CERN COURIER

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European Organization for Nuclear Research

CERN by night. The cover photograph was taken by A. Bondi and shows the outside of the North Experimental Hall in the moon-light.

Comment

At the meeting of the CERN Council in December, no other European country was able to add itself to the short list of Austria, Belgium and France who have already declared their willingness to participate in the project for the construction of a 300 GeV accelerator. However, a significant step forward was taken with the approval of the revised Convention which makes it possible to set up a new Laboratory under the same organization as CERN-Meyrin. This in itself represents no commitment to the project by the different countries, but it is a preliminary step which has to be taken before the project becomes a reality.

The outcome of the Council Meeting does not mean that the programme for the 300 GeV has slipped back significantly yet; some preparatory work can continue. But this will not be true for much longer and it must be remembered that European progress in sub-nuclear physics has to be considered with half an eye to what is happening elsewhere. If a machine capable of the same physics is completed in the USA many years in advance, the implications on the vitality of a European project need no underlining. The speakers representing the scientific community at the Council meeting (such as Professor Amaldi, Chairman of the European Committee for Future Accelerators, and Professor Puppi, Chairman of the Scientific Policy Committee) stressed the urgency of making a start as early as possible.

The December meeting also brought out clearly that the project itself should not be regarded as static. The team to whom the construction of the next big European machine is assigned, would not be bound by the 300 GeV design which has already been done. This design serves as a sound basis for decisions but the machine to be built would incorporate any relevant technological developments to make it as up-to-date as possible at the time the design has to be finally frozen.

This point, which is covered more fully in the report on the following pages, has perhaps always been tacitly implied, but it emerged very strongly at the Council meeting and is of considerable significance in view of any revised programme.

Contents

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

The experimental programme is based mainly on the use of two proton accelerators — a 600 MeV synchro-cyclotron (SC) and a 28 GeV synchrotron (PS). At the latter machine, large intersecting storage rings (ISR), which will allow experiments with colliding proton beams to be carried out, are under construction. Scientists from many European Universities and national Laboratories as well as from CERN itself take part in the experiments and it is estimated that some 700 physicists outside CERN are provided with their research material in this way.

The Laboratory is situated at Meyrin, Canton of Geneva, Switzerland. The site covers approximately 80 ha about equally divided on either side of the frontier between France and Switzerland. The staff totals about 2300 people and, in addition, there are over 400 Fellows and Visiting Scientists.

There are thirteen member States participating in the work of CERN. The contributions to the cost of the basic programme, 172.4 million Swiss francs in 1967, are in proportion to their net national income. Supplementary programmes cover the construction of the intersecting storage rings and preliminary studies on a proposed 300 GeV proton synchrotron for Europe.

36 th Session of CERN Council

A report of the meeting which took place on 13 and 14 December under the chairmanship of Dr. G. W. Funke.

CERN 1967

The Director General, Professor B. Gregory extracted some highlights from a detailed Progress Report presented by the different Departments in CERN, to illustrate the work of the Laboratory during 1967.

Particular mention was made of the excellent performance of the 600 MeV synchro-cyclotron and the increasing volume of research being done with the machine, particularly in nuclear structure physics. The start of the isotope separator on-line, ISOLDE, has been extremely promising and during the week before the Council observations on two new isotopes of mercury were added to the haul of new isotopes seen in the very first run with the new equipment in October (see CERN COURIER, vol. 7, page 222). By far the greater part of the physicists using the synchro-cyclotron come from Laboratories in the Member States with high representation from smaller countries.

At the proton synchrotron, the performance of the machine itself has been maintained with an improved reliability. The three bubble chambers have been in operation — the 81 cm and 2 m hydrogen chambers took over 3 million pictures (most of which went out to Member States for analysis), and the heavy liquid chamber took part in the very successful neutrino experiments (reported on page 248). The progress with automatic measuring devices has been a major factor in the important increase in statistics associated with bubble chamber experiments — they can cope with ten times the number of pictures than was possible with previous methods of film measurement and also achieve greater accuracy. Well over a million pictures have been measured on HPD 1 and Luciole at CERN during 1967. The performance of the main computer system, which is so vital for the analysis of this large volume of information, showed a great improvement during the year and the early troubles seem to have been completely overcome.

Experiments using electronic counter and spark chamber techniques have scored some more important successes. The 'g-2' of the muon has been measured to an accuracy of 5×10^{-7} (CERN COURIER, vol. 7, page 223). The investigation of elastic scattering of protons at wide angles revealed a surprising change in behaviour when the incident proton energy reached about 10 GeV (CERN COURIER, vol. 7, page 108). An increase in the number of electronics experiments which can be accommodated at the machine and an increase in the efficiency of the experiments themselves has been made possible by the bringing into operation of the slow ejected proton beam in the East Experimental Hall. This beam can be split by special magnets and directed onto different external targets making it possible to draw five secondary beam lines from the slow ejected beam. Several of these have already been used for experiments. The efficiency of the ejection system remains low (about 50 %) but there are hopeful signs that the addition of a new septum magnet will bring about a considerable improvement (CERN COURIER, vol. 7, page 151).

The Theoretical Physics Department is continuing its work on the various theoretical approaches to understand the intricate picture of particle behaviour. Particularly successful has been an attempt to extend the Regge pole treatment of two-body interactions (which interprets the mechanism of events in which two colliding particles result in two particles, as being due to the exchange of an intermediate particle or 'Regge pole') to collisions resulting in three particles. Tackling the problem as if it were two two-body steps has worked in the cases investigated so far.

The construction of the intersecting storage rings is going well (see page 252); the design of practically all the major components is now complete and many of the most important contracts have been placed. A contract for the 270 sputter-ion pumps to meet the very demanding requirements of the vacuum system of the storage rings has just been decided. (The contract went to Varian, Italy, for a sum of nearly 2 million Swiss Francs). Theoretical work on the possibilities of beam storage have indicated that interaction rates in the ISR can be at least a hundred times higher than those anticipated when the design parameters of the rings were decided. These new possibilities have greatly influenced the design of the 800 MeV booster injector for the proton synchrotron which was finalized towards the end of the year.

CERN/PI 15-12-67

The Director General concluded with the remark that 1967 has proved again that sub-nuclear physics is a fascinating field of research and that this research can be done very well by international collaboration. Both these facts are essential premises in the case for a large European 300 GeV accelerator.

300 GeV

The Director General announced that a formal 'letter of intent' from France has been received; France had previously given verbal indication of its willingness to join the project. No other letters have been received and the number of countries willing to commit themselves at this time remains at three — Austria, Belgium and France. It had been hoped that by this Council Meeting, a sufficient number would have been received to enable the decision in principle to build the accelerator to be taken. Other countries however are not yet ready to present a letter of intent.

However, delegates from both Italy and the U.K. were able to report a very favourable attitude in their countries. H. E. Giusti del Giardino said that, in Italy, the various bodies responsible for science policy have supported the project and the matter is now going through the various administrative procedures. He stressed that the next steps would be greatly simplified if it were possible to present documents, such as the revised CERN Convention and detailed financial proposals, to help in taking decisions.

Professor B. Flowers for the U. K., attending the Council as British delegate for the first time, remarked that he regards CERN as the spearhead of European science. He also was able to report support of the 300 GeV project by the senior science policy bodies. The high energy physicists in the country give the proposed machine top priority, even though they appreciate that this might mean less support for their national accelerators. The government now has this advice before it, and the implications of extended participation in this field on other scientific activities, and of the effects of the recent devaluation are being studied.

On the question of 'national' accelerators Professor Flowers stated that the U. K. would welcome extensive international co-operation in their use. The U. K. is very ready to consider how their two Laboratories (Rutherford and Daresbury) can be used on a European basis. This proposal was taken up with enthusiasm by Professor Amaldi, Chairman of the European Committee for Future Accelerators, who said that ECFA will fully discuss this aspect of European collaboration in the near future.

Questions from Germany

Professor W. Jentschke, for the Federal Republic of Germany spoke on a resolution passed by the Atomic Energy Advisory Committee which posed several questions about the 300 GeV project. These concerned the design study on the machine, especially in the light of the new developments on the 200-400 GeV machine in America (see CERN COURIER, vol. 7, page 199) and with a view to reducing costs; the possibilities of fuller co-operation with America and USSR; and the financial consequences of the different geological characteristics of the proposed sites for the machine.

The Director General qualified his reply to these important questions by saying that full answers will be given after consultation with the various people involved in the 300 GeV proposal — particularly ECFA.

With regard to the design, the latest review in 1967 has reiterated the principle requirements for a future European machine — an energy of 300 GeV, high intensity, a large capacity for exploitation, flexibility and reliability. All these are incorporated in the design study which has been done, and this is a sound basis for all the necessary decisions. Many technical developments, which have come up since the present CERN proton synchrotron was built, are already incorporated but it should be clearly understood that the final design would follow the selection of the site, of the Director General of the new Laboratory, and of his construction team.

Cost comparisons between the figures deduced from the American design and the European design are difficult because budget headings in the two continents differ in what they cover. A true comparison is probably something like 1800 million Swiss Francs for the 300 GeV and 1500 million Swiss Francs for the 200 GeV, where the 300 GeV figure covers more extensive facilities for experiments, which is considered essential in the European project catering for many groups of physicists from many countries.

On the question as to whether collaboration with the USA and the USSR has been sufficiently explored, the Director General insisted that any such collaboration must start with Europe on an equal footing. Collaboration can be no substitute for the 300 GeV project. Finally, the question on the sites will be fully resolved in the Council itself.

Professor Amaldi, as Chairman of ECFA, also stressed that the existing design study cannot be considered as binding on the Group who will actually build the accelerator. This group will certainly make the machine as up-to-date as possible; this up-dating, however, awaits the election of the project leader.

Professor Puppi, Chairman of the Scientific Policy Committee, said that we have no reason to believe that there is anything magical about any of the energies 200, 300 or 400 GeV. More important is reliability and flexibility.

Professor Perrin from France said that the 300 GeV project has been more thoroughly studied by this time when the European scientists are asking for a decision, than the 200 GeV project had been when it was authorized to advance to its present stage. Further, Europe could not do its research in America or Russia — collaboration was not feasible without the 300 GeV.

It is hoped to have the final detailed answers to the questions raised by the German Atomic Energy Advisory Committee ready in about a month's time.

The Convention

The final draft of the revised CERN Convention was presented to the Council. It enables a new Laboratory for the 300 GeV machine to be set up under the same organizational control as the existing Laboratory at Meyrin.

The Council, with abstentions from some delegations whose governments have not been able to complete their studies of the final draft, passed a resolution which approves the revised Convention and recommends its acceptance by the Member States. The new Convention will now go to the respective governments. In itself, such acceptance involves no commitment to participate in the 300 GeV project but the Director General thanked the Council for taking this essential, constructive step towards the project.

The Sites

Council delegates received two reports concerning the proposed sites for the 300 GeV Laboratory. One was from the Site Evaluation Panel (Mr. J.H. Bannier, Professor J.K. Boggild, Mr. A. Chavanne) discussing the relative merits of the sites as regards the construction and development of the Laboratory, its operation and the factors affecting personnel. The other, from Dr. L. Bjerrum (Director of the Norwegian Geotechnical Institute) makes a geotechnical assessment of the sites. The reports will be discussed at the Council meeting in March.

The Site Evaluation Panel also prepared a proposal on the programme and procedure by which the site could be selected. This involves two stages — the first producing a short list from the nine site offers, the second making the final decision. An elaborate voting procedure has been worked out.

A preliminary discussion was held on this topic and several delegations said that they would like to see a large number of countries declare their willingness to participate in the project before the site selection procedure begins. The Committee of Council will make a formal proposal on this matter at the March meeting.

Budgets for 1968

The financial contributions from the Member States to the work of CERN in 1968 were agreed as follows:

for the basic programme (principally, operation, improvement and use of the existing accelerators) — 197.51 million Swiss Francs;

for the supplementary programme covering construction of the intersecting storage rings — 78.43 million Swiss Francs;

for the supplementary programme covering the preparatory work on the 300 GeV accelerator project — 4.09 million Swiss Francs.

This finance is divided among the 13 Member States in proportion to their net national income:

Austria	1.90 %
Belgium	3.56 %
Denmark	2.05 %
Federal Republic of Germany	23.30 %
France	19.34 %
Greece	0.60 %
Italy	11.24 %
Netherlands	3.88 %
Norway	1.41 %
Spain	3.43 %
Sweden	4.02 %
Switzerland	3.11 %
United Kingdom	22.16 %

Both the U.K. and Spain abstained from voting the budget for the basic programme and the storage rings because the review of the effects of devaluation in both countries has not yet been completed. In recognition of the financial problems of these two countries the Council did not vote on the budget estimates for forth-

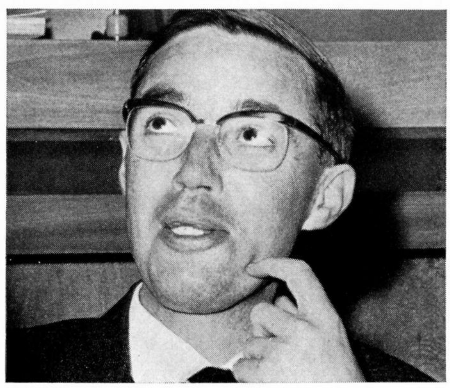
People in the news :
1 Dr. W. Kummer
2 Professor W. Thirring
3 Dr. G. Brianti
4 Mr. G. Ullmann
5 Dr. W. O. Lock

1 *CERN/PI 94-12-67*


2 *CERN/PI 93-12-67*


3 *CERN/PI 92-12-67*


4 *CERN/PI 96-12-67*


5 *CERN/PI 97-12-67*

coming years (1969-70-71). These forward estimates come under what is known at CERN as the 'Bannier procedure' which involves agreeing a firm estimate for the next year (1969) and provisional figures for the following two years (1970-71). This procedure is of very great importance in planning the future of CERN's work because of the necessarily long-term nature of so many of the projects. It is hoped that it will be possible to vote on these forward estimates at the March Council meeting.

As a gesture, to show the importance that is attached to the 300 GeV machine, all countries voted for the modest budget covering the preparatory work for this project.

New Appointments

The Council re-elected Dr. G. Funke (Sweden) as its President and H. E. Giusti del Giardino (Italy) and M. J. Martin (France) as its Vice-Presidents for 1968. Professor Puppi (Italy) remains Chairman of the Scientific Policy Committee and Dr. W. Kummer (Austria) succeeds Dr. W. Schulte-Meerman (Federal Republic of Germany) as Chairman of the Finance Committee; Dr. Schulte-Meermann has served as Chairman for the past three years and was therefore not eligible for re-election. He was warmly thanked by the President for his work.

In the physics committees which decide on the experimental programmes for the two CERN accelerators the only major change is that Dr. J. H. Mulvey from Oxford University in the UK succeeds Professor M. W. Teucher (Federal Republic of Germany) as Chairman of the Track Chambers Committee.

Within CERN, Professor W. Thirring will come to the Laboratory to succeed Professor L. Van Hove as Director of the Theoretical Physics Department from 15 July 1968; Professor Van Hove wishes to devote himself full-time again to his research and will remain in the Theoretical Physics Division. Professor Thirring is a well known theoretical physicist who has been involved in the affairs of CERN for many years as a member of the Austrian delegation to the CERN Council. He was born in 1927 and completed his education at Innsbruck and Vienna Universities. During the 1950s he gained wide experience working at several European Universities (Glasgow, Gottingen, ETH Zurich and Bern) and in the United States (Princeton, MIT, Washington). Since 1959, he has been Director of the Institute for Theoretical Physics at Vienna University. Professor W. Jentschke from the DESY Laboratory in Germany will come to CERN for a year as guest Professor. He will be present at meetings of the CERN Directorate.

A new Division is to be set up for the construction of the 'booster' which will raise the injection energy into the proton synchrotron from 50 MeV to 800 MeV. This is a large project (which will be described in the January issue of CERN COURIER) with a construction programme spread over five years involving a staff rising to over 100 and a total expenditure of almost 70 million Swiss Francs (of which just over 30 million will be for the booster itself). The Division will be known as the Synchrotron Injector Division and will join the Proton Synchrotron Machine Division and the Nuclear Physics Apparatus Division within the Proton Synchrotron Department. Dr. G. Brianti, at present Leader of the Synchrotron-cyclotron Machine Division, will be Leader of the new Division. Dr. Brianti has been at CERN since 1954 when he joined the magnet group during the construction of the proton synchrotron. He became head of the Controls Group in the Proton Synchrotron Machine Division before becoming Leader of the Synchrocyclotron Division in 1964.

Mr. G. Ullmann, Leader of Personnel Division, is taking a year's leave of absence from CERN to serve as an I.L.O. (International Labour Office) expert on personnel matters. His work will be to assist in a project to set up a Management Training Centre at Istanbul in Turkey. Mr. Ullmann joined CERN in 1955. He became Head of Personnel in 1961 and remained Leader when Personnel was set up as a separate Division in 1964. During his absence Dr. W. O. Lock will be Acting Leader of the Division. Dr. Lock came to CERN in 1959 to do nuclear emulsion physics. He continued in this field until 1965 when he moved into the Personnel Division with particular responsibility for scientific and engineering staff, and for the fellows and visitors service.

The Progress of Science

This article is taken from a series of three interviews with Professor L. Van Hove, Director of the Theoretical Physics Department, by F. Le Lionnais, President of the French Association of Science Writers, which was broadcast by the ORTF (Paris).

In 1962, in the series of radio interviews 'The Progress of Science', F. Le Lionnais talked with Professor V. Weisskopf, at that time Director-General of CERN, and Professor Charles Peyrou, now Director of the Physics II Department. That interview, concentrated on our understanding of atomic nuclei, the particles (nucleons) of which they are composed and the means by which these particles are studied. In the recent talk with Professor Van Hove, the emphasis was not the experimental techniques but on the problems of our theoretical understanding of elementary particles.

I think that before stating the problems and outlining the solutions or hypotheses, it would be a good idea to define the general background and then introduce the characters in this 'drama of a hundred acts which has the universe for its stage', as La Fontaine expressed it. As you introduce them, perhaps you will give a rough outline of each character, but first of all would you describe the particular field of physics in which you work ?

This field of physics, which has expanded rapidly in the last fifteen years, is sometimes called 'high energy physics', because the experimental tools used are high energy accelerators, or 'particle physics', because the physical systems studied are particles ; or 'sub-nuclear physics' because the phenomena studied are smaller than the atomic nucleus — it probes deeper than the structure of the nucleus.

The high energy accelerator is the most powerful microscope we have for studying the structure of matter on a very small scale. On this scale we find that matter appears in the form of a very great variety of particles.

The particles do not remain motionless, but respond to the action of various forces and interact with each other. Perhaps before introducing these actors you could tell us, as if in a classical tragedy, of the underlying forces of love, friendship or hatred. What forces are at work in sub-nuclear physics ?

The forces can be divided into a very few categories, and it is remarkable that over a period of almost forty years there has been no change in the number of fundamental forces while the number of particles has increased so rapidly ! Four types of force, or interaction, govern the whole of physics: the first is the gravitational interaction which is very well known on earth in the form of weight, and as the interaction which governs the movement of the planets and of celestial bodies on a cosmic scale in general. The next is the electromagnetic interaction, which is also well known not only in every-day life where it manifests itself in electricity and magnetism, but also in a more fundamental way in the whole structure of matter as we know it at the level of the atom.

I should like to point out that it is the electromagnetic interaction which controls the world as we experience it because it is responsible for chemical reactions and consequently for our sensations such as taste and smell, and also responsible for the different characteristics of matter, such as colour. We are immersed in a world in which, besides gravitational phenomena, we are continually encountering electromagnetic phenomena which affect us and which are used by us. The other two forces are less well known.

The other two are known as the 'strong' and the 'weak' interactions. They were discovered quite unexpectedly on the scale of nuclear physics, and are something really new to us. The strong interaction is the binding interaction which creates the stability of the atomic nucleus, and makes the atomic nucleus such an extraordinarily dense piece of matter. It governs all phenomena in which nuclear energy plays a part.

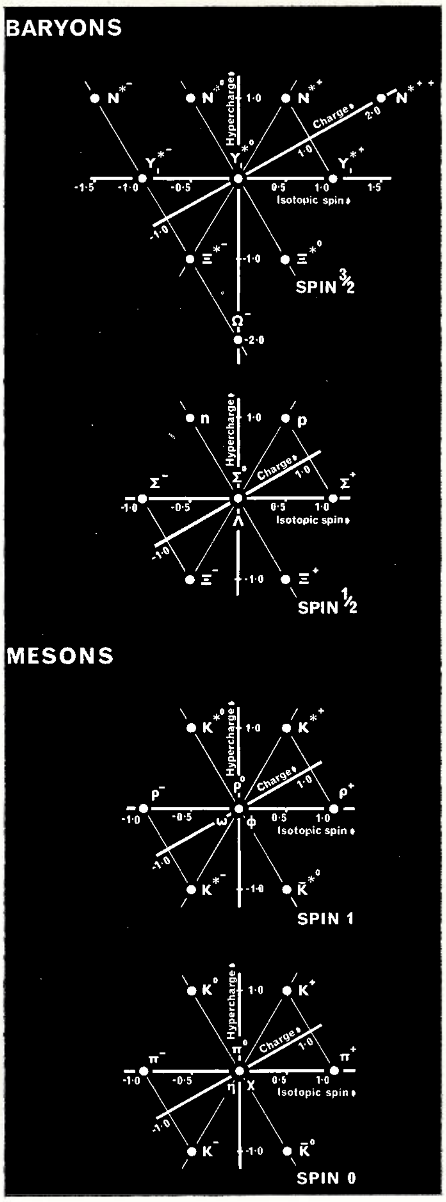
The second new interaction which has been discovered in nuclear physics is called the weak interaction. It has been known for a long time in nuclear physics because it governs one of the forms of radioactivity, beta decay, which is characterized by the emission of electrons and neutrinos. It is above all in regard to the neutrino that this so-called 'weak' interaction shows itself in the most remarkable way, because the neutrino is a particle which seems to be entirely controlled by this mysterious interaction.

Well, those are the four types of force or interaction, and now I should like to ask you to present the dramatis personae — the particles.

Although it is true that the fundamental interactions in physics are few and appear to have been clearly identified, the actors in this multiple drama, the particles, have been discovered through the years in ever-increasing variety and in a most disorderly way. It is quite a new development that there appears to be some kind of order among them, and we will return to this point later. For the moment, the main point is to recognize, on the one hand, that on a

Below: A preliminary classification of particles according to the interactions they undergo.

Right: Four of the 'families' of hadrons which have emerged from the theoretical work of the past few years, which has imposed some order on the large number of strongly-interacting particles identified at the high energy accelerators.



Three classes of particles

	leptons	hadrons	
		baryons	mesons
photon	electron	proton	pion
	muon	neutron	kaon
	electron-neutrino	lambda	eta
	muon-neutrino	sigma	rho
		.	.
		.	.
		.	.
(the elementary particle of light and of electro-magnetic radiation)	(take part in weak interactions and in electromagnetic interactions when they are charged)	(take part principally in strong interactions)	

sub-nuclear scale all matter manifests itself in the form of particles and, on the other hand, that these particles are of very different types.

How many of these particles are there altogether ?

Between 100 and 200 are known. Some are the anti-particles of others and if these are not counted, about 110 to 120 particles must have been discovered and studied — some in great detail already, many, as yet, quite incompletely.

These, then, are the witnesses we shall call into the box. However, I should like to ask you if we could review these hundred or so particles in an attempt to make some kind of synthesis, because a hundred is a rather large number to deal with.

Those studying chemistry from the 16th century onward, first identified a few chemical elements which were well known such as iron, hydrogen, oxygen, etc, and then towards the middle of the 19th century the list grew to more than 60, and towards the end of the 19th century to more than 90 elements. However it was obvious that some of the elements resembled each other — sodium and potassium, chlorine and fluorine — and it was clear that there must be some kind of unity behind this multiplicity. This led to the emergence of the Mendeleiev table which played an outstanding role in chemistry. I should like to ask you whether there is any hope of finding a new table of this kind and whether you could already make a preliminary classification, however elementary, of all these particles ?

I will start by dividing them into three groups. I will say little about the first because it contains only the photon, which is the elementary particle of light and of electromagnetic radiation, and is perhaps the simplest particle in nature because of its very pure properties.

Then there are the leptons, which are light particles which take part in weak interactions, and in electromagnetic interactions when they are charged. They include the familiar electron and the more recently discovered muon, which resembles the electron in that it has the same electric charge, the same rotation property (or as we say in technical language, the same 'spin') but at the same time has a mass 200 times greater. The muon is thus a heavy electron.

In addition to these charged leptons, there are uncharged leptons which are the neutrinos. These are extremely light particles which perhaps have no mass at all, or an extremely small one. They have the curious property of participating only in weak interactions, which makes it extremely difficult to perform experiments with them. Nevertheless, at CERN for example, it has been possible to do precise experiments with neutrinos, by using extensive experimental equipment.

These neutrinos are quite mysterious — there are two of them ; one is closely connected with the electron and in fact its presence is generally connected with the presence of an electron ; the other is linked to the muon in a similar way. Thus there is the electron neutrino and the muon neutrino. We do not know why there are two of them, and neither do we know why there is a muon, the heavy brother of the electron.

Science still has some secrets to be uncovered... There is still the large family, the one with most particles, which I believe gives rise to the most difficulties — the hadrons. What does this word mean and what does it represent ?

Hadrons take us right into what may be called sub-nuclear chemistry, namely the very recent field of physics research in which numerous particles, completely new and unexpected, have been discovered and where there are the greatest problems of classification. 'Hadron' means an object which participates in strong interactions (hadros means 'strong' in Greek).

Several types of hadron are known. First there are those called 'baryons', or the heaviest hadrons. The baryons include the proton and the neutron, which are familiar to us because they form the atomic nuclei, and in addition include a whole series of particles similar to the proton and the neutron, which seem to a certain extent to be heavy members of the same family, and which are very numerous. Then there are the anti-baryons, which are simply the anti-particles of the baryons, and finally there is the third category, the mesons. The mesons are also particles which have strong interactions ; they are hadrons, but in their case the masses are generally lighter and they have the curious property of being identical, or practically identical, to their anti-particles. They are also very numerous.

All the mesons we know are unstable particles, as are all the baryons with the exception of the proton. The most simple and best known meson is the pi meson or pion. Pions are relatively light mesons which fit the theoretical predictions made by Yukawa round about 1935, and to which have since been added a large number of other mesons, not predicted by the theoreticians, which have been produced experimentally and studied in detail round the large accelerators.

You say that, except for the proton, these other particles are unstable. Could you tell us very briefly what is their lifetime, since some are more unstable than others; is it true that the neutron, for instance, has a longer lifetime than many other particles?

The instability of all these particles is of great importance and explains why it took so long to discover and study them, because they disappear as soon as they have been produced in the laboratory.

The neutron is one of the more easy to examine because it lives, on an average, almost a quarter of an hour before decaying. On the other hand, most of the other particles have a very short lifetime of the order of, say a thousandth of a millionth of a second or a millionth of a millionth of a second. Sub-nuclear physicists are quite accustomed to these really microscopic lifetimes and it is one of the most difficult technical problems to develop methods to simultaneously produce and observe the death of all these unstable particles.

I should now like to ask you whether you have a Mendeleiev table to propose for the elementary particles ?

Although there is as yet no Mendeleiev table, there are increasing signs that broad principles of classification are emerging for the overwhelming but fruitful wealth of particles with strong interactions. The basic features have a certain similarity to valency and mass, which played such an important part in the classification of the chemical elements.

In our case, the first feature which led to classification of the hadrons was the recognition of the great similarity between particles which differed solely by their electric charge. The simplest example is that of the proton and the neutron. These are particles which, apart from the fact that the proton has a charge and the neutron has not, are practically identical — almost twins. From a mathematical point of view, it has been possible to develop a very general formalism, the formalism of isospin, by which the particles showing this similarity can be classified, because it turned out that many particles resembled each other in the same way as the proton and the neutron.

This theory has been generalized and we now have a system of several quantum numbers, the most important and oldest of which is isospin, which tells us for instance that the proton and the neutron form an isospin doublet. With regard to isospin, they are classified in the same small family, which is called a doublet because it has two members. Let us take another example from the mesons. We have the pion, which exists with three kinds of charge, positive, neutral and negative, and this is called an isospin triplet — three brothers that differ only by their electric charge. This then is the first example of a quantum number, which serves to classify the hadrons.

Quantum numbers are numbers which are all multiples of the smallest of them and they are counted in units or half units, but there is never a third or a quarter of a unit or any other irrational number. You have just demonstrated to us that isospin is a fundamental quantum number. There are others which are useful to you.

For twelve years another important quantum number has been known, it unfortunately got the name 'strangeness', because it related to a category of baryons and mesons, discovered experimentally, which behaved rather more strangely than the others. It is better to call this new quantum number differently and we usually now speak of the 'hypercharge'; it allows us, for example, to distinguish the proton-neutron doublet from the heavier baryons such as the lambda hyperon and the sigma hyperon.

I should like to ask you a question concerning these two properties, isospin and hypercharge. Are they independent or is there a tendency to bring them together and use them in the same way as valency and mass were brought together in the Mendeleiev table ? Have they anything in common ?

This is one of the topics which has led to the greatest progress in the classification of hadrons. In 1962, it emerged that hypercharge could be combined with isospin in a much wider and mathematically more elaborate principle of classification. It makes use of one of the most powerful tools of classical mathematics, namely the mathematical concept of groups, which proves particularly suitable for representing the symmetries and the similarities that may exist between different particles. Accordingly, the proton and the neutron

Professor Leon Van Hove, Director of the Theoretical Physics Department, gave the interview, from which this article is taken, for French radio. Professor Van Hove has a flair for talking about sub-nuclear physics to all types of audience.

are no longer in a small family by themselves, but are two members of a family of eight. This family is an octet, a multiplet of eight particles in a higher form of symmetry known as SU(3), or unitary symmetry. The mathematical symbol, SU(3), refers to the group by which this classification is described mathematically.

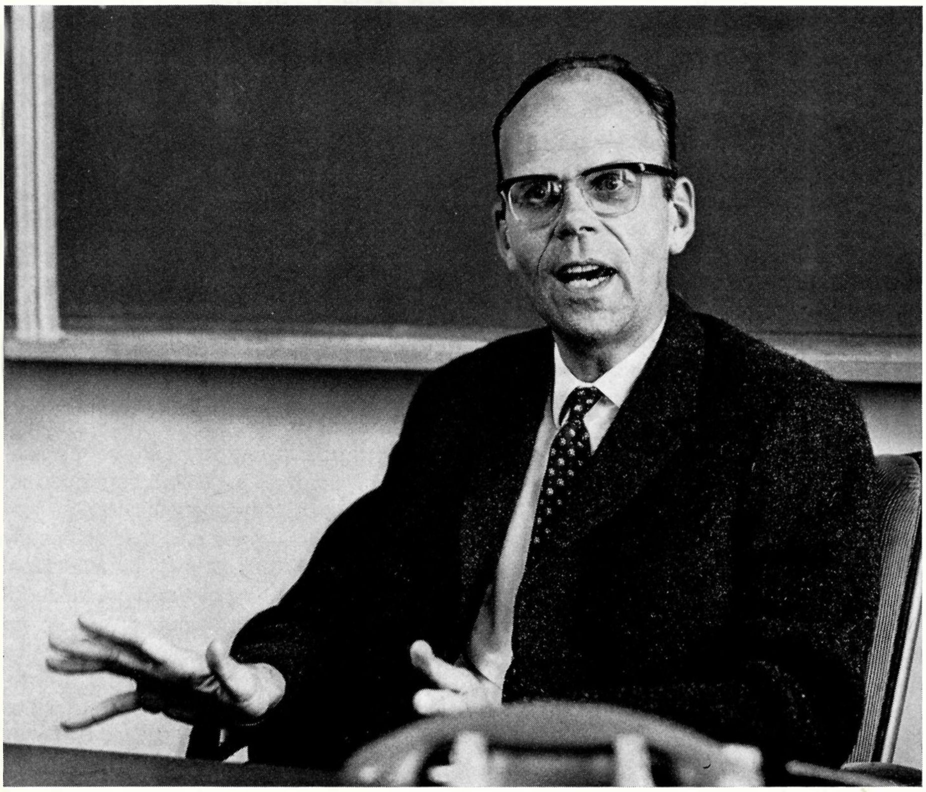
Most of the well-known hadrons can now be grouped in octets (families of eight) nonets (families of nine) or decuplets (families of ten), and simple, but powerful, mathematical considerations of group theory have led to the discovery of profound similarities inside each family, which, I believe, make it possible to claim that on the sub-nuclear scale a new Mendeleiev table is emerging.

One of the great virtues of the Mendeleiev table, which more or less convinced the sceptics, was that Mendeleiev could say : "I will leave this space empty, otherwise the whole table will be wrong. I think there is another chemical element, which we shall discover later and which will fill the gap". Haven't you found the same thing with a multiplet, an octet for instance, about which you have said : "This should be an octet, but I have only seven particles at present. There must be an eighth ?"

Certainly, and this is how, historically the validity of these principles of classification was confirmed in a remarkable way. The discovery of certain baryons such as the omega hyperon, and certain mesons, showed that in cases where the theoretician suspected the existence of an octet and where nature had revealed only six or seven particles, further experimental work led to discoveries which showed that the family did consist of the number of particles predicted by the theoretician.

That is of course the best proof. We have talked about isospin and hypercharge, but there is the word 'spin' that is still more mysterious for a lot of people.

Every particle, in addition to isospin and hypercharge, has a spin, which means that it turns in a certain way round itself. It was when attempting to combine the ideas of spin and unitary symmetry that the most recent advances were made in classifying the hadrons.



CERN/PI 39.10.66

It was observed that the structure of the families of particles, the octets, nonets and decuplets that I have mentioned, is closely connected with the spin. In the same family, all the particles have identical spin, but two families with different spins have unitary symmetry properties which are not independent of one another. There are new, striking relations ; for example, between the octet and decuplet of the baryons, and between the various meson nonets. This whole rather complicated picture, translated into mathematical terms, suggested in a most convincing way that hadrons are not objects without any internal structure, but on the contrary have an internal structure of their own which had not so far been noticed.

The simplest way of representing this internal structure, which we have discovered in the baryons and mesons, is to say that they are made up of objects which are even more elementary. They were introduced by the theoreticians as a working hypothesis under the name of 'quarks'.

The word 'quark', which sounds like a word more suitable for ducks then men, was chosen by the physicists, who are not without humour. They took it from the famous book by James Joyce 'Finnegan's Wake'; so even literature has made its contribution to this subject.

'Quarks' are one of the most important concepts in present day sub-nuclear physics, although we do not yet know whether these quarks, whose existence is assumed for theoretical purposes, can really have physical existence as independent particles. But, inspite of this uncertainty, many observations can be understood if we suppose that quarks are the basic bricks of which all the baryons, mesons and anti-baryons can be built up. So far, it gives us the simplest possible representation we can conceive for the multitude of particles. These problems will be solved only by further research, and particularly by research with future accelerators of even greater energy. These will enable us to go down to still smaller dimensions, to solve these problems and to test the challenging ideas which have emerged from recent progress in classifying the particles.

CESAR 1960-1967

The CERN Electron Storage and Accumulation Ring, CESAR, will be closed down this month. This article on the history and achievements of CESAR has been written by M.J. Pentz, Leader of the CESAR Group since 1962.

"I come to bury Caesar, not to praise him. The evil that men do lives after them ; the good is oft interred with their bones". — From Mark Antony's oration over the body of Caesar (Shakespeare).

At the end of this year, independent research in accelerator physics is to be discontinued at CERN, at least for some years to come. This closes a chapter in the history of CERN which opened in 1956.

Accelerator research began in the Proton Synchrotron Division, graduated to a separate Division (the Accelerator Research Division) and finally was absorbed as a Group in the Intersecting Storage Rings Department. The work with CESAR has been an important part of this research, accounting for about 50 % of the total expenditure on accelerator research (about 22 million Swiss francs) during the years 1960-67. Now it is running on its last experiment before being closed down. This is the moment therefore to write its obituary.

The story of CESAR begins in 1960 when the performance of the CERN synchrotron had improved to the point where the addition of storage rings could be seriously considered. Studies of plasma betatrons and of a two-way beam stacking electron accelerator had been going on previously, and the latter had reached a fairly advanced stage. But the new possibility of proton storage rings led to the decision to construct instead a storage ring for 2 MeV electrons, in which it would be possible to study the basic problems of design and operation of the proton storage rings.

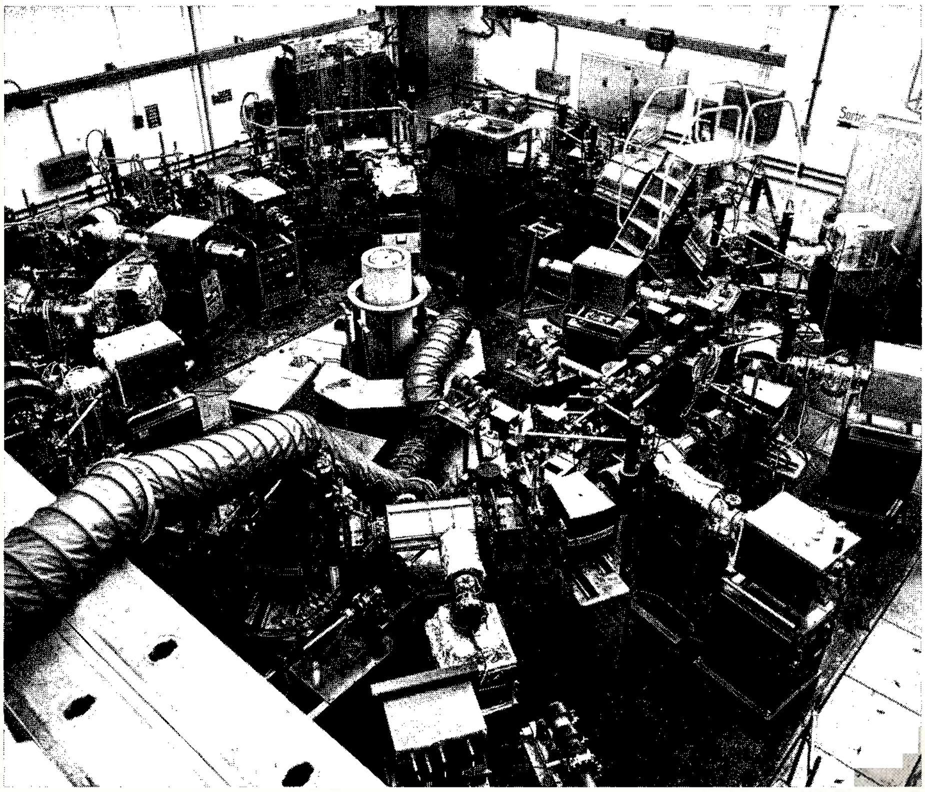
The storage ring was christened CESAR (CERN Electron Storage and Accumulation Ring). The immediate purposes for which it was constructed were :

a) to provide an experimental verification of the theory of radio-frequency beam stacking

b) to investigate certain beam instabilities that could be of importance in the operation of proton storage rings

c) to study the technological problems of producing ultra-high vacuum (pressures of less than 10^{-9} torr) in complicated vacuum chambers.

In 1961, the design of the electron storage ring was finalized and its main components were ordered. The construction was completed in the spring of 1963 and, after a long and difficult running-in period, a circulating beam was obtained at the beginning of 1964. During the four years since then, development and refinement of the machine have gone in parallel with its exploitation for experimental research. It may be said, however, that only in its final phase of operation (June-December 1967) has CESAR become an experimental tool which is sufficiently well understood and sufficiently amenable to manipulation to open the door to its full exploitation as such. The most important experimental results were obtained in 1966 and 1967.



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It has undoubtedly fulfilled all three purposes for which it was built, and a number of others besides.

The basic theory of radio-frequency stacking was experimentally verified, and the possibility of achieving high 'stacking efficiency' even with high values of the stable phase parameter (as envisaged for the ISR) was demonstrated. A new phenomenon, due to radio-frequency noise, was observed and a series of experiments verified a theoretical interpretation of it.

The possibility of three exercises in what may be called 'radio-frequency gymanistics' (all of them of interest to the ISR) was experimentally confirmed. In the jargon of the specialists, these were stacking with 'missing buckets', stack-shaping by phase displacement, and stacking with phase-lock. A pronounced blow-up of the beam energy-spread at injection was observed, with the practically certain inference of the so-called 'negative-mass instability'.

The lifetime of the circulating beams which is limited by gas scattering (hence the need for ultra-high vacuum in CESAR), was found to agree with the predictions of scattering theory. The 'half-life' (which is the time at which the circulating current is reduced to half its initial value) at the lowest-pressure reached (7×10^{-11} torr) was 12 seconds. It would have been longer, but for the relatively high proportion of argon in the residual gas mixture ; argon scatters electrons much more strongly than hydrogen does. Incidentally, the pressure of 7×10^{-11} torr was more than an order of magnitude lower than the design aim of 10^{-9} torr. This achievement, in a vacuum chamber full of joints, moving targets and various other undesirable objects from the vacuum engineer's point of view, gives further grounds for confidence that similar, or better, results will be achieved in the ISR.

CESAR turned out to be a highly 'non-linear' machine. In plain language, this means that the electrons 'saw' magnetic fields (and particularly field gradients, and gradients of field gradients) that were really not supposed to be there. This was because the average magnetic field around the ring was only 20 Gauss, and every kind of field error or stray field (such as the earth's magnetic field) produced a relatively large effect. This circumstance made CESAR extremely tricky to operate but it was exploited to carry out a wide range of experiments on higher order non-linear resonances, including their effects on beam lifetime, and from this work, tentative inferences can be made about the long-term stability of the beams in the ISR.

One of the pet bogeys of storage ring specialists — the 'coherent transverse instability' — was studied in some detail. The results agreed with theory up to a point, but a new phenomenon was observed which is being investigated at this moment. It is hoped that it will be sorted out satisfactorily before the shut-down.

An exercise in beam gymnastics in the transverse phase plane (beam splitting on a third-order resonance) was successfully performed. This exercise is of interest for accelerators and storage rings in general, and for the booster-injector / PS / ISR / 300 GeV family in particular.

As can be seen from the above summary of the ten main experiments done with CESAR, it has more than fulfilled its purpose. Nevertheless, these represent only a fraction of the research which could be done with the machine, even in, essentially, its present form.

How much effort went into this project ? Its financial cost has been mentioned — about 11 million Swiss Francs of which 42 % went on salaries. It absorbed 144 man-years over the eight years of its life. But these are only quantitative measures. In the last analysis, it is the quality of people that determines the quality of the work they do, and in a scientific research group, the existence of a good group spirit is often more important than the individual brilliance of its members. From its first beginnings to the end of its life, the CESAR group has had an atmosphere of informality, co-operation and subordination of individual interests to those of the team as a whole, which will be recalled with satisfaction and pleasure by all who have participated in it.

To end on a personal note, I would like to place on record my profound appreciation of the work of all the people who made this group probably the most pleasant to work in, and certainly not the least effective in CERN.

Neutrino Experiments

The first series of experiments using the new neutrino beam-line finished in November. The run was extremely successful. In the alloted seven weeks of proton synchrotron time, about 1 125 000 pictures were taken in the heavy liquid bubble chamber and preliminary examination of the photographs indicates that a harvest of about 1 000 neutrino events has been gathered. Possibly about 100 of these will be suitable for analysis as neutrino interactions with a 'free' proton — the first time that such events have been observed.

The previous experiments at CERN in 1963-64 were done with freon in the heavy liquid bubble chamber. They provided valuable information on neutrino interactions (it could be said that at that time any information on the interactions of the elusive neutrino was 'valuable' information) particularly concerning the 'elastic' interaction with a neutron to give a muon and a proton

$$\nu_\mu + n \rightarrow \mu^- + p.$$

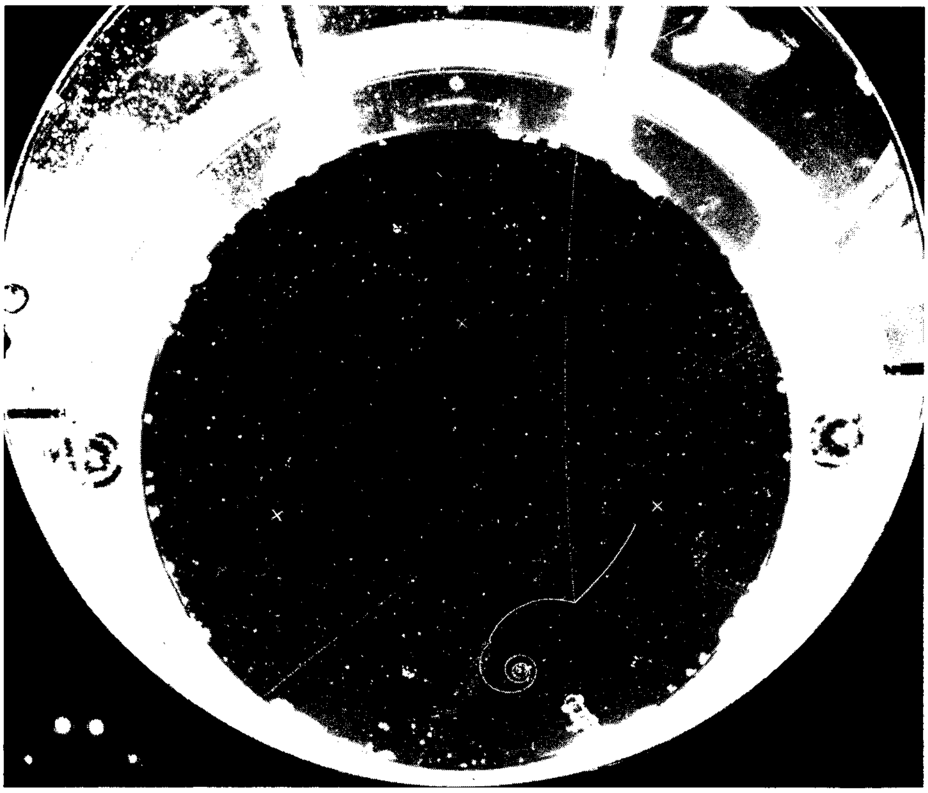
Inelastic interactions, such as that yielding a muon a pion and a proton

$$\nu_\mu + p \rightarrow \mu^- + \pi^+ + p$$

were much more difficult to investigate. The proton with which the neutrino collided, was bound in a heavy nucleus (carbon, fluorine or bromine) and the pion was likely to be absorbed by the nucleus, making the analysis of the interaction less accurate.

With the new neutrino beam-line, the flux of neutrinos which is fired into the chamber, is much higher and it is possible to fill the chamber with propane while still having a useful number of interactions in this 'thinner' liquid. In propane, there are 'free' protons, the nuclei of the hydrogen atoms (and there are more hydrogen atoms per unit volume than in liquid hydrogen itself). The neutrino interactions with these protons are then unaffected by the presence of other nucleons.

Analysis of the photographs has started and the first results are expected during 1968. The preliminary scanning went on as the experiment proceeded and almost kept pace with the very high rate of taking the photographs. More than 850 000 were



An example of a 'candidate' for a neutrino interaction with a 'free' proton. This interaction was observed for the first time in the recent series of neutrino experiments at CERN. The neutrino entering from the bottom of the photograph interacts with a proton (the nucleus of a hydrogen atom in the propane which filled the heavy liquid chamber) to give a proton (short track to the right) a muon (long upward track) and a positive pion which decayed eventually into a positron (the tight spiral).

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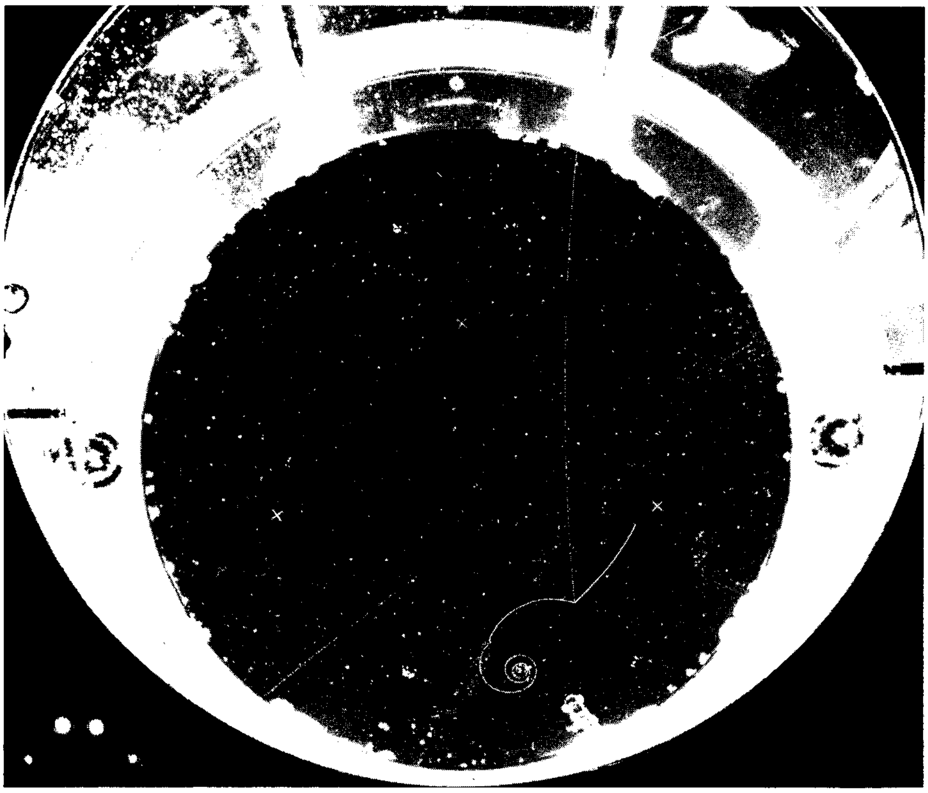

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The horizontal pipe protruding across the car park connects the 'jet area', where the heavy liquid bubble chamber has been newly positioned, with the neutrino area. It serves as the safety exhaust pipe for the propane in the chamber in case of accidents and is connected with the tall chimney which would release the propane high in the air. It proved cheaper to make this connection rather than build a separate chimney for the jet area. The formidable concrete supports are no doubt necessary because propane is a heavy liquid !

scanned by the time data-taking finished on the synchrotron. The pictures are very good — the heavy liquid bubble chamber excelled itself in this experiment both in its reliability of operation and in the quality of the photographs it produced. The various beam-line components also performed well and of particular importance was the use of a boron-carbide target after testing many possible materials. It gave a more than 20 % increase in neutrino flux compared with the previous copper target.

In addition to the main purposes of the experiment, the data is being used to test the 'Adler theory' that the production of pions by neutrinos is equivalent to the production of pions by pions. Several centres are interested in this test (CERN, Ecole Polytechnique, Milan, Orsay and Turin) and the neutrino photographs have been copied and distributed among these centres. Comparison will be made with pion production photographs taken in propane at the 3 GeV accelerator, Saturne at Saclay.

The spark chamber experimenters, who set up their detectors either side of the bubble chamber in the neutrino beam-line, were also happy with the quality and quantity of their data. Their experiments concern the muon number conservation and measurements of any variation in the neutrino-nucleon interaction cross-sections with the size of the nucleus in which the nucleon is bound.

And there neutrino experiments rest until the arrival of the heavy liquid chamber, Gargamelle, scheduled for 1969. This chamber is being constructed for use at CERN by the French Laboratory at Saclay. The large volume of Gargamelle will further increase the possibilities in observing the intriguing behaviour of the neutrino.

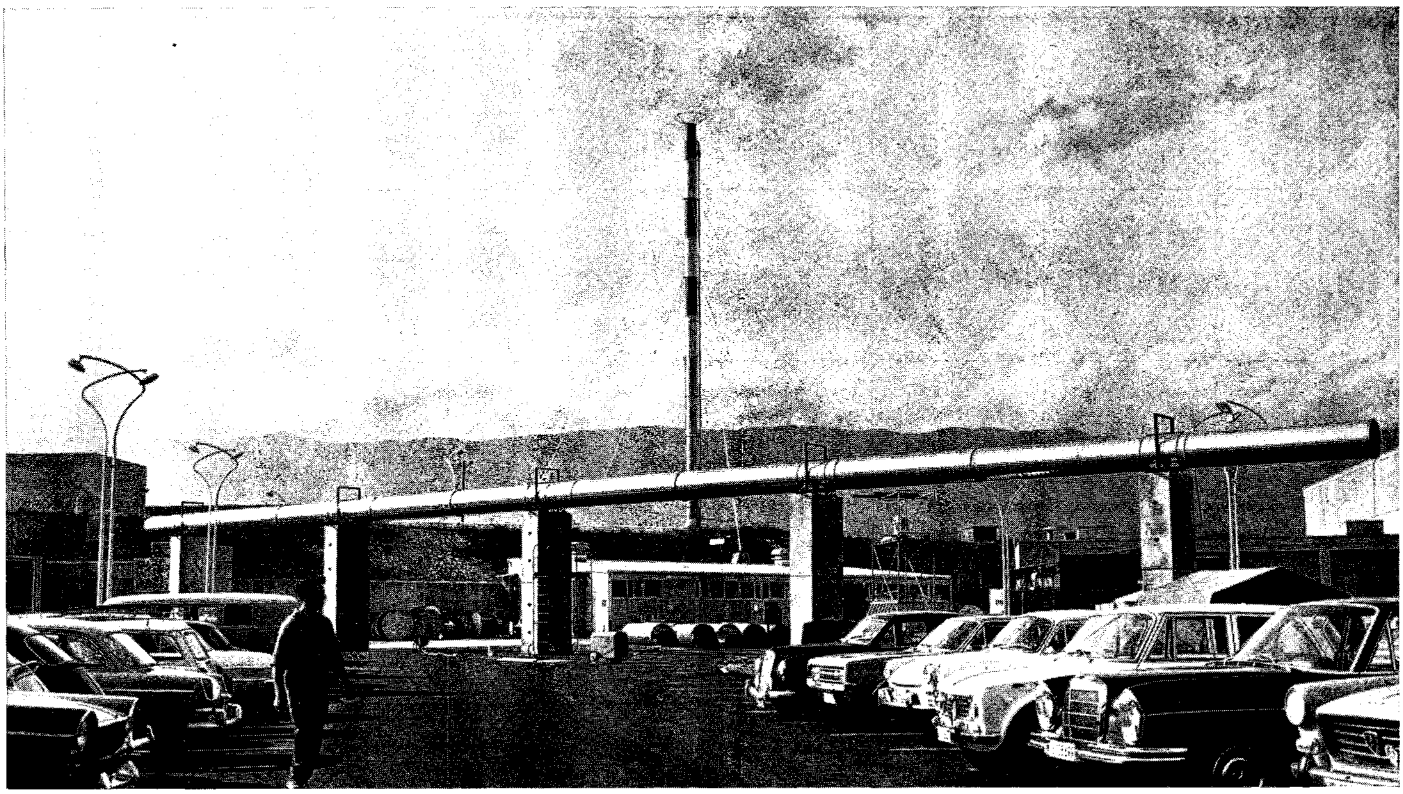
Jet Set

Immediately after the conclusion of the neutrino experiments, the heavy liquid bubble chamber was dismantled and moved to a new position, directly behind the 2 metre hydrogen bubble chamber, in the 'Jet Area'. Here the chamber will be used for the 'jet experiment' scheduled to begin in January.

The experiment is a collaboration of Berkeley, Ecole Polytechnique, Milan, Orsay and Saclay. It will look at the interactions of high energy kaons with nuclei, carrying out a similar survey to one which has already been done for high energy pions. Both positive and negative kaon beams will be available with momenta up to 10 GeV/c.

Special arrangements have been made so that the heavy liquid will receive the kaons which pass straight through the hydrogen without interacting. A beam exit window has been fitted to the hydrogen chamber and the direction of the incoming kaons has been fixed so that the curvature of the kaon paths as they pass through the magnetic field of the hydrogen chamber still allows them to enter the heavy liquid chamber.

The experiment has become known as the jet experiment because the sort of interaction which is looked for at these high kaon energies, produces a forward spray of particles, giving a bubble chamber photograph similar to the jets seen in nuclear emulsion experiments with cosmic rays. The heavy liquid chamber is being used so



CERN/PI 14.10.67

Arrival of the CDC 3100 at Cointrin airport. The computer joins the central computer complex to take care of liaison with on-line experiments, in the 'FOCUS' development project.

The Distinvar reading head showing the different elements of this very fast and accurate method of alignment measurements.

that interactions producing more than one neutral pion can be analysed. This is often not the case with hydrogen since the neutral pions, which leave no track themselves, since they carry no charge, often escape from the chamber before 'materializing' into charged particles. But the distance that the pions travel in heavy liquid (a propane/freon mixture has been chosen for the experiment) before converting into charged particles is shorter.

FOCUS

The latest addition to the central computer complex at CERN is a CDC 3100 to be used in the FOCUS development project. FOCUS is an acronym for 'Facility for On-line Computations and Up-dating Services'. Its main purpose is to serve as the manager of the data-links to the central computers, the CDC 6600 and the CDC 6400, coming from the smaller computers which are being used on-line to electronics experiments (CERN COURIER vol. 7, page 184).

To carry out the full, detailed calculations on the information gathered in these experiments almost always requires the resources of the central computers. The small on-line computers carry out preliminary checks and then record the data on magnetic tape for processing later on the central machines. Some of them, up to now, have been connected with the central computer, via separate data-links, so that they could call for this processing directly. Unfortunately, this method of operation is inefficient in the use it makes of the memory of the central computer and the demand for such data-links would soon overload the memory of the 6600 and 6400.

The solution is to use the 3100 as an intermediary to accumulate the data. It receives all the data-links from the on-line computers and 'manages' their access to the central computers via one data-link.

Another advantage from the use of this additional computer is gained by the fact that it makes it possible to add a typewriter console at each on-line computer. By using these consoles, the physicists will be able to select and modify their programs which are in the central computers, again with the 3100 as intermediary, and to receive their results printed out by the consoles.

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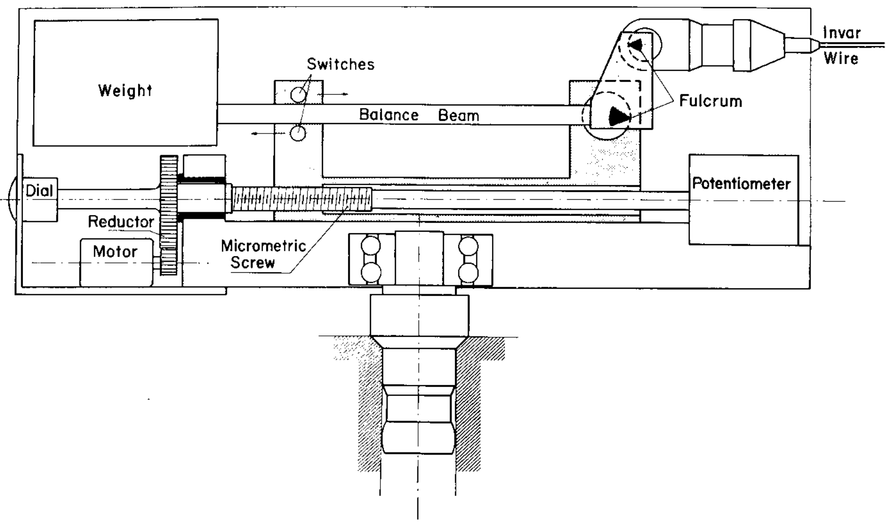
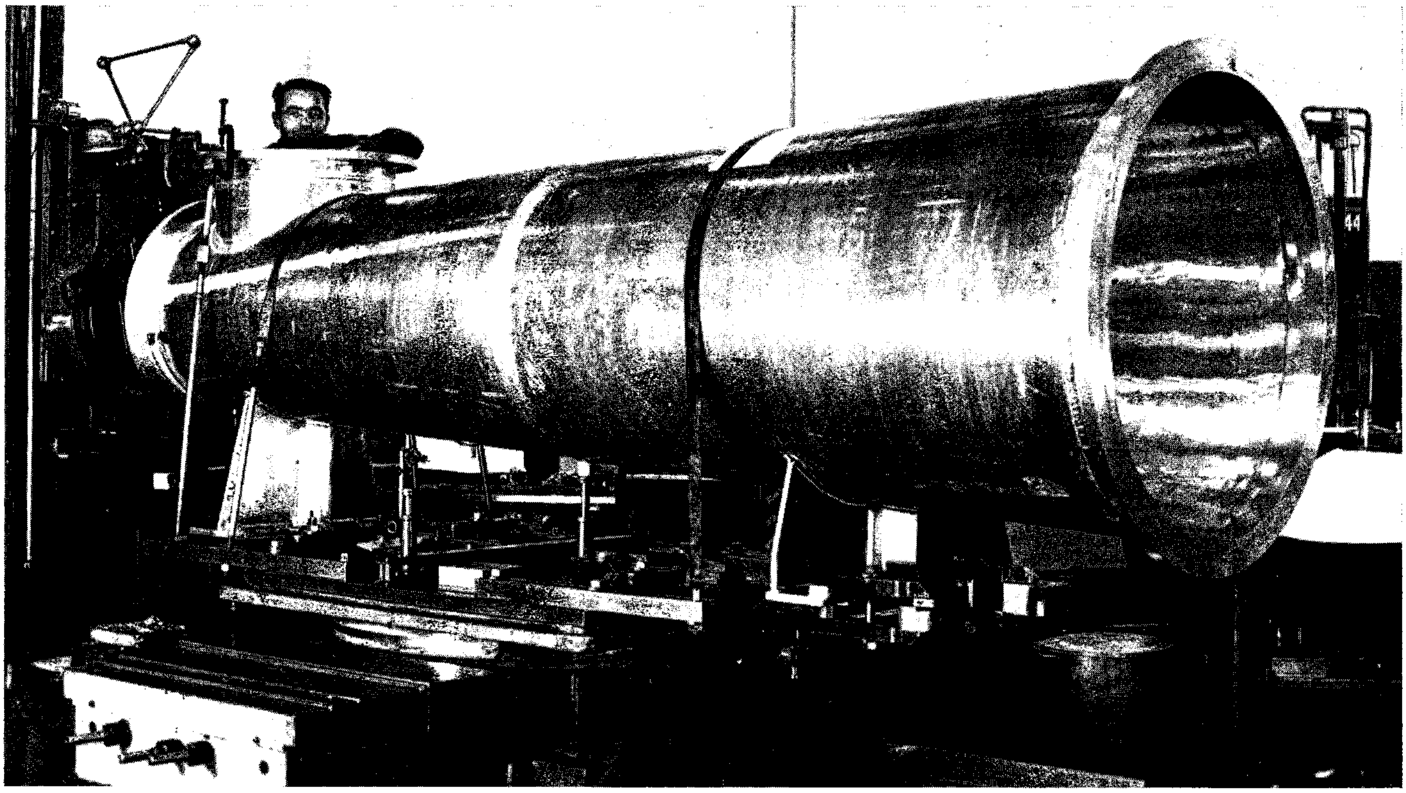


We all live in a yellow submarine... The biggest Cherenkov counter ever to be built at CERN was photographed in the main workshop where the inside walls of the counter were being polished.



CERN/PI 125.10.67

Better than one part in a million

An automatic measuring device, called the Distinvar, has been developed at CERN for rapid and accurate measurements of distances up to 55 metres. It was tested in one of the proton synchrotron tunnels for a thousand measurements over a distance of 50 metres and gave a relative accuracy of better than one part in a million. The total time involved in each measurement is three minutes of which the reading itself is only a matter of seconds. It is also possible to carry out the measurements by remote control.

Considerable attention has been given at CERN to the problems of metrology. This is because of the immediate requirement for the alignment of the intersecting storage rings and the future requirement of the alignment of the 300 GeV machine. Compared with the 28 GeV proton synchrotron, which itself posed quite severe alignment problems at the time of its construction, the 300 GeV is ten times the diameter with smaller magnet apertures which reduce the alignment tolerances still further.

Five devices have been produced (some still in the prototype stage) — a laser device for alignment in air up to 50 m ; a 'Mekometer Type III' (developed together with the National Physical Laboratory at Teddington, UK) which gives optical measurements in air with automatic compensation for changes in atmospheric conditions ; an interference fringe method using a helium-neon laser ; an automatic liquid level for level measurements ; and the Distinvar. All the devices make use of automation and can be coupled to computers.

The Distinvar uses a calibrated invar wire attached to a special reading head which reads off the difference between the calibrated length and the actual distance between the measured points.

In the head, a 'balance beam' oscillates between two electrical contacts fixed to a carriage. The contacts achieve balance by causing the carriage to move along a precision micrometer screw until the tension in the wire is balanced by a weight (see the diagram). The position of the carriage (and hence the distance to be measured) is then transferred via a potentiometer to be read off directly at the recording station or passed to a computer.

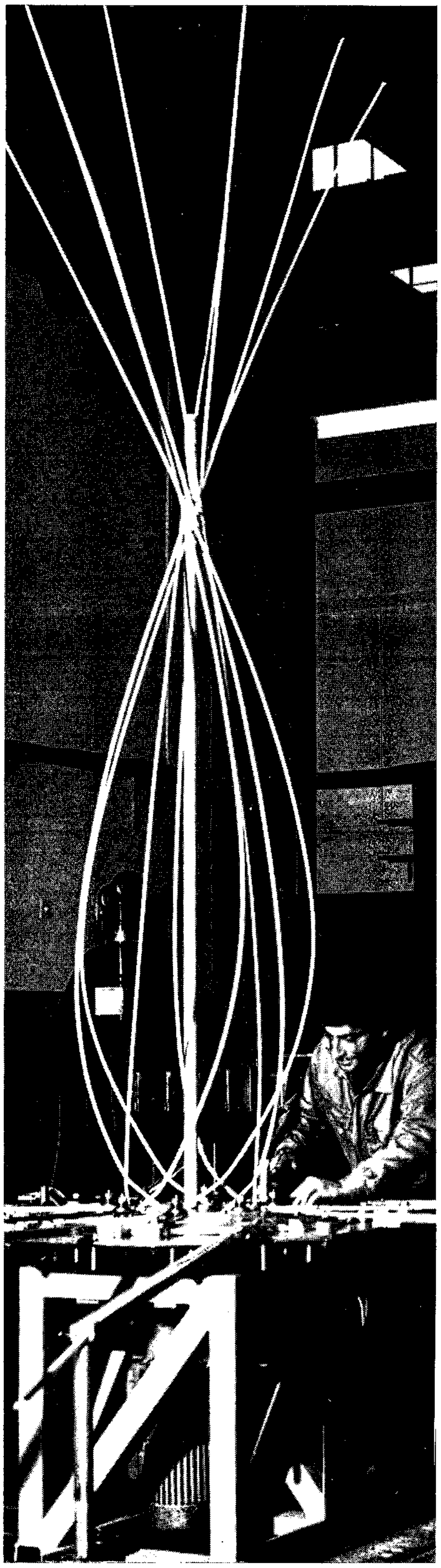
The relative precision between different measurements has been tested to be better than one part in a million. The absolute precision is obtained by calibrating the invar wire before and after a measurement against an invar rule, 4 m long, calibrated by the International Bureau of Weights and Measures, (Sèvres).

The whole measurement procedure is entirely automatic and could, for example, be performed by robot in radio-active areas. The Distinvar will be used in the alignment of the ISR magnets and a significant comment on its performance is that, because of the speed and reliability of the instrument, it has not been necessary to allocate any time for alignment in the construction programme.

(A detailled description of the Distinvar will appear in a paper by J. Gervaise in the Proceedings of the 6th International Conference on High Energy Accelerators.)

Folk art at CERN. This basket-work was photographed in the synchro-cyclotron workshop during the winding of a new magnet coil.

Opposite page: an aerial photograph of the cake made of the site of the intersecting storage rings where the major excavation work is now complete.



CERN/PI 80.10.67

Separators for Serpukhov

As part of the collaboration between the Serpukhov Institute for High Energy Physics and the European Organization for Nuclear Research, CERN is busy studying a radio-frequency particle separator system and a fast-ejection system to be used on the 70 GeV proton synchrotron which came into operation at Serpukhov in October. The design of both schemes is now at an advanced stage and it has been found that only minor extensions of the techniques developed for use on the CERN synchrotron are necessary to meet the requirements of the higher energy machine. The spirit of collaboration is excellent and the practical aspects of implementing such an extensive collaboration between two high-energy physics Laboratories are working well.

The purpose of a particle separator is to sift out a particular type of particle at a particular momentum from the spray of many particles with a wide momentum range coming from a target bombarded by the accelerated proton beam. (The operating principle of a two-cavity radio-frequency separator was described in CERN COURIER vol. 7, page 125.)

The proposed design for Serpukhov is based on a new three-cavity system which completed a very successful test run at CERN in June of this year. Ideas on using three cavities were first put forward by W. Schnell and the two-cavity system, brought into operation at CERN in 1965 by a group led by B.W. Montague, was designed for possible extension to three cavities. This was realized by P. Bernard, P. Lazeyras, H. Lengeler and V. Vaghin in the u4 beam to the 2 metre hydrogen bubble chamber.

They succeeded in separating anti-protons with a momentum of 12 GeV/c, which is about twice as high as previously achieved. It is also about the highest momentum which can be reached with the CERN proton synchrotron if a useful number of anti-protons is to be separated (the separator itself could handle higher momenta). 104 000 pictures of anti-proton events were taken in the chamber. There were two anti-protons per picture on average and the pion and kaon contamination was below 5 %; this involves the separator rejecting about 100 000 negative pions for each anti-proton it feeds to the chamber. The low anti-proton intensity was due to the fact that the fast-ejection system of the proton synchrotron operated with protons of comparatively low momentum (20.6 GeV/c) which is far from ideal for the production of anti-protons.

With three cavities it is possible to overcome a limitation of the two-cavity system namely that the separation of one type of particle from two other types is only possible for very narrow momentum regions. The only possibility for anti-protons with the previous CERN system was a momentum of 7.3 GeV/c. With the new separator, pure pion beams, kaon beams or anti-proton beams over a nearly continuous momentum region from 7 to 16 GeV/c are possible.

The design of the separator for Serpukhov covers a momentum region from 17 to 36 GeV/c. Most of the technical details have been examined and some preliminary work, such as low-power measurements on the r.f. structures and brazing of the structures, has been done. The construction programme has been discussed at several of the meetings, which are held once every three months between the scientists from Serpukhov and CERN, and has been agreed. The group at CERN have benefited from the help of V. Vaghin from Serpukhov who has been at CERN for the past 18 months. Serpukhov, whose job it is to build the beam in which the separators will operate (this is the beam to the large hydrogen bubble chamber 'Mirabelle' which is being provided by France) has benefited from the advice of P. Lazeyras from CERN and A. Samoilov has come to work for some time in the beams group.

All the way round

The bulk excavation of the circle, 300 metres in diameter, for the intersecting storage rings was completed in October. It has involved digging out over a million cubic metres of earth and rock (molasse), most of which has been moved off the site; about a third is retained to be used as shielding over the top of the ring tunnel when it is built.

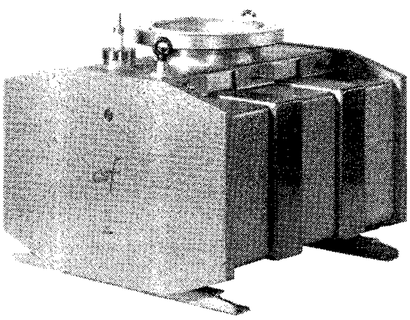
The civil engineering work on the ISR site is being done by the contractor Sogene with Albanese as excavation sub-contractor, both firms from Italy. They began the excavation in November 1966 and this particular item of the construction programme has been achieved about six months ahead of schedule. Detailed excavation of the foundations of the ring and concrete work are under way. About 100 000 cubic metres of concrete will be poured during the construction.

The foundations of the large West Experimental Hall have also been completed and assembly of the steel frame of the building began this month. This is an important item in the construction programme since it is intended to have the hall ready in July 1968 to receive components for the storage rings as they arrive on the site. The hall will be used as a laboratory to assemble and test equipment, such as the magnets, before they are placed in position in the tunnel.

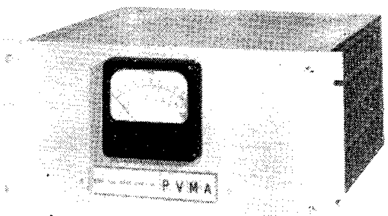
CERN/PI 245.11.67

CSF ULTRA/VACUUM ION PUMPS

F 9111 – 50 liters per second
F 9125 – 100 liters per second
F 9112 – 200 liters per second
F 9132 – 400 liters per second



- Clean ultra-vacuum.
- Silent operation, no forced cooling, no liquid nitrogen.
- One supply voltage only.
- Closed circuit operation.
- Vacuum measurement facilities.
- Limit vacuum : 1×10^{-11} Torr.
- Very long life.



power supplies for ion pumps

Deliver the voltages required for operating the pumps, even under the most severe running conditions. Provided with all necessary protections for personnel and equipment.

clean ultra-vacuum pumping or evaporation racks

Constructed with the 100-200-400 liters per second pumps ; primary pumping using sorbtion pumps ; ultra-vacuum pumping by pyrolitic Titanium sublimation pumps ; bell-jar and valves fitted with stovable metal joints.

OTHER PRODUCTS

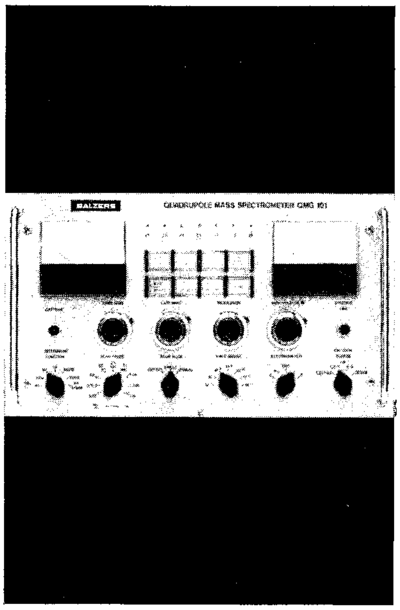
PROFESSIONAL AND INDUSTRIAL APPLICATIONS TRANSMITTING TUBES • "O" AND "M" CARCINOTRONS • TYPE "O" AND CROSSED FIELDS TRAVELLING WAVE TUBES • OSCILLATOR AND POWER KLYSTRONS • MAGNETRONS • T-R CELLS • STORAGE AND CATHODE-RAY TUBES • MINIATRON • SUBNITRON • REPEATER TUBES • CERAMIC TUBES • NOISE GENERATORS • NEON INDICATOR TUBES • DISPLAY TUBES • ELECTROLUMINESCENCE • GAS LASERS • VACUUM OVENS • SEALED LEAD-INS.

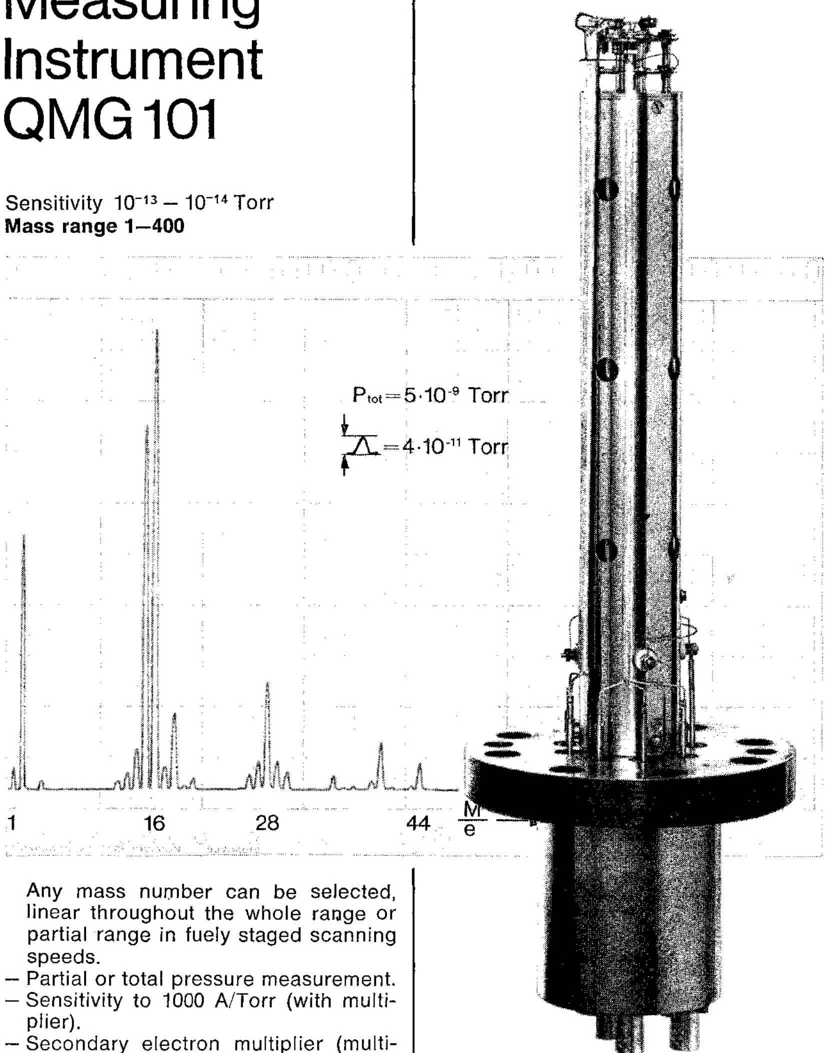
CSF - COMPAGNIE GÉNÉRALE DE TÉLÉGRAPHIE SANS FIL
GROUPEMENT TUBES ELECTRONIQUES
55, rue Greffulhe - 92 Levallois-Perret - France
Phone : 737-34-00 - Extension 109

SPI. 730

Partial Pressure Measuring Instrument QMG 101

Sensitivity $10^{-13} - 10^{-14}$ Torr
Mass range 1—400





– Accurate and rapid residual gas analysis in high and ultra-high vacuum systems;
– Measurements in space simulation chambers and particle accelerators;
– Residual gas measurements in work processes;
– Leak detection in high and ultra-high vacuum systems.

. . . a few typical fields of application where partial pressure measurement is particularly useful.
For many requirements of research, and to an increasing extent in industrial production, accurate and rapid information on the gas composition in high and ultra-high vacuum equipment is essential. A high standard of efficiency is required of the measuring instruments. In view of the very wide field of application, greater reliability in operation, more compact construction and simplicity of operation and maintenance are expected.

BALZERS partial pressure measuring instrument QMG 101, which symbolises our many years of experience, satisfies these requirements to a large extent. With this instrument residual gases can be analysed rapidly, reliably and with high sensitivity; as a quadrupole mass spectrometer, it works on the principle of mass separation in the high frequency, electrical quadrupole field.

Major features of the QMG 101
– Two mass ranges can be selected: 1 to 100, 10 to 400.
Choice of mass setting.

Any mass number can be selected, linear throughout the whole range or partial range in fuely staged scanning speeds.
– Partial or total pressure measurement.
– Sensitivity to 1000 A/Torr (with multiplier).
– Secondary electron multiplier (multiplier) for improving the sensitivity and oscillographical recording of rapidly changing processes.
– Good resolution ($\frac{M}{\Delta M}$ 10 % = 100)
The resolution can be readily adjusted to suit particular problems and reproducible setting.
– The analyser can be baked-out up to 400° C. The high precision rod system provides perfect and reproducible mass separation, and can be very easily dismantled and re-assembled if necessary.
– Open, immersion ion source, which can be effectively out-gassed by ion bombardment. The hot cathode is protected against excessive pressure rise, and can be changed without additional adjustment.
– Very compact construction; the complete supply and control instrument is contained in only one 19″ rack unit.
– Indicating instruments and controls are clearly visible for simplicity of operation.
– The instrument is non-magnetic and therefore free from stray magnetic fields.

BALZERS will be pleased to supply full details.

BALZERS®

HIGH VACUUM TECHNIQUE

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

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