# CERN COURIER

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# CERN COURIER

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## Contents



**The cover photograph** was taken at a reception on 8 December in honour of the departing Director General, Professor Weisskopf, and his wife. The reception was organized by CERN's theoretical physicists, who presented Professor Weisskopf with the first copy of a new book, dedicated to him, called 'Preludes in Theoretical Physics'. The book contains 42 essays by 50 theoretical physicists who have worked at CERN either as staff members or visitors. The essays treat a variety of topics from a mainly intuitive standpoint, trying to go to the heart of a problem without extensive mathematical reasoning — an approach Professor Weisskopf himself masterfully demonstrated throughout his scientific career.

In the photograph, Professor Weisskopf (left) is taking his first look at the book together with his successor as Director General, Professor Gregory (right) and Professor Van Hove, the new Directorate Member for Research.

**The CERN COURIER** is published monthly by CERN in English and in French editions. It is distributed free of charge to CERN employees, and others interested in the construction and use of particle accelerators or in the progress of nuclear physics in general.

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**The European Organization for Nuclear Research,** more commonly known as **CERN** (from the initials of the French title of the original body, 'Le Conseil européen pour la Recherche nucléaire', formed by an Agreement dated 15 February 1952), was created when the Convention establishing the permanent Organization came into force on 29 September 1954.

**In this Convention,** the aims of the Organization are defined as follows:

> **'The Organization shall provide for collaboration among European States in nuclear research of a pure scientific and fundamental character, and in research essentially related thereto. The Organization shall have no concern with work for military requirements and the results of its experimental and theoretical work shall be published or otherwise made generally available.'**

**Conceived as a co-operative enterprise** in order to regain for Europe a first-rank position in fundamental nuclear science, CERN is now one of the world's leading laboratories in this field. It acts as a European centre and co-ordinator of research, theoretical and experimental, in the field of **high-energy physics,** often known as **sub-nuclear physics** or the **physics of fundamental particles.**

**High-energy physics** is that front of science which aims directly at the most fundamental questions of the basic laws governing the structure of matter and the universe. It is not directed towards specific applications — in particular, it plays no part in the development of the practical uses of nuclear energy — though it plays an important role in the education of the new generation of scientists. Only the future can show what use may be made of the knowledge now being gained.

**The laboratory comprises** an area of about 80 ha (200 acres), straddling an international frontier ; 41 ha is on Swiss territory in Meyrin, Canton of Geneva (the seat of the Organization), and 39.5 ha on French territory, in the Communes of Prévessin and St.-Genis-Pouilly, Department of the Ain.

**Two large particle accelerators** form the basis of the experimental equipment :

— a 600 MeV synchro-cyclotron,
— a 28 GeV proton synchrotron,

the latter being one of the two most powerful in the world.

**The CERN staff** totals about 2200 people.

**In addition** to the scientists on the staff, there are over 350 Fellows and Visiting Scientists, who stay at CERN, either individually or as members of visiting teams, for periods ranging from two months to two years. Although these Fellows and Visitors come mainly from universities and research institutes in the CERN Member States, they also include scientists from other countries. Furthermore, much of the experimental data obtained with the accelerators is distributed among participating laboratories for evaluation.

**Thirteen Member States** contribute to the cost of the basic programme of CERN in proportion to their net national income:

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

Poland, Turkey and Yugoslavia have the status of Observer.

**The 1966 budget for the basic programme** amounts to 149 670 000 Swiss francs, calling for contributions from Member States totalling 145 860 000 Swiss francs.

**Supplementary programmes,** financed by twelve states, cover construction of intersecting storage rings for the 28 GeV accelerator at Meyrin and studies for a proposed 300 GeV accelerator that would be built elsewhere ●

# Farewell to Professor Weisskopf

**At the end of 1965, after five years as Director General of CERN, Professor Weisskopf returned to the Massachusetts Institute of Technology (MIT), Cambridge U.S.A.**

**Several ceremonies were held to show the appreciation of CERN for Professor Weisskopf's services to the Organization and we reproduce here three representative speeches given in his honour.**

**Extracts from an address by Mr. Albert Picot, delivered at a farewell Dinner for Professor Weisskopf on 4 November 1965. Mr. Picot was President of the Conseil d'Etat of Geneva in 1938, 1944 and 1947. He played a prominent part in establishing CERN at Geneva and was leader of the Swiss delegation to the CERN Council until December 1958.**

'Dear Professor Weisskopf: Among the cultural benefits which have enriched Geneva, I should like to make particular mention of the privilege of being able to welcome to our city the eminent personalities who have succeeded each other as Director General of CERN: Prof. Amaldi from Rome during the preliminary period; the great scientist Professor Bloch from Zürich and the United States; Professor Bakker from Amsterdam, who died so tragically in an aeroplane accident in the United States; his successor Dr. J. B. Adams from the United Kingdom; and finally yourself, Professor Weisskopf. I cannot tell you how much we admire your strong and pleasant personality. The Viennese in you has become slightly American, and we read with great interest your books in English and German, which make us vividly aware of the heights to which science has risen in the sixties of this century. Inside CERN itself, your teams, working with the synchro-cyclotron and proton-synchrotron accelerators and the bubble chambers, are making human knowledge progress at a rate undreamed of thirty years ago. With you, we are all looking forward to further astonishing progress on both the Swiss site and the French site over the border in the 'Pays de Gex'. Furthermore, Professor, I should like to pay tribute to you by mentioning in a general way three successes for CERN and for nuclear physics.

First of all let me mention the success of Europe. The cry of alarm uttered twenty years ago by eminent scientists in Lausanne and Florence has not been forgotten. Europe had been the home of physics ever since the days of Galileo, Descartes, Copernicus, Kepler and Newton. However, it was losing its prestige because scientists like Einstein and Fermi had gone to the United States and the younger scientists were also being attracted to the other side of the Atlantic. The answer to that cry of alarm was the creation of CERN, which is now the friendly rival of Berkeley, Stanford and Brookhaven. The battle was won on the day when, at Meyrin, our dear friend Niels Bohr, before a gathering of scientists from all over the world, started up the proton synchrotron with its 624 metre circumference. Europe took the lead again.

Then there is the success of science at CERN, where it is no longer restricted by national frontiers and chauvinism. At CERN one marvels at the drawing offices and workshops, where staff from twelve different nations work together in a spirit of friendship. Still more wonderful are the teams studying the most complex scientific problems, where nationality plays no role whatsoever in the composition of the TEAM. This absence of frontiers is an excellent contribution to the preservation of peace and the creation of a better future for mankind. CERN mathematics is a universal language, more so than English, French, German, Russian or Chinese.

Finally, the old physics of the 19th century was deterministic and, through its materialistic tendency inherited from Democritus, it often appeared hostile to philosophical and religious ideals based on liberty. With the new physics of Einstein, Planck and Heisenberg, with the indeterminate nature of the quanta in the field of thermo-dynamics, electricity and light, with laws which are no longer merely statistics, the gulf between the physical and the moral sciences is gradually narrowing. It is Niels Bohr and his school who perceived the bridges uniting the two.

The research done at CERN and by nuclear scientists everywhere is not remote from man's efforts in all spheres of human progress. This science, which has been blamed for producing the atom bomb, can and must contribute through its philosophy and its inventions to the development of a happier and more spiritual life on this planet. It is not Democritus with his indivisible atoms but Plato with his vision of Timaeus who will win the day.

And you, dear Professor, are going to leave us, alas ! We shall not forget what you have been and still are for us.'

**Extracts from the speech by Mr. J. H. Bannier, President of the CERN Council, at the end of the 31st Session of the Council on 16 December 1965:**

'My dear Weisskopf: When you came to CERN as Director General we had, after a most successful beginning, just entered the difficult transition period. The machines were ready and worked remarkably well. Would the physics done with them be just as successful ?

Remembering the many occasions when in your Progress Reports to the Council you could tell us of important results of research, and remembering the survey which you were able to present yesterday of what has been accomplished in the period of your stewardship, the answer is unreservedly positive.

You have always been the first to give credit to the many people who have done this research and to maintain that you yourself had practically nothing to do with it. But none of the many who have, according to you, been actively responsible for these successful results, would let you get away with this. All of them agree that they could only do their work because you had created the intellectual and spiritual surroundings, the atmosphere, the stimulating climate, without which their endeavours would have been fruitless.

And there is another very essential condition for the success of CERN which also is in a very large measure of your making: the confidence which has formed the basis of the cordial relations between the Director General and the Council.

You have instilled your spirit into us. This must surely have been to the good of CERN but it has also been to the good of each of us personally.

In saying this, I know I am not speaking on behalf of the Council only, but also on behalf of the many people who are working within CERN, men and women, scientists, administrators, engineers, technicians and all the others. For each of us the experience of being in contact with a great man has meant a lasting enrichment of our personal life. Let me humbly express the gratitude of us all.

Our sincere gratitude accompanies you across the Ocean. We hope to see you often here again, and to be able to show you that as good gardeners we are carefully tending the garden in which you have been working, so that we can show you the flowers which you have planted.'

**Extracts from the speech given by Mr. P. Lazeyras, President of the CERN Staff Association, at a gathering of all the CERN Staff on 17 December 1965:**

'Dear Professor: I should like to talk about the life of those who have worked here during the years when you have been at the head of the Organization. It is not easy to put into words all that you have been for us here. In any event, you will be remembered as a man who was always ready to listen to what we had to say. You have allowed — and this is an understatement in view of all the encouragement and help you have given us — you have allowed CERN to be not just a physics factory, but also a place where the staff could increase their knowledge at all levels. Need I say that it is directly due to you that the Education Section was established and that we have been able to organize good concerts and interesting lectures. Your help has also made it possible for many Cernites to enjoy artistic and sporting activities of their choice. In many cases no doubt the initiative came from the staff, but we want to thank you for having helped and supported us in this cultural side of our activity. This is important, because the quality of one's work depends not only on the conditions under which it is done, but also on the life one leads.


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**Professor Weisskopf raises his glass to the assembled staff at the farewell gathering on 17 December.**


CERN/PI 149.12.65

**Mr. J. H. Bannier delivering the farewell address to Professor Weisskopf at the end of the December Council Session.**


CERN/PI 209.12.65

**Professor Fierz at the Council Dinner declaiming the poem to Professor Weisskopf, which he had composed during the evening.**

It is impossible for me to mention all that has been done, especially since it would mean giving an account of all that remains to be done. However, the impetus which you have given will continue to have its effect and we know that it is never possible to halt progress once it is under way. As Director General, you could have restricted yourself to organizing and giving orders, but you have done a great deal more than that. On the social and cultural side CERN can truly be said to have made great progress.

Also during these five years, CERN has played an increasing part in international collaboration going far beyond the frontiers of its Member States, maintaining relations which on the whole transcend the prevailing political context. I believe that this is your particular concern and that you have striven to bring about this kind of collaboration, in so far as it lay within your power. I therefore feel that CERN provides a fine example of international collaboration, however limited it may be, which spans all kinds of frontiers.

It only remains for me to express the hope that when you draw up the balance sheet for the time you have spent at CERN, the reasons for satisfaction will outweigh the rest, and that you will find a new and great source of joy in the work to which you are now going'.

**The CERN Council gave a Dinner for Professor Weisskopf on 15 December 1965. Professor Fierz composed and read the following poem in the course of the evening:**

**Trauerode zum Abschied von Prof. Weisskopf**

Lasset uns weinen
Lasst uns klagen,
Wir wollens in Reimen,
In Prosa sagen:
Weisskopf das CERN verlässt !
Und doch in Treuen
Wir uns freuen
An dem, was er uns hinterlässt !
Denn ganz katholisch
Und apostolisch
Hat sein Charakter viel getan.
Hat Frieden brungen
Der uns umschlungen
Und sicherlich noch Jahre dauern kann.
Denn aufgespeichert
Und angereichert
In Storage Ringen
Ist dieses Friedenskapital
Drum danken wir ihm
Tausendmal.

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# International Symposium on Magnet Technology

by **F. Wittgenstein**
**Track Chambers Division**

**An International Symposium on Magnet Technology was held on 8—10 September 1965 at the Stanford Linear Accelerator Centre (SLAC), in California, U.S.A. There were 300 participants including several representatives from CERN. The Conference, the first of its kind, was organized jointly by the Universities of Berkeley and Stanford and sponsored by the United States Atomic Energy Commission (AEC).**

Although magnets represent the first generation of electrically powered machines and although construction of the first powerful electro-magnets dates back 70 years, it was only with the development of high energy physics that the demand for magnets reached semi-industrial proportions. Because of this, several representatives of American and European industry attended the conference alongside delegates from high-energy physics Laboratories in America, Asia and Western Europe. Those attending the conference also had the opportunity of visiting a number of firms specializing in the manufacture of electro-magnets.

Seventy papers were presented and discussed under five main headings:

General magnet technology;

Magnetic field analysis and magnet construction;

Superconducting magnets;

Techniques for magnetic field measurement;

Magnet power supply circuits.

Magnets with widely differing characteristics are used extensively at high energy physics Laboratories, in the construction of the particle accelerators themselves, in the transport systems for guiding secondary beams, and also in the detection apparatus. This explains why CERN sent several delegates to this conference — A. Asner (MPS), B. Hedin (MSC), M. Morpurgo (NP), R. Perrin (AR), C. A. Ramm (NPA) and the author.

A number of CERN papers were presented. C. A. Ramm had been invited to report on the present state of magnet technology for high energy physics in Europe. B. Hedin spoke about potential function for establishing the pole profiles to produce a required magnetic field. A. Asner briefly reviewed field analogue theory, by which it is possible to study magnetic field distribution on a rheoelectric model (metal plate and conducting paper, etc.). He demonstrated the application of this theory to some particular cases for which analytical calculation is very difficult. At the same session, he also reported on the new beam transport components developed in the CERN proton synchrotron division during the last three years.

**Interest in Superconductivity**

One of the most important sessions of the symposium was that devoted to superconducting magnets. Although some Laboratories have achieved steady magnetic fields of 30 tesla* and pulsed magnetic fields of 75 tesla over useful volumes of the order of cubic decimetres, using conventional copper-wound coils, these are exceptional performance figures. The idea of achieving induction levels even 5 or 6 times smaller over volumes of the order of 100 $m^3$, (such as could be called for in the next generation of particle detection apparatus) is probably out of the question because of the problems of the large power supplies and cooling plant which would be needed.

In two other fields also — the direct conversion of thermal energy into electric power by means of magneto-hydrodynamic generators, and the production of energy from controlled thermo-nuclear fusion in 'magnetic bottles' of the Stellarator type — the development of powerful magnets without Joule losses, capable of producing fields of 6 tesla over a volume of several cubic metres, is of the greatest interest.

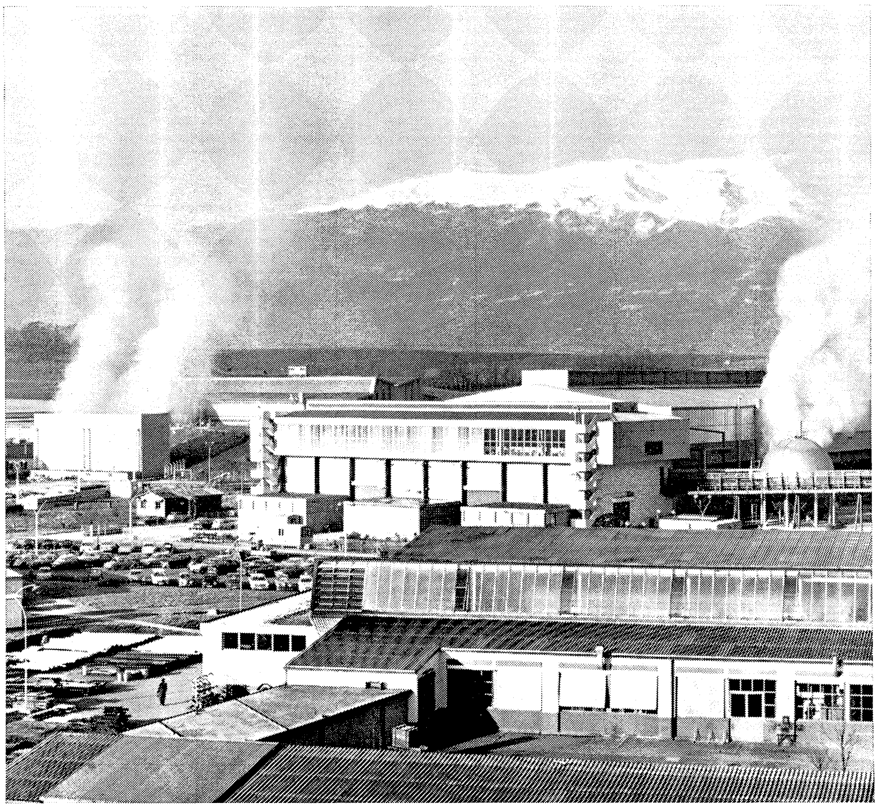
After the enthusiasm which greeted the production of the first superconducting coils, came a rather long period of disappointment, because, until quite recently, the construction of medium-sized coils, requiring several tons of kilogrammes of superconducting wire, had proved impossible. The experimental results never agreed with the predictions based on measurements made on short samples exposed to powerful external magnetic fields. Moreover, the prohibitive price of the coil material, alloys of niobium (Nb — Zr and Nb — Ti) which cost about 4000 Swiss francs per kilo, is a serious drawback. Efforts to produce satisfactory coils seem to have advanced by trial and error in the laboratory rather than by scientific deduction, and the specialist literature contains many new terms attempting to explain the difficulties. The various complications have been termed 'effects', e.g. 'degradation effect', 'split coil effect', 'training effect', etc. . . .

From some reports presented at the symposium it seems possible that progress will now be made in a new direction. The 'effects' can be completely eliminated if the coils are sufficiently 'stabilized', so that transitory perturbations (due to vibration, movement of the superconductors, flux jumps, etc.) do not lead to the destruction of the coils. This stability is now achieved by first electroplating the surface of the superconductor with copper, and then wrapping the coated superconducting wires with pure metals of high electrical and thermal conductivity. However, this results in the coil having a 'filling factor' amounting to only a few per cent (in other words the cross-section of the superconductor is only say 3 % of the total cross-section of the coil).

A further limitation has been that, up till now, superconducting wire has been produced with a maximum diameter of about 0.25 mm. This meant that the current through the wire was 20 to 80 A, according to the magnetic field to which it was exposed. Metallurgical tests are now being carried out on superconducting strips about 100 mm wide, to enable currents of up to 10 000 A to be used in a field of 4 tesla.

To summarize the situation, since it is possible, using techniques developed up to now, to produce commercially, coils which can give 4 tesla over volumes of about 50 litre, it should be possible without too much difficulty, to achieve this level of induction over volumes of several cubic metres in a year's time.

* In the MKSA system, the 'tesla', is the unit of magnetic induction (equivalent to weber/metre²). In the CGS system, the unit is the 'gauss' and 1 tesla = 10 000 gauss.



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**This view of two plumes of condensing water vapour rising from the cooling units in the CERN site was taken during December 1965. The magnet cooling circuits from the experimental halls dissipate some 15 to 20 MW, which gives an indication of the saving which could be possible if superconducting magnets without Joule loses become widely used.**

# The Analysis of Track Chamber Photographs Using Flying Spot Digitizers

by **Brian W. Powell**

**Data Handling Division**

**A vast quantity of data pours from the experiments on particle accelerators throughout the world. For example, over 300 000 photographs per week came from the three bubble chambers operating on the CERN PS at the end of 1965. The conventional method of processing these bubble chamber photographs is for each one of them to be examined ('scanned') to see whether it records an interesting particle interaction. The interesting photographs are then passed to hand operated measuring machines to obtain precise measurements of the particle trajectories recorded on the film. Similar measurements are carried out on photographs taken in film spark chamber experiments.**

**This article on the Flying Spot Digitizers at CERN describes one of the most fruitful attempts to speed and make more accurate the process of analysis of bubble and spark chamber photographs. There are two types of Flying Spot Digitizer at CERN — the HPD or Hough Powell Device (named after Professor Hough and the author who, together, initiated the development in 1959) and Luciole, a further development initiated by Professor Kowarski.**

On the afternoon of 24 July 1965, measurements were completed on the last pictures from the first bubble chamber experiment to be measured on the mechanical Flying Spot Digitizer at CERN. The previous two weeks had seen the completion of the third and fourth spark chamber experiments processed using the flying spot method. These events marked, for me, the end of the second, and probably the most difficult, phase in the development of this technique. To reach this happy state of affairs had taken us nearly six years. It has developed from a part-time activity for one or two people into a full-time activity for more than thirty people in the Data Handling Division, to say nothing of the many people from Track Chambers and Nuclear Physics Division now involved with the utilization of the system.

If a date can be attached to the start of the HPD and Luciole projects, it should be 21 September 1959 when Paul Hough, who was then a Professor of Physics at the University of Michigan, arrived at CERN to spend a Sabbatical leave working on data processing for bubble chamber pictures.

Encouraged by Lew Kowarski (then Head of the Data Handling Division) and Yves Goldschmidt-Clermont (then Deputy Head of the Division) we spent a year doing primitive tests and evolving what, at the time, were openly called 'crazy ideas'. However, by September 1960, the main ideas had evolved and the first tests had been encouraging. This first phase ended in May 1961 with the successful operation of a prototype device at CERN, thanks to a collaborative effort involving members of the Lawrence Radiation Laboratory, Berkeley, and the Brookhaven National Laboratory (where Hough now worked) in the USA, the Rutherford Laboratory in England and CERN itself. The outcome was a decision at each of these Laboratories to move into phase two — the development of devices of this type for production use. (The CERN prototype was always foreseen as for experimentation only.) The aim of production use, I feel, has now been realized at CERN and we should enter the third phase, which I would define as a consolidation of our position. By this I mean the analysis of more and more experiments using the Flying Spot Digitizers and a steady improvement in the techniques we use.

**How pictures are processed**

The aim is to reduce as far as possible the human intervention in the analysis of bubble and spark chamber photographs. With the conventional IEP (Instrument for the Evaluation of Photographs) measuring machines an operator uses the machine to make precise measurements on the film. With the Flying Spot Digitizers, the role of the machine is increased — it makes its own precise measurements and the operator provides help for those experiments which are too complex to be analysed by the machine alone.

The machine can be made to operate automatically and is faster than the average operator. This led to a second decision that, as far as possible, any help from the operator would be prepared in advance as a separate operation so that once the machine began a sequence of measurements, the measuring would not be hindered by the operator's speed.

These aims have been realized in the following way. Attached to a computer is the Flying Spot Digitizer, which explores the whole of each photograph with a small spot of light, about 0.015 mm in diameter (Fig. 1). Each time the spot of light encounters something black on the film, the coordinates of its centre are transmitted to the computer for examination. The computer program, which has been specially prepared to recognize specific patterns on the pictures which are being examined, is

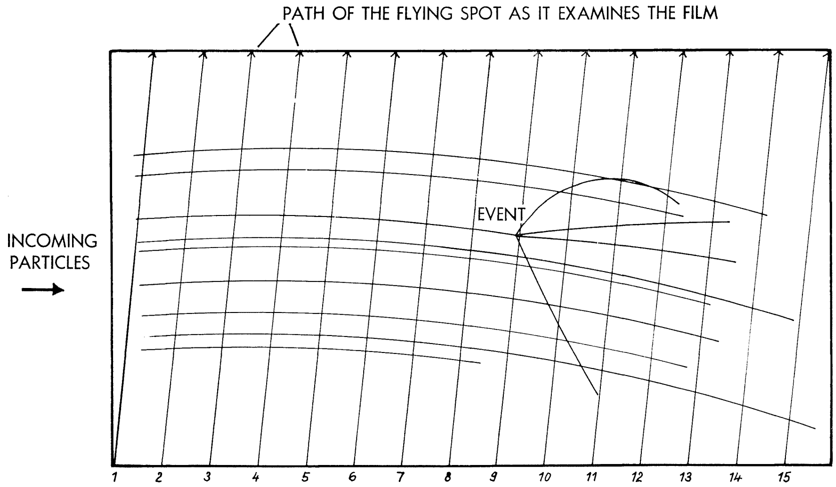



**Fig. 1. A schematic representation of how the pictures are scanned. In practice, the lines representing the path of the flying spot are much closer together and the flying spot travels across about 1500 times to cover the whole picture.**

able to search through the coordinates corresponding to a given area on the photograph, identify a pattern (such as a cross), which it expects to find there and compute the position of its centre (Fig. 2).

There is nothing very magical about this operation which allows the computer to 'see' a certain shape on the film. The program is merely a means of specifying in advance what steps should be gone through at certain times, which regions should be searched, and what one expects to find there. If something unexpected occurs, the computer is no help. If in a certain region one expects to find a cross and in fact it lies just outside the region, nothing will indicate that it has just been missed ; the computer will merely say that nothing was found.

For each experiment the procedure is similar though not identical. A program is prepared which specifies the regions in which certain patterns are to be expected and all coordinates falling inside those regions are inspected by the program to see if they constitute a part of the expected pattern.

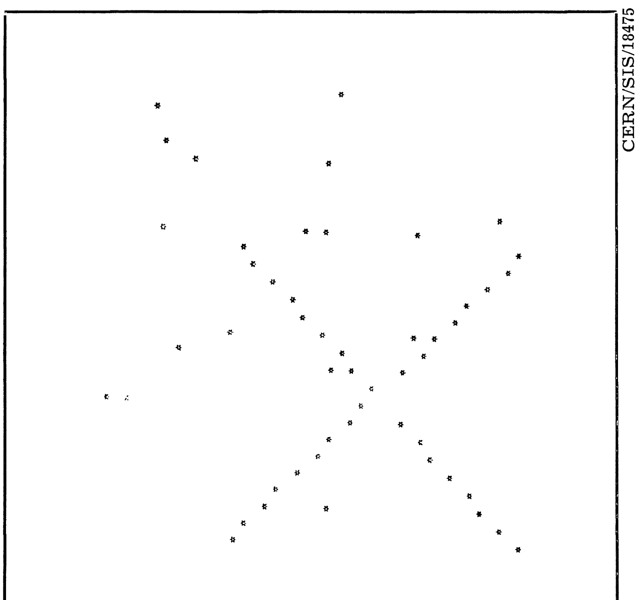



**Fig. 2. An example of a reference cross within the region of the film being examined by the flying spot, together with random digitizings coming from background on the film.**

The computer program has a second important role to play and this is the control of the sequence of events. Once the operator has loaded his roll of film into the Flying Spot Digitizer, the computer takes over all control. In addition to processing the pictures, the computer controls the advance of the film from one picture to the next, checks that the next picture is the correct one, decides whether any special procedure is necessary (such as rescanning the picture) and prints out a summary of what happened for each picture.

**Scanning, Measuring and Guidance**

For some of the experiments we have analysed using spark chamber photographs, the patterns of tracks have been simple enough to allow a completely automatic processing. In other words both the selection of those pictures which should be measured (the process normally called scanning) and the measurement itself were carried out simultaneously by the machine. Because the coordinates sent to the computer are of high precision, the measurement stage has already been carried out before it has been decided whether or not the picture is one for measurement. The role of the computer program is then only to recognize which coordinates belong to the interesting features on the picture and to retain them for the subsequent stages of analysis. If the program rejects a picture as not meeting the specifications, the reasons for failure are given, the measurements are thrown away and the machine proceeds to the next picture.

For many types of experiment (such as bubble chamber experiments) we are not yet able to provide a computer program which can do the automatic recognition of interesting pictures. To overcome this difficulty, we use what we have called 'guidance', which involves providing the program in advance with sufficient information about the pictures to reduce the problem to a complexity we can manage. In effect, it amounts to finding a method which eliminates most of

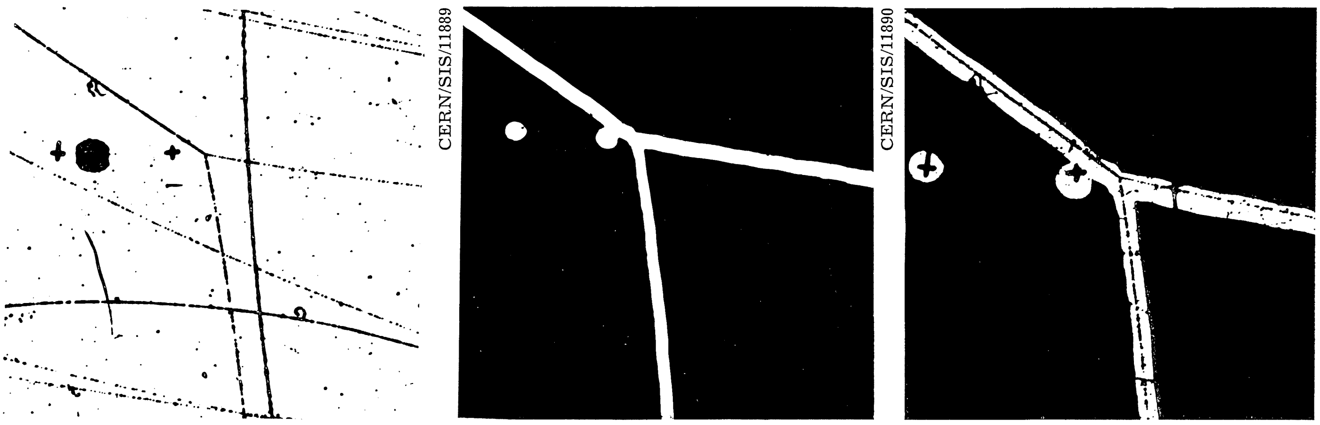



**Fig. 3. a) This is the original photograph which contains a simple event.**

**b) A 'mask' is prepared which serves to hide the background tracks.**

**c) When the mask is superimposed on the original photographs, the flying spot can see only the tracks corresponding to the event or in the immediate vicinity of the event.**

**This idea of selecting the area of the film which the flying spot is to examine, is still maintained but now the computer selects the area, after being informed by several 'rough digitizings' where the interesting event occurs on the film.**

the unwanted background tracks in advance so that what remains belongs mainly to the tracks one wishes to measure. (With spark chamber pictures this is usually done already in the process of selecting the data in the experiment itself.) From there it is not too difficult to select correctly the points belonging to the interesting tracks and to derive from them the desired information.

At a very early stage, we saw this guidance in the form of a mask as illustrated in Fig. 3. Using this method, coordinates would reach the computer only from those regions in the immediate vicinity of the desired tracks. The masks would have been prepared beforehand and automatically superimposed on each picture at the time of measurement. Before long, it was seen that a much easier and more flexible method of doing this would be to define the approximate position of each track by means of three points (or rough digitizings) which would allow the computer program to do its own selection by computing a curve through the three points and then selecting only those coordinates from the flying spot digitizer which lie in the vicinity of this curve. This is how we now operate for bubble chamber experiments and three scanning tables ('Milady' scanning tables), equipped in this way, are in operation. The operator searches the film for interesting events and when one is found, the number of the picture and the rough digitizings are registered on punched cards which subsequently provide the computer program with its guidance to do the precise measurement of the events.

We have also done one experiment which may be considered as a case of 'minimum guidance'. Here, spark chamber pictures which resembled very simple bubble chamber pictures were to be processed (Fig. 4). In particular, the number of tracks on each picture did not exceed 6 and of these 4 represented the event. Because of this feature, we were able to write a program which needed to be provided only with a list of the pictures where events occurred and the gap numbers in which the vertices were located.

**HPD and Luciole**

I have so far avoided distinguishing between the two devices — HPD and Luciole. It has probably become clear that a major part of the ingenuity required in using flying spot digitizers lies in the writing of the computer programs. The digitizer itself has to provide the program with as faithful a representation of the picture as possible, it is the writer of the program who really has to solve the problem of what that representation means.

As far as the programs are concerned, there is very little difference between the two devices — indeed pieces of program written for one device are used for the other and vice-versa. Both provide coordinates in a similar manner, both scan the film in a similar manner, both are controlled by the computer in a similar manner. The main difference lies in the mechanism for producing a spot of light to scan the film. With the HPD the flying spot is produced mechanically and with Luciole it is produced using a cathode ray tube. This difference results, at least for the present, in a greater accuracy for the HPD and, therefore, application to large film formats such as bubble chamber pictures is


**Fig. 4. An example of the decay of two neutral V particles in the CERN-E.T.H. magnet spark chamber (Experiment 3 in Table 1).**

| Type of experiment | Physicist in charge of experiment | Detector | Processing device |
|---|---|---|---|
| 1. $\pi^{\pm} + p$<br>$p + p$ scattering | Harting | Spark Chambers | HPD |
| 2. $\pi^- + p \rightarrow Y^- + K^+$ | Lundby | Spark Chambers | Luciole |
| 3. $K^- + p \rightarrow K^0 + n$<br>$\pi^- + p \rightarrow K^0 + K^0 + n$ | Michelini | Spark Chambers | HPD |
| 4. $\pi^+ + p \rightarrow \Sigma^+ + K^+$<br>$K^- + p \rightarrow \Xi^- + K^+$ parity determination | Rubbia | Spark Chambers | HPD |
| 5. $\bar{p} + p$ at 5.7 GeV/c all interactions giving 4 charged secondaries | French | Bubble Chamber | HPD |

**Table 1.**

easier. Secondly, the method used for deriving the coordinates with Luciole necessitates a calibration which is more frequent and more complex than that needed for HPD. However, since this is carried out using the computer, it is not a very serious complication.

The Luciole project was initiated in the Spring of 1962 by Lew Kowarski as a further development of the HPD system aimed in particular at spark chamber picture analysis. It was clear at that time that spark chamber experiments could be analysed using HPD alone but it was also thought that with the very high rate at which spark chamber pictures can be produced, it would be desirable to foresee a greater capacity than that allowed by the HPD project alone. Moreover Luciole might, in time, offer substantially higher processing rates than the mechanical system. It was also clear that we would gain by making the machines 'look alike' to the computer so that experience gained with one instrument would be of benefit in the use of the other.

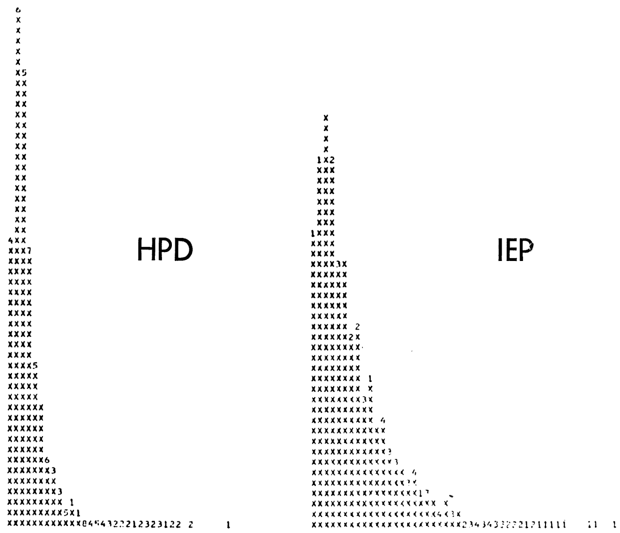
At the moment Luciole has been used for one experiment, but the experience gained, coupled with that derived from programming for the HPD system, does not leave any doubt about its future as a useful device.

**Results to date**

In Table 1 the experiments which we have processed to date are listed, together with some details of the techniques used and the size of the analysis problem. Although all of these experiments are now finished in so far as we are directly involved, the assessment of the results is still in progress for the last three at the time of writing.

To give an idea of the performance, I shall describe some of the checks which we have made on our results to verify that no undesirable effects were present. For the first spark chamber experiment, a large number of hand measurements had also been made so that a comparison between the two methods was possible. In Fig. 5, we show one such comparison. The measurement of the incoming track to the target and of the two outgoing tracks allows one to calculate the position of their intersection inside the target. Only with perfect accuracy would the three tracks meet at a single point, and therefore the extent by which they deviate from this ideal is a measure of the quality of the results. In the figure, these deviations are plotted for data from a few hundred pictures so that the width of the histogram is an indication of the average quality of the measurements. It is clear that the automatic measurements in this case are more accurate than the hand measurements. According to our estimates, the histogram for the HPD indicates an accuracy of $\pm$ 0.006 mm in determining the position of each track on the film.

Another, and most important, part of this study consisted of checking that the automatic selection as to which pictures should be accepted and which should be




CERN/SIS/R 10173

**Fig. 5. The distributions compare the accuracy of HPD and hand measurements on spark chamber pictures from an experiment on $\pi$-p scattering. The measurements were performed on three tracks reconstructed to form a single vertex. The width of the distribution is a measure of the accuracy of the method ; the narrower the distribution the more accurate the measurement.**

| Processing speed | Number of pictures or events processed | Type of processing | Completion date |
|---|---|---|---|
| 1200/h | 200 000 pictures | Automatic selection and measurement | March 1964 |
| 1800/h | 100 000 pictures | Automatic selection and measurement | February 1965 |
| 120/h | 19 000 events | Automatic measurement (with minimum guidance) | July 1965 |
| 320/h | 56 000 pictures | Automatic selection and measurement | July 1965 |
| 70/h | 21 000 events | Automatic measurement (with full guidance) | July 1965 |

rejected was reliable. Comparison made with several thousand spark chamber pictures showed that the agreement between the human and the machine was about 92 %, the discrepancies coming mainly from conditions which we considered to be legitimate (such as the failure of the Flying Spot Digitizer to detect, reliably, a particularly faint spark on the film).

For the bubble chamber experiment too, a particularly thorough study of the results is being made. Here again, a rather better accuracy is obtained with the automatic device. But our main concern has not been to establish the average accuracy, which we expected to be good, but rather to discover whether occasional large errors were occurring which would lead to a false interpretation of an event. This might result from a track being incorrectly measured and, as a result, being assigned a too high momentum. Without necessarily giving obvious sign of error, it might nevertheless give rise to a spurious interpretation. Table 2 summarizes our present knowledge based on a comparison of 691 events measured with both the IEP and the HPD. The small number of discrepancies and the proportion of these ascribed to incorrect IEP measurements indicates

| | Number | % |
|---|---|---|
| Compared events | 691 | 100 |
| Discrepancies | 23 | 3.3 ± 0.7 |
| HPD, false interpretation | 11 | 1.6 ± 0.5 |
| IEP, false interpretation | 7 | 1.0 ± 0.4 |
| Unsolved | 5 | 0.7 ± 0.3 |

**Table 2. A comparison of HPD and IEP measurements.**

that the reliability of the automatic measurements approaches, and may soon be better than that of the hand measurements.

It is not the aim of this article to provide a detailed assessment of the results we have obtained but I hope that these few examples will give a general idea of the work that has been done and help to show that the results are very favourable.

**The future**

During the time that work has been in progress no less than eight other Laboratories have decided to install similar measuring devices (making twelve Laboratories in all). Many of these new machines will soon be in operation and will add very substantially to the processing capacity currently available for bubble and spark chamber pictures.

Simultaneously with the development of the method outlined here, efforts have been made, first at Brookhaven and subsequently at Berkeley, to write programs which will perform a completely automatic selection of interesting events in bubble chamber pictures. We intend to start work on this difficult problem here also in the near future but, although the results obtained have been encouraging, it is too soon to envisage the automatic selection of events for any but the simplest types. How far we can go in this direction is by no means clear but with the present system, using various degrees of guidance, we must certainly extend our variety of experience as far as possible. This is necessary to come to a full appreciation of the problems which may occur and to develop confidence in dealing with them. Only when that stage is reached can we claim to have an analysis system which competes in every way with the hand operated machine.

So, while keeping a considerable interest in the developments toward complete automation, our immediate aim is to achieve greater adaptability to different kinds of experiment and to improve further the quality of the results which we produce. It is for this reason that, at the beginning of this article, I defined the next phase of our work as one of consolidation.

# CERN News

## Council Session

The 31st Session of the CERN Council held on 15 and 16 December, 1965, took several decisions of the greatest importance for the future of CERN.

1) The budget for the CERN basic programme for 1966 (149.67 million Swiss francs) and the estimates for the following three years (of 160, 180 and 198 million Swiss francs) were approved. The figures approved by the Council correspond closely to those the Director General had asked for, and will allow the improvements programme planned for the 28 GeV proton synchrotron to go ahead. This programme includes not only improvements to the machine itself, to increase intensity and repetition rate, but also new experimental facilities like the heavy liquid bubble chamber GARGAMELLE to be built by the French in co-operation with CERN. This large bubble chamber will be used in the new neutrino area.

2) At the 30th Session of the Council in June 1965, the Council agreed in principle to the construction of intersecting storage rings (ISR) at the CERN PS. At the December meeting, all the Member States with the exception of Greece, agreed to participate in the project. Construction work can now proceed on the newly acquired area of the CERN site on French territory and is expected to begin in the early Summer of 1966. The ISR budget for 1966 is 21.7 million Swiss francs.

3) The preliminary studies on the proposed 300 GeV accelerator for Europe will continue. The expenditure on these preliminary studies is small and a major part of it is for detailed site studies. Sites in nine Member States are under consideration; an overall report on the site studies will be presented to the Council Meeting in June 1966. The European Committee on Future Accelerators (which, under the Chairmanship of Professor Amaldi, recommended the 300 GeV machine in their report of June 1963) is to be reconvened to look at some of the scientific questions which such a project poses.

The scale of contributions to the basic programme of CERN (not including ISR or 300 GeV studies) for the next three years, was revised in accordance with the CERN Convention. The new scale is based upon national income figures for 1962-64 prepared by the United Nations Statistical Office. Germany takes over from the U.K. as the largest contributor; the revised scale can be seen on page 2.

As reported on page 3, the Council bade farewell to Professor Weisskopf and welcomed Professor Gregory as the new Director General from 1 January 1966. Professor Van Hove was appointed, ad interim, Directorate Member for Research to succeed Professor Gregory. Dr. Prentki replaced Professor Van Hove, ad interim, as leader of the Theoretical Study Division and Mr. Tirion was appointed leader of Site and Buildings Division. Also, following the Council decision on the storage ring project, a new Division — the Intersecting Storage Ring Division — is to be set up under the leadership of Dr. Johnsen with Dr. Zilverschoon as deputy Division leader.

A more detailed report of the Council Meeting will be given in the February issue of the COURIER.

## At the PS

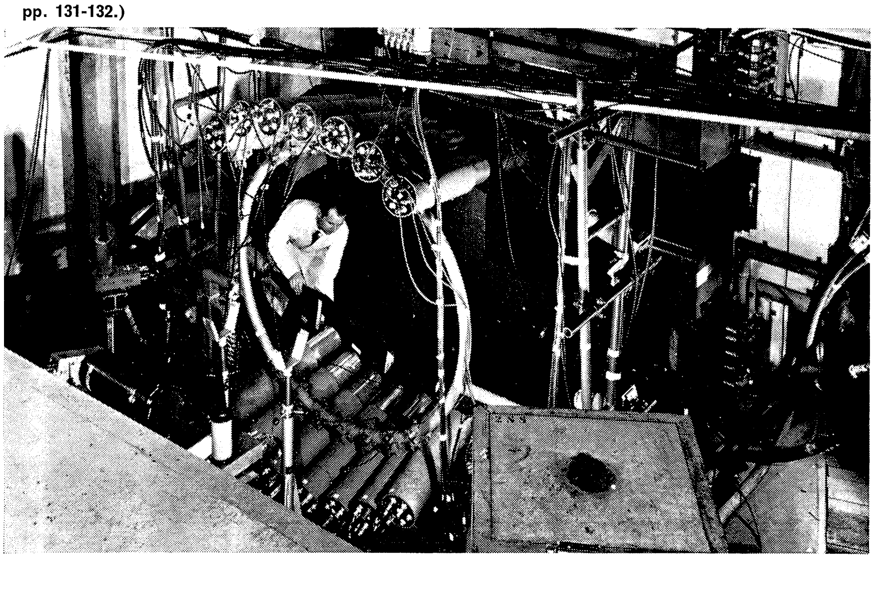
The 2 metre hydrogen bubble chamber is being overhauled in January having completed its first 2 million expansions. During the 4 weeks immediately preceeding the bubble chamber shut-down, the PS beams were used predominently for bubble chamber experiments (involving the CERN heavy liquid chamber and the Saclay 81 centimetre chamber also); during January, electronic counter experiments are the 'main users'. The Saclay chamber has now taken 7 million photographs since 1961, including 2 million with deuterium as the chamber liquid. 1 million of the deuterium photographs were taken during 1965.

Two experiments, X2 and K5, which have been running simultaneously since July 1965 using the heavy liquid chamber, were completed at the end of November. Both experiments used positive K meson beams, in the momentum range 800-1200 MeV/c, which were stopped in the bubble chamber liquid (genetron), to examine the decay properties of positive K mesons. The X2 team (CERN, Ecole Polytechnique, Nijmegen, Padua and Turin) took 750 000 pictures; the K5 team (Rutherford Laboratory) took 570 000 pictures.

Also in November the slow extraction of the PS beam into the East Hall (ejection system 62)* was successfully tested for future physics experiments. Tests on this system earlier in the year had been concerned with the technical problems of extraction. The latest studies were of small angle proton-proton scattering using the extracted beam to learn something of the problems of beam exploitation. Also measurements to assess the radiation shielding requirements connected with regular operation of the beam have been done.

* For a description of this system see CERN COURIER vol. 5, no. 10 (October 1965), pp. 148-158.

**A symmetric array of electronic counters in position on the m4d beam line. This experiment, involving a CERN/E.T.H. team, is now collecting data on the decay of the neutral eta meson into three pions (positive, negative and neutral). This decay might show up a possible violation of charge invariance in the strong or electromagnetic interaction and thus contribute to the current intensive investigation of the CP invariance law. (See CERN COURIER, vol. 5, no. 9 (September 1965), pp. 131-132.)**



CERN/PI 42.12.65

## Physics Prizes

The Italian Physical Society has awarded the 'Ettore Majorana' prize for 1965 to T. Massam of Nuclear Physics Division. The French Academy of Sciences has awarded the 'Prix Louis Bonneau' to M. Borghini also of Nuclear Physics Division for work on the physics of polarized targets.

## Visits in 1965

A total of 9197 visitors were received at CERN during 1965. This figure is 20 % higher than that for 1964 and 9½ % higher than the previous 'record year' in 1963.

About three-quarters of the visitors took part in the Saturday guided tours which have now become a regular feature of CERN life. Many of them came from near by and the Saturday visits remain one of the most effective links with the local population. A number of CERN staff members with their families and friends also took part in these guided tours and this trend will continue to be encouraged in 1966. For groups coming from outside CERN, the initial contact is with the Public Information Office. For CERN staff, details of forthcoming visits are given each week in the 'Bulletin'.

32 CERN staff members, with a broad knowledge of the site and its equipment, can be called upon to help with the reception of these visitors by giving introductory talks and by guiding groups round the site.

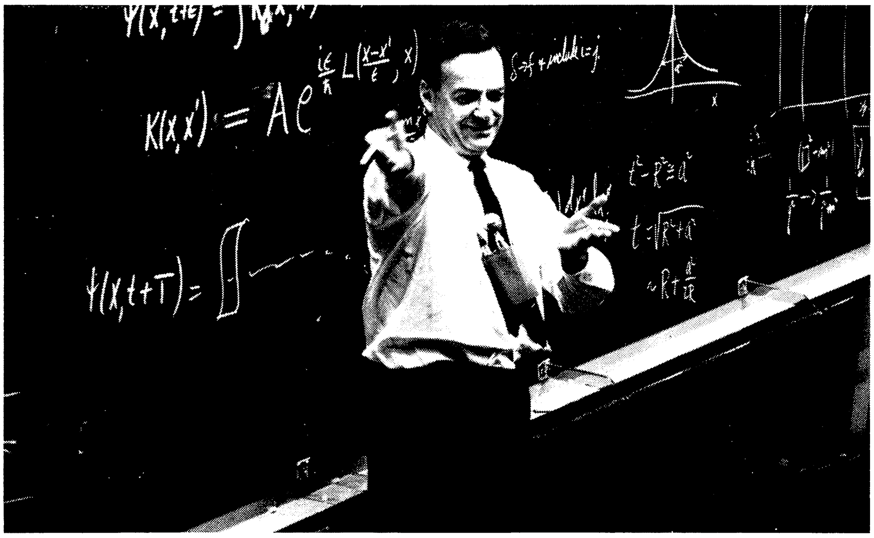
Another category of visitors, who usually have a close professional interest in the work of the Laboratory, come to CERN on mid-week visits. Among them in 1965, there were many 'VIP's' and a number of specialists seeking detailed information on their own field of work. There were also about 100 representatives of information media : newspaper and periodical reporters, scientific authors, radio and television teams and several film units.

Yet another category of mid-week visitors to CERN comprises groups from universities or technical colleges, whose aim in visiting CERN is to study sub-nuclear physics at first hand. These visits arouse great interest and enthusiasm, because they provide the opportunity not only of seeing the complex apparatus and the associated experimental techniques in action but also of meeting experts in the various fields of CERN's work. It is possible that many of the students taking part in these visits will return to CERN in the future as members of the CERN staff or of visiting scientific teams.

One of these visitors conveyed his appreciation of a day spent at CERN as follows: 'It was of great value for all of us to gain new knowledge and impressions, which lie outside the normal scope of a technical college. We saw and learnt much that was new and several of us glimpsed new possibilities for our future careers'.

The success of the visits owes much to the generous help and encouragement given especially by the panel of guides, and by all those called upon for assistance.

**The 1965 Nobel Prize in Physics was awarded to Schwinger, Tomanaga and Feynman for their fundamental work in quantum mechanics on the theory of the interaction of charged particles with the electro-magnetic field. Richard Feynman, from the California Institute of Technology, visited CERN while in Europe to receive the Nobel prize. He fascinated a packed auditorium, on 17 December 1965, with a brilliant and entertaining lecture on his Nobel prize work.**



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# News from abroad

## Brookhaven

The United States 'Joint Committee on Atomic Energy' in their Report of February 1965 recommended, 'Conversion of the Brookhaven AGS to a high intensity facility'. The Atomic Energy Commission has requested funds for this conversion of the 33 GeV proton synchrotron, to take place over the next five years.

The present intensity is around $10^{12}$ protons per pulse at a repetition rate of 1 pulse/2.5 second. It is intended to improve this to $10^{13}$ protons at 1 pulse/second (with the possibility of a slower repetition rate to allow for longer beam spill). The main limitation on the present intensity is space charge effects at injection and the original conversion plans included the construction of a 500 MeV injector. This has now been modified to 200 MeV with provision for a further 300 MeV stage at a later date.

The magnet power supply (now 35 000 kVA) will be doubled in size to cope with the increased repetition rate. The number of r.f. accelerating cavities in the magnet ring will be reduced from 12 to 8 to release straight sections for beam extraction etc... The r.f. equipment will also be moved outside the ring so that servicing will be possible while the machine is in operation.

Special measures will be needed to cope with the radiation problems which increased intensity will bring (levels of up to 400 R/hour are predicted for the target areas). These measures will include adding another 10 foot of earth shielding around the AGS tunnel.

It is hoped to restrict the 'down time' which the conversion will involve, to eight months. Some of this time will be for the installation of shielding in the second year of the conversion programme, and the remainder at the end of the five years to bring in the injector, etc...

# Serpukhov

In the first week of December, four Russian scientists — Prof. Logunov (Director of the High Energy Physics Institute at Serpukhov), Prof. Prokoshkin, Dr. Selivanov and Mrs. Samokhvalova — visited CERN. They had spent two previous weeks at CEN, Saclay. The following information on the 70 GeV proton synchrotron, now under construction, was given in a talk by Prof. Prokoshkin, Director of Experimental Physics at Serpukhov.

The design intensity is $10^{12}$ protons per pulse at the maximum energy of 70 GeV with a repetition rate of about 8 pulses per minute. The injector is a 100 MeV linac and space charge effects at 100 MeV injection will be the limiting factor on the machine intensity.

The magnet ring is 470 metres in diameter; there are 600 magnets (maximum field about 12 kG) in the ring, with straight sections 5 metres long and 53 accelerating stations. Acceleration time is 3.8 second with a 0.5 second flat top available. The cross-section of the vacuum chamber is $17 \times 11.5$ cm.

One large experimental hall with no internal supports straddles the ring and has an office and laboratory block on each side. The main items of experimental equipment at present under construction are a $4.5 \times 1 \times 1.5$ metre heavy liquid bubble chamber and a 6 metre magnetic spectrometer. The 2 metre hydrogen chamber being built at Dubna may be used at Serpukhov and there is also a possibility of using a hydrogen chamber from Saclay.

About 1000 people are now involved in the Serpukhov project. It is hoped that the first full energy beams will be achieved at the end of 1967 and that high energy physics experiments will begin a year later. The Russian machine will then take over from the Brookhaven and CERN machines as the highest energy accelerator in the world.

# Orsay

The following information was released from the Linear Accelerator Laboratory of the University of Paris, at Orsay, on 16 November 1965 :

'On the 25 October 1965, the first attempt was made to inject electrons into the storage ring (A.C.O. - Anneau de Collisions d'Orsay). The storage ring is designed for electron-positron collisions with each particle beam having an energy up to 500 MeV. Several hundreds of particles were stored at the first attempts.

From one pulse it is now (16 November 1965) possible to inject several millions of electrons and to store them for a lifetime of half an hour. This has enabled the first measurements to be made of closed orbits in the storage ring, of the number of oscillations per turn, of resonances and of the beam shape in regions of weak and strong focusing.

No important difference has been observed between the experimental results and the theoretical predictions.'

# Rutherford Laboratory

The 7 GeV proton synchrotron, Nimrod, is back in action. At the time of writing, one of the two alternators from the magnet power supply has been returned to the Laboratory after modifications at the manufacturers. It is being used to pulse Nimrod, though not yet up to full energy. The second alternator is due to return at the end of 1965.

A 1.4 metre heavy liquid bubble chamber operated for the first time on 29 October. The bubble chamber was designed by engineers and physicists from University College, London, and the Laboratory. The capacity of the chamber is 450 litres ; the magnetic field strength is 21.5 kG. The first experiments using the chamber will begin early in 1966.

Progress is also being made on the construction of an 80 centimetre helium bubble chamber. This will be the largest helium chamber in the world and will be used especially for studies on light hypernuclei. The refrigerating system, which is required to hold the helium temperature down at 3 to 4° K for up to 30 days, has been successfully commissioned.

CERN/SIS 25 491

**The magnet tunnel of the Serpukhov 70 GeV proton synchrotron. Several of the magnet blocks can be seen in their aligned positions. The ring of magnets is now almost complete.**

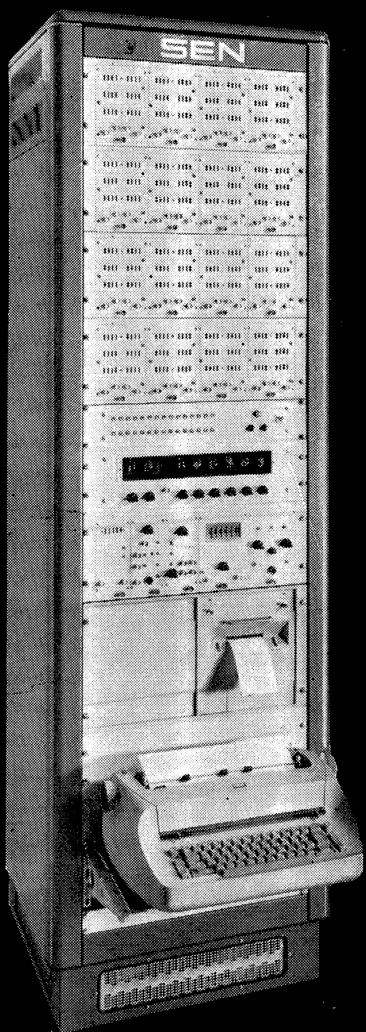
## Stanford

In November, 1965, successful acceleration of a beam of electrons in a superconducting cavity was achieved at Stanford. The cavity was a copper cylinder 4 inches long coated inside with lead, which becomes superconducting near absolute zero, cooled by liquid helium to 1.8° K. Acceleration equivalent to 4 MeV/ft was obtained.

With the conventional cavity, energy losses in the copper walls are considerable and they restrict operation to a duty cycle of 0.1 % or less to avoid overheating the walls. The superconducting cavity has very small loses and holds out the prospect of continuous rather than pulsed operation. One of the main problems concerns the refrigeration down to the very low temperatures involved. The Stanford workers are now planning larger superconducting accelerators.

## DESY

In the first week of December, 1965, it was announced that the production of antiprotons in the interaction between gamma rays and protons had been observed at DESY. This is the first time that antiproton production in this way has been detected. 30 examples of the event, in which gamma rays of energy around 3 GeV, from the electron synchrotron, interacted with protons in a liquid hydrogen target, were recorded.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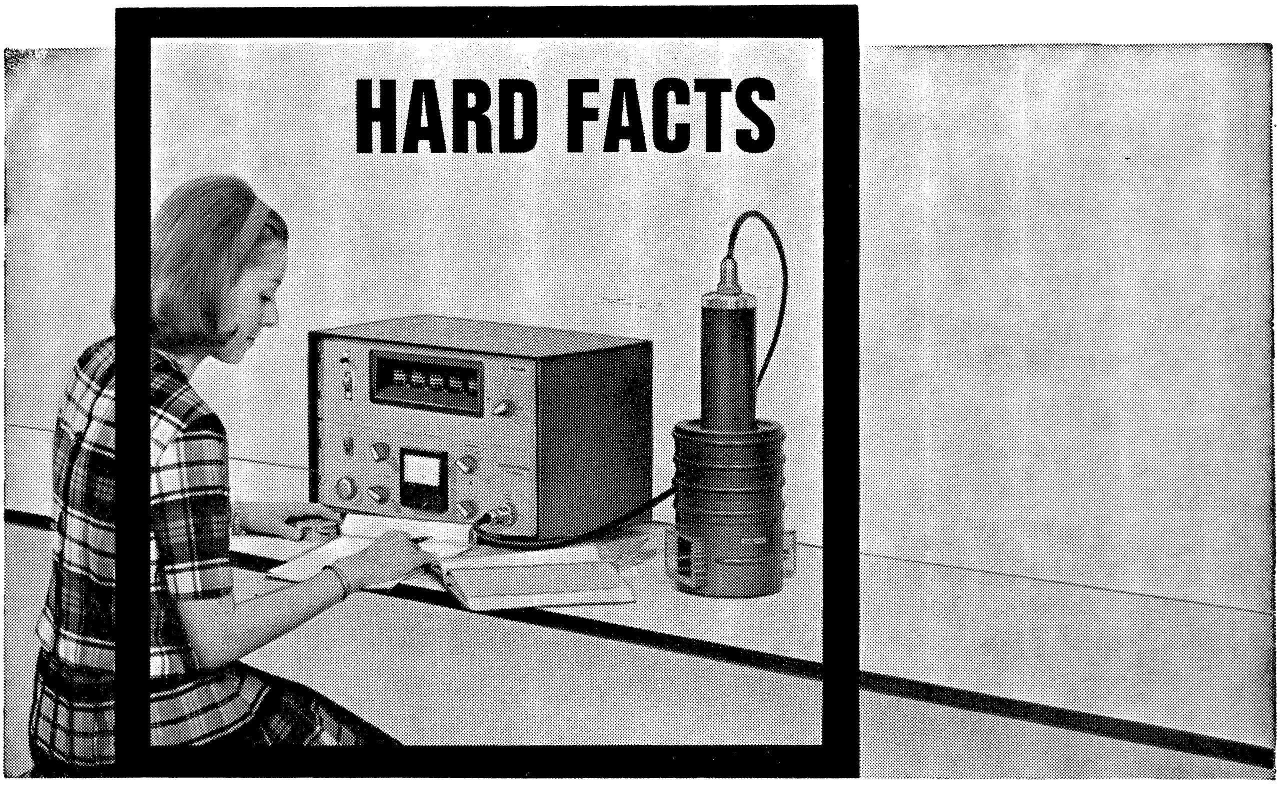


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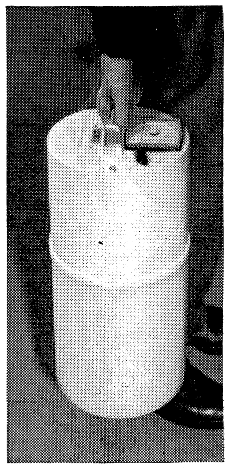

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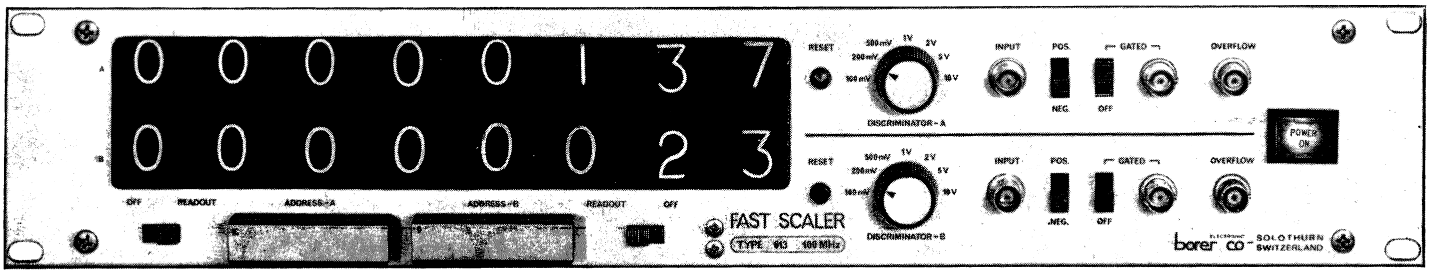


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