *28*, (4), p. 432-542, 1956.

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Repr. from Nuclear Physics, *3*, p. 592-597, 1957.

CERN 57-33 WILDERMUTH, K. and BAUMANN, K. Some remarks on self-acceleration and similar effects in quantum field theory.
Repr. from Nuclear Physics, *3*, p. 612-623, 1957.

CERN 57-34 RAKAVY, G. The classification of states of surface vibrations.
Repr. from Nuclear Physics, *4*, p. 289-294, 1957.

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Repr. from Nuclear Physics, *4*, p. 375-394, 1957.

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Repr. from Nuclear Physics, *3*, p. 689-690, 1957.

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Reprint in 1957 of K. Danske Videnskabernes Selskab. Matematisk-fysiske Meddelelser, *27*, (16), p. 1-174, 1953.

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CERN 57-42 COOPER, W. A., Filthuth, H., Newth, J. A., PETRUCCI, G., SALMERON, R. A. and ZICHICHI, A. Examples of the production of (K^o, K^o) and (K^+, K^o) pairs of heavy mesons.
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CERN 57-44 FERRETTI, B. On the conservation of nucleons.
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CERN 57-46 D'ESPAGNAT, B. Sur les interactions faibles baryons-mésons π.
Extr. Comptes rendus des séances de l'Académie des Sciences (Paris), *245*, p. 894-896, 1957.

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Repr. from Nuovo Cimento, Ser. 10, *6*, p. 745-747, 1957.

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Repr. from Nuclear Physics, *4*, p. 529-531, 1957.

CERN 57-53 Petermann, A. Fourth order magnetic moment of the electron.
Repr. from Helvetica Physica Acta, 30, (5), p. 407-408, 1957.

CERN 57-54 Dell'Antonio, G. and Duimio, F. On the Ruijgrok-Van Hove model.
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CERN 57-55 Hillman, P., Johansson, A. and Tyrén, H. Polarization of high energy protons in elastic and inelastic scattering.
Repr. from Nuclear Physics, *4*, p. 648-661, 1957.

CERN 57-56 Omnès, R. Sur les théories des champs invariantes par rapport au groupe conforme.
Extr. Comptes rendus des séances de l'Académie des Sciences (Paris), *245*, p. 1382-1384, 1957.

LIST OF COLLOQUIUM LECTURES

GENEVA — MEYRIN
1957

R. E. PEIERLS (January 10th) : Current work on nuclear theory in Birmingham.

B. FERRETTI (January 16th) : High energy inelastic diffraction phenomena.

C. F. POWELL (January 23rd) : Nuclear disintegration in the energy range between 10^{11}-10^{15}eV.

H. STAUB (January 30th) : Pair production by lower energy γ rays in the field of nuclei and electrons.

L. ROSENFELD (February 6th) : Recent work on systems of alpha-particles.

O. PICCIONI (February 13th) : Experiments on anti-protons and anti-neutrons.

W. HEITLER (February 20th) : Problems of meson theory.

L. KOWARSKI (February 27th) : Present state of nuclear reactors for power stations.

F. VILLARS (March 6th) : Non-conservation of parity.

G. WATAGHIN (March 13th) : High energy electromagnetic events observed with emulsion-techniques in cosmic rays.

L. MICHEL (March 20th) : Problèmes de parité.

D. H. WILKINSON (March 27th) : Some problems of low energy physics.

G. SALVINI (April 3rd) : The Italian electron synchrotron and its research programme.

T. R. GERHOLM (April 10th) : Applications of millimicro-second coincidence methods.

B. GREGORY (April 17th) : Résultats récents du Pic du Midi.

S. DE BENEDETTI (May 15th) : Experiments on the annihilation of positrons.

B. FERRETTI (May 22nd) : Report on Rochester conference.

F. STIELTJES (May 29th) : The physics of transistors.

T. HUUS (June 5th) : Coulomb excitation of nuclei.

H. L. ANDERSON (June 12th) : New search for the electronic decay of the pion.

B. TOUCHEK (June 19th) : Non-conservation of parity.

V. F. WEISSKOPF (October 16th) : On properties of nuclear matter.

E. R. CAIANIELLO (October 30th) : The brain : human and mechanical.

S. J. LINDENBAUM (November 6th) : Collisions of particles having energy of $\leqslant$ 1 BeV with nuclei.

W. HEISENBERG (November 13th) : General remarks on the theory of elementary particles.

G. BERNARDINI (November 20th) : The structure of the nucleon. The ground states and the resonance state of the pion-nucleon system.

O. CHAMBERLAIN (November 27th) : Antinucleons.

H. S. W. MASSEY (December 4th) : Problems in ultra-high energy physics.

W. E. LAMB, Jr. (December 11th) : Recent studies of hydrogen fine structure.

A. BOHR (December 18th) : The energy spectra of nuclei.

APPENDIX C

LIST OF LECTURES AND COLLOQUIA OF THE THEORETICAL STUDY DIVISION IN COPENHAGEN

A. Mesons and the Field Theory of Nuclear Forces

M. LEVY (May 3rd): Nucleon — antinucleon forces.

G. KÄLLÉN (May 6th): Some impressions from the conference in Rochester (mainly concerning strong interactions and related problems).

G. WATAGHIN (May 24th): Macroscopic causality and the choice of form-factors in a non-local theory of fields.

J. CRUSSARD (May 27th): Recent results on strange particles at the Ecole Polytechnique.

A. PAIS (June 7th): Some theoretical remarks about K-particles.

A. PAIS (June 24th): K-particles and hyperons.

B. Quantum Electrodynamics

G. KÄLLÉN: Weekly lectures on " Consistency problems in quantum electrodynamics " (starting on February 6th 1957).

A. PETERMANN (February 25th): Fourth order magnetic moment of the μ-meson and related problems in atomic levels shifts.

S. KAMEFUCHI (March 18th): A comment on Landau's method in quantum electrodynamics.

C. Nuclear Constitution

S. JOHANSSON (February 1st): Photonuclear reactions in light elements.

T. V. KANELLOPOULOS (February 15th): Polarization experiments in p-p scattering.

R. M. EISBERG (March 1st): Recent experiments and theories concerning the elastic scattering of fast alfa-particles by nuclei.

J. P. ELLIOTT (March 8th): The application of the shell model to nuclear spectroscopy.

G. M. TEMMER (March 13th): Nuclear properties revealed by Coulomb excitation.

R. SHELINE (March 22nd): About radioactive nuclei.

R. E. PEIERLS (March 27th): A variational approach to collective motion.

C. PORTER (May 8th): Compound nucleus problems.

B. ELBEK (June 3rd): Inelastic scattering of 4 MeV protons and deuterons from odd isotopes of Dy and Yb.

L. I. SCHIFF (June 11th): Scattering of high energy electrons from nuclei.

H. KOPFERMAN (June 14th): Recent experiments on hyper-fine structure.

D. General Topics

O. KLEIN (January 16th, 17th, 23rd and 24th): General relativity and quantum field theory.

A. S. WIGHTMAN (January 30th): On the interpretation of the experiments on the conservation of parity.

V. FOCK (February 18th): Homogeneity, co-variance and relativity.

V. FOCK (February 20th): Some approximate solutions of Einstein's equations (motion of rotating bodies of finite size).

V. FOCK (February 22nd): On gravitational waves from a system of moving bodies.

V. FOCK (March 4th): On the Schrödinger equation for the helium atom.

H. WERGELAND (April 1st): Irreversibility and recurrence.

M. PRESTON (April 5th): On the coupling constants in beta decay.

W. PAULI (April 8th): Some remarks about parity conservation and weak interactions.

D. TER HAAR (April 10th): Theories of collective behaviour.

D. R. HARTREE (April 15th): Subharmonics in the forced oscillations of a non-linear system; a numerical approach.

A. BOHR (May 6th): Report on the Rochester meeting— Weak interactions.

E. HYLLERAAS (May 16th): Asymptotic calculations of zeroes of Bessel functions of higher order.

S. ONEDA (May 31st): On some aspects of weak interactions.

E. P. WIGNER (June 12th) : Measurements of distances in space-time and of curvature.

W. A. FOWLER (June 13th) : Synthesis of the elements in stars.

A. BOHR (June 13th) : Discussion on weak interactions.

C. N. YANG (June 21st) : The weak interactions.

A. HERZENBERG (August 29th) : The earth magnetism.

E. High Energy Nuclear Physics and Accelerators

P. MEYER (March 15th) : Inelastic scattering of high energy protons by light nuclei.

M. SCHARFF (May 15th) : Strange particles at Rochester.

P. HILLMAN, T. MARIS and H. TYRÉN (June 27th) : Inelastic nuclear scattering processes with 200 MeV protons from the Uppsala cyclotron.

F. Solid State and Molecular Physics

J. M. BLATT (February 8th) : The chemical equilibrium approach to superconductivity.

P. O. LÖWDIN (March 18th) : Some recent developments in the quantum theory of many-particle systems.

D. PINES (June 17th) : Superconductivity.