CERN COURIER

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European Organization for Nuclear Research

Cover photograph : The CERN Council in session on 14 June. Representatives from the 13 Member States discussed the proposed 300 GeV accelerator and took important decisions on collaboration with the Serpukhov Laboratory in the Soviet Union, and on the construction of a very large hydrogen bubble chamber. (CERN/PI 152.6.67)

Comment

About 8000 cubic centimetres of printed information concerning the proposed European 300 GeV accelerator confronted CERN Council delegates for their 34th Meeting on 14 and 15 June.

The documents included the 1967 Report of the European Committee for Future Accelerators, ECFA, (119 pages) ; three volumes of 'Utilization Studies for a 300 GeV Proton Synchrotron' put together by the various sub-groups of ECFA (1036 pages) ; two volumes of further information on 'Sites for the Proposed CERN 300 GeV Proton Synchrotron' one by the CERN Study Group on sites and the other by experts of those Member States offering sites (328 pages) ; an 'Addendum to the Report on the Design Study of a 300 GeV Proton Synchrotron' prepared by the machine study group at CERN (110 pages); and various documents concerned with the revision of the CERN Convention to accommodate the proposed Laboratory.

The ECFA Report in particular is of great significance for the future of sub-nuclear physics in Europe. Though the 300 GeV project is a major topic, the Report deals also with its context, the international and national programmes in this field of research and their inter-relation.

The construction of a 300 GeV proton synchrotron is the unanimous decision of the European sub-nuclear physics community as the next step forward. It does not often happen in science, or in any other field, that all the interested parties are in agreement as to what is required to pursue their work in the future. The ultimate decision rests, of course, with the Governments of the Member States who have to balance it against all the other demands on their resources. The vast amount of information presented at the Council Meeting provides a sound basis for their decisions.

It is hoped that many of the Member States will be in a position by the Council Meeting next December to present a 'letter of intent' with regard to the 300 GeV project.

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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 200 acres 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 360 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.

ECFA Report 1967

A summary of the Report presented to the CERN Council at its June meeting by the European Committee for Future Accelerators.

In this summary, much of the background to the recommendations and statements in the Report has, necessarily, been omitted. In particular, the scientific arguments for the recommended future European programme are not given. (They were covered in some detail in CERN COURIER vol. 6 no. 12).

The design of the proposed 300 GeV proton synchrotron and its utilization are referred to in the second article in this issue of CERN COURIER, concerned with the Addendum to the initial Design Study.

In 1963 a Committee of European physicists was set up, with Professor E. Amaldi as Chairman, under the name of the 'European Committee for Future Accelerators (ECFA)'. Its main task was to make recommendations for the construction of new accelerators, international and national. It presented the 'Report of the Working Party on the European High Energy Accelerator Programme' (document CERN/505) on 12 June 1963, recommending *on the international scale:* the construction of intersecting storage rings for the CERN proton synchrotron at Meyrin, and of a proton synchrotron of an energy of about 300 GeV.
on the national scale: the construction of a number of accelerators of different types and the development of data-handling facilities.

To take account of the developments since then, ECFA was reconvened at the end of 1965, at the instigation of the then Director General of CERN Professor V. F. Weisskopf, to bring the 1963 recommendations up-to-date. The Committee was again chaired by Professor E. Amaldi with Professor A. Citron as Secretary, and was composed of some 60 representative European physicists and accelerator experts. Two working groups were set up: one made recommendations on both the form and scale of national and international programmes and on the relations between them; the other undertook a critical study of the design for the 300 GeV accelerator and a survey of the utilization of the machine. Three volumes of 'utilization studies' have been produced.

The two main themes of the Report are the 300 GeV accelerator and the structure of both international and national programmes needed for a healthy overall European effort in high energy physics. Broadly speaking, the 1967 Report confirms the analysis and conclusions of 1963.

Recommendations

The Report lists five recommendations:
1) If European scientists are to continue to contribute to the advance of high energy physics into the 1980s, a large proton accelerator should be built in Europe with the least possible delay.

A maximum-energy of 300 GeV and a beam intensity of 10^{13} protons per second are confirmed as design figures and the project as described in the Design Study (document CERN/563) is considered to be a good basis for taking a decision. The necessary cost and manpower foreseen in the Design Study are considered to be sufficient.
2) The basic foundation of scientific advance lies in the universities and steps should be taken to ensure a full participation of European scientists from universities and national laboratories in the use of the large international accelerators.

This involves opportunity to participate at all levels in the planning and execution of the experimental and technical programmes, keeping resident staff to the minimum compatible with efficient operation, adequately equipping national teams to work at the international centres, and making it easy for physicists to visit the international centres.
3) For a balanced development of high energy physics, other accelerators and large instruments, built at national or regional laboratories, will be needed in addition to the international facilities.

Several such laboratories should be further developed or established around new machines within the next decade and joint participation by Member States in the construction and, particularly, operation of existing and future national accelerators is recommended. These laboratories should also provide for the preparation of equipment, which is too large to be built at universities, for use at the international centres. Exchange of scientific and technical staff between the large laboratories, national and international, should be encouraged.
4) A detailed study was made of the numbers of experimental physicists involved in high energy physics, using a hypothetical but conservative model for a future European programme of national and international machines. Using this model, the total of experimental physicists in 15 years time is less than twice the total for 1966, implying a growth rate of only 4 ½ %. It is therefore considered that Member States can decide now on the construction of the 300 GeV machine and on national accelerators with no risk of committing an undue

share of European scientific manpower to one branch of physics.

5) The financial implications for the Member States were also considered on the basis of the model programme. By 1981, the total cost of the programme is estimated to rise by a factor of about 3, over the 1966 figure for European expenditure on high energy physics, to a total of 1800 million Swiss Francs.

Member States are recommended to maintain their financial support of national teams collaborating at the international centres at a figure of 50 % of the operating budget of the international centres. (This is currently the situation with regard to the Meyrin laboratory). Approximate equality between the cost of independent national research in high energy physics and the contribution to international centres is considered a sound situation when the 300 GeV accelerator is in full operation.

Model for the future European programme

ECFA placed its studies of separate problems in the framework of a hypothetical overall European programme to examine in a more concrete way the relation between the different parts and to check that the total resources of money and manpower required for high energy physics could be justified in any broader discussion of overall science policy. The figures which are deduced from this model are not in themselves 'targets' recommended by ECFA.

The ECFA Report of 1963 made the first analysis of this kind for Europe as a whole. Four years later, a rather conservative programme has been considered with the aims of demonstrating clearly that the decision to build the 300 GeV accelerator can be taken with no risk of overcommitting the resources of Europe and that the continuation of national accelerator building and exploitation is justifiable by the same criteria, at least at the rate proposed as a minimum in 1963. The programme can be divided into two parts — the international and the national or regional. This second part again divides into two — collaboration with the international centres and the purely national centres.

Table 1. Manpower and cost estimates for the model European programme in high energy physics. The manpower figures give the number of experimental physicists involved. The costs are at 1967 prices in units of a million Swiss Francs.

Table 1	No. on payroll			Annual cost		
	1966	1974	1981	1966	1974	1981
International programme						
i) 300 GeV Laboratory						
operating	—	—	200	—	—	400
large capital	—	20	—	4	280	20
ii) CERN-Meyrin operating						
Synchrotron and synchro-cyclotron	108	170	120	151	270	200
Intersecting storage rings	—	30	60	—	80	100
iii) Other international projects	—	—	—	22	30	60
TOTAL	108	220	380	177	660	780
National and regional programmes						
i) Collaboration with international centres						
300 GeV Laboratory operating	—	20		—	10	
CERN-Meyrin operating						
Accelerators and storage rings	685	1100	1500	80	170	380
Other projects	—	—		5	20	
ii) National centres						
University groups	480			60		
Large laboratories -		750	850		400	650
operating	163			210		
large capital	—	—	—	50	150	
TOTAL	1328	1870	2350	405	750	1030
GRAND TOTAL	1436	2090	2730	582	1410	1810

Table 1 gives the estimates of manpower and cost for this model programme. The different elements in the programme are described in more detail below. Three dates are taken to yield significant figures in the Table :

1966 as a known starting point

1974 when the 300 GeV accelerator could be at the peak of construction, CERN-Meyrin will have completed the intersecting storage rings and its improvements programme and no other new accelerators will be in full operation

1981 when the 300 GeV accelerator could have taken over the major role in Europe and new national machines could be in full operation.

International programme

i) 300 GeV Laboratory

Tables 2, 3 and 4 give the estimates of the costs and the manpower for the 300 GeV laboratory, to construct the machine and to bring it into operation for physics. They are based on the assumption that approval of the project will be given at the end of 1967, that the site will be accessible mid-1968, that the project group can be set up at the same time and that building work can start mid-1969. If these initial dates are met, construction could be completed and research using the machine started in 1976.

ii) CERN-Meyrin

The broad lines of the future of the existing international Laboratory were effectively laid down in 1965 when Member States agreed to support the construction of intersecting storage rings, the improvement of the 28 GeV proton synchrotron and the provision of several large particle detectors. All these developments will be completed early in the 1970s.

By 1974, a much increased programme of 28 GeV physics will be under way and in addition, research will have started using the storage rings. By 1981, a sizeable transfer, from the 28 GeV machine, of interest and resources to the 300 GeV Laboratory can be expected. (However, if the number of potential users grows at a rate faster than anticipated or if purely national programmes are restricted, extensive exploitation of the 28 GeV machine could continue.)

Table 2: Construction	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976	Total
Machine proper	3.5	7.5	17.5	60.5	171.5	184.0	177.5	142.5	93.0	73.5	931.0
General laboratory facilities and services	1.0	2.0	5.0	27.5	46.0	53.5	52.0	78.5	84.0	82.0	431.5
Preparations for high-energy research	—	—	—	5.0	17.0	25.0	40.0	72.5	115.5	138.5	413.5
TOTAL	4.5	9.5	22.5	93.0	234.5	262.5	269.5	293.5	292.5	294.0	1776.0

Estimated budgets, at 1967 prices in units of a million Swiss Francs, for the 300 GeV Laboratory : Table 2, during construction of the accelerator ; Table 3, during the first years of operation.

Table 4. The estimated staff figures.

Table 5. The total number of experimenters, both based at CERN-Meyrin and from throughout Europe, and the budgets anticipated for the Laboratory at CERN-Meyrin (budget figures at 1967 prices in units of a million Swiss Francs).

Table 3: Operation	1977	1978	1979	1980	1981
Operation of accelerator and experiments	70.0	76.0	103.0	130.0	155.0
Experimental equipment and facilities	135.0	120.0	115.0	110.0	105.0
General laboratory facilities and services	90.0	99.0	112.0	125.0	140.0
TOTAL	295.0	295.0	330.0	365.0	400.0

Table 4 Manpower	1968	1969	1970	1971	1972	1973	1974	1975	1976	1978	1981
Research	—	—	—	—	—	70	120	280	370	540	940
Equipment	—	—	—	10	60	120	230	290	350	430	615
Computer operation	—	—	—	30	40	60	80	100	120	150	210
Machine group	80	120	200	300	400	500	500	520	520	500	560
Service groups	10	70	160	280	365	530	720	970	1150	1350	1775
TOTAL	90	190	360	620	870	1280	1650	2160	2510	2970	4100
Total Staff and Fellows	90	190	360	620	870	1270	1630	2130	2460	2870	3880
Visitors	—	—	—	—	—	10	20	30	50	100	220

Table 5	Total number of experimenters			Annual cost		
	1966	1974	1981	1966	1974	1981
Synchrotron and synchro-cyclotron	790	1230	650	151	270	200
Storage rings	—	70	130	22	80	100
Large detectors	—	—	—	—	20	10

The 600 MeV synchro-cyclotron programme will be similarly affected by the coming into operation of a 'pion factory' in Switzerland (see below).

The intersecting storage rings, on the other hand, will be an almost unique facility and increasing exploitation until well after 1981 can be assumed. These considerations are reflected in Table 5.

iii) Other international projects

Other projects, in the years under examination, which are likely to be internationally planned and financed include for example collaboration with Serpukhov and the USA ; a large particle detector for the storage rings ; a giant bubble chamber for the 300 GeV machine ; etc...

National programmes

i) Collaboration with international centres

This part of the model programme concerns the financing from national budgets of the national teams who take part in the research at the international Laboratories.

In October 1966, there were 1330 experimentalists working in high energy physics

Table 6. Accelerators, with energies higher than 200 MeV, and storage rings at national centres in Europe.

Table 6	Energy	First operation	Remarks
1. Proton synchrotrons			
Chilton (UK) (Nimrod) . . .	7 GeV	1963	
Saclay (France) (Saturne) . .	3 GeV	1958	
2. Synchro-cyclotrons			
Liverpool University (UK) . .	0.4 GeV	1954	Expected to cease operation by end 1968
3. Electron synchrotrons			
Hamburg (Fed. Rep. Germany) (DESY)	6 GeV	1964	
Daresbury (UK) (Nina) . . .	4 GeV	1966	
Bonn University (Fed. Rep. Germany)	2.3 GeV	1967	
Lund University (Sweden) . .	1.2 GeV	1963	
Frascati (Italy)	1.1 GeV	1959	
Bonn University (Fed. Rep. Germany)	0.5 GeV	1959	
Glasgow University (UK) . .	0.45 GeV	1954	Expected to cease operation by end 1968
4. Colliding-beam devices			
Frascati (Italy) (Adone) . . .	1.5 GeV $e^+ e^-$	1967	Particles accelerated from 400-1500 MeV
Orsay (France) (ACO) . . .	0.5 GeV $e^+ e^-$	1966	
5. Electron linear accelerators			
Orsay (France)	2.3 GeV	1963	
Frascati (Italy)	0.45 GeV	1966	Special design for positron acceleration : e^+ average intensity 3×10^{12} e^+/s at 350 MeV
Mainz (Fed. Rep. Germany)	0.31 GeV	1966	(70μA at 180 MeV)

in the CERN Member States. Of these, 52% (690) were working exclusively with CERN, and, adding 110 experimentalists on the CERN payroll (only half of them as staff members), a total of 800 experimentalists were dependent on CERN. (Similar analysis has not been done for theoretical and applied physicists working in high energy physics.) Of these 800, about 230 were at the Laboratory at any one time.

Also in 1966, the total national budgets for high energy physics research of the Member States was 391 million Swiss Francs of which 75 million was spent on collaboration with CERN. This was 51 % of the cost of the CERN basic programme.

ECFA believes that, as long as the policy of maximum participation at the international centres by outside physicists is continued, the amount spent at home by Member States on this collaboration must be increased proportionally to retain this ratio of about 50 %.

ii) National centres

The backbone of independent national research programmes for large countries, and perhaps for groups of smaller countries, is formed by national accelerators. Independent national high-energy physics research should be carried out at a number of centres in the Member States. These centres should have a wide geographic spread to bring every university within comparatively easy reach of one of them. Since with the increase in magnitude of the accelerators their number will necessarily decrease, each particle accelerator should as far as possible be exploited on an international basis, even when the accelerator has been built by a national organization.

A list of the existing national accelerators, of energy higher than 200 MeV, and of storage rings in Europe is given in Table 6. In addition, a 'pion factory' (a 500 MeV isochronous cyclotron) has been authorized in Switzerland and construction, at Villigen near Zurich, will begin soon.

The existing machines have a limited useful life in their present form and will need to be improved or replaced if they are not to become a hindrance rather than an asset for European progress.

Some examples of new accelerators which ECFA considers desirable are :

— a proton synchrotron of normal intensity at an energy intermediate between the 28 GeV and the 300 GeV machines

— electron-positron storage rings at a higher energy than available so far

— a large electron accelerator with a good duty cycle

— a 'kaon factory'.

A programme on this scale would involve costs rising from 320 million Swiss Francs in 1966 to about 650 in 1981. The ratio of expenditure on national centres to international centres could then fall from 1.8 in 1966 to 0.85 in 1981. ECFA considers that a healthy balance would be endangered if this ratio were to drop much below unity.

The Report concludes with a few comments on the manpower and costs presented above in Table 1. The total number of physicists who would be involved by the model programme corresponds to an almost steady annual growth of 4 ½%. This figure is considerably lower than for the recent past in high energy physics or for almost all other branches of science. More important, it is about half the past growth rates for numbers of children entering universities in many European countries. Thus the proportion of university students going into and staying in high energy physics would considerably diminish in the future.

The growth of the total annual cost is affected by the construction periods for the new accelerators ; it rises at a rate of 11 ½% between 1966 and 1974 levelling off to 4 % after. If the construction costs of the machines were removed the growth rate would be fairly steady at 7 to 9 % which, taking into account the growth in the number of physicists, implies a cost per physicist growing at a rate of 4 %.

The existence of the 300 GeV proton synchrotron will not in any way lead to an overemphasis on high energy physics in Europe in the next 15 years ; in fact, it will be necessary to supplement this machine with several new national accelerators if anything like the present position of high energy physics is to be maintained in the future.

300 GeV Up-dated Design Study

The 'Report on the Design Study of a 300 GeV Proton Synchrotron' (document CERN/563) was issued in November 1964. An Addendum (document CERN/702) to this Design Study was issued on 30 May as one of the up-to-date set of documents and relevant costs presented to the June Council Meeting.

In general, the 1964 study is still regarded as technically and economically sound and no reasons have emerged to change the main parameters of the design (which, in principle, resembles that of the existing 28 GeV proton synchrotron at CERN-Meyrin). Some of these parameters are given in the Table.

The Addendum is in three parts covering injection systems (where some of the major advances in accelerator technology over the past few years have been made), experimental exploitation (where the study group worked in close collaboration with the ECFA Working Group on utilization studies), and a revision of the time-schedule, manpower and costs.

In the initial Design Study, the injection system involved a 200 MeV linear accelerator feeding a 8 GeV 'booster' synchrotron, of 200 metres diameter, in turn feeding the main synchrotron ring. This design has now been superseded by three possibilities for the injection system. These are outlined in the Addendum :

a) A 60 MeV linear accelerator feeding a 600 MeV TART (Twin Accelerator Ring Transfer) feeding a 8 GeV booster synchrotron.

b) A 300 MeV linear accelerator feeding a 8 GeV booster synchrotron.

c) A 200 MeV linear accelerator feeding a twin ring 8 GeV booster synchrotron (100 metres in diameter).

No clear-cut best solution has emerged yet and the three systems remain under study.

Because of the rapid progress of subnuclear physics, the experimental exploitation of the 300 GeV machine has always been recognized as an area of machine design which needs to incorporate the maximum possible flexibility. Nevertheless, a more detailed study has been carried out to see if an experimental programme based on reasonable extrapolations of present knowledge might affect seriously the machine design, the specifications for the site of the Laboratory, or the cost estimates. These studies have covered representative experiments, beam-line designs and components, large detectors, detection techniques, provision for a 'by-pass' to the main ring structure, extraction problems, etc...

A new lay-out of the experimental areas has been proposed. Two areas, each fed by an extracted proton beam, will be built initially, and will probably be adequate for the first six years of experiments. One area would be mainly for counter and spark chamber experiments using relatively short beam lines of a few hundred metres. The second, situated about 3 kilometres from the accelerator, would be mainly for bubble chambers.

The final section of the Addendum updates the estimates of the time schedule for construction, the manpower, and the cost.

The revised time schedule is based on the hope that the fundamental decisions about the project will be taken at the end of 1967, that the site will be accessible mid-1968, that the project group can be set up at the same time and that building work can start mid-1969. If these dates are met, the physics programmes at the 300 GeV machine could start early in 1977.

The staff estimates during the construction period, remain the same as in the initial Design Study rising to a total of 2540 in 1976.

A definite cost-estimate can only be made after the site and project leaders have been chosen. The best estimate at present, covering construction and bringing into operation for physics of the 300 GeV accelerator, is a total cost of 1776 million Swiss Francs (at 1967 prices) spread over a period of ten years.

Main parameters of the 300 GeV proton synchrotron

1. General	
Proton energy	50-300 GeV
Max. proton intensity per pulse	3.3 x 10^{13} protons/pulse
Max. flat top length	0.7 s
Cycling time with max. flat top	3.3 s
Proton intensity with max. flat top	10^{13} protons/s
2. Main ring	
Diameter	2.4 km
Length of each straight section	55.8 m
No. of straight sections :	
for r. f. cavities	6
for injection	1
available for ejected beams	5
Max. guide field	1.2 Tesla
Injection energy	8 GeV
Vacuum chamber inside dimensions	100 mm horizontal x 60 mm vertical
Magnet weight : steel	25 000 ton
copper	2 100 ton
Magnet peak power	180 MW
Accelerating r. f. peak voltage/turn	13.4 MV
R. f. frequency	183 MHz
Peak r. f. power with full beam	7.2 MW

34th Session of CERN Council

The 34th Session of the CERN Council was held on 14 and 15 June under the Chairmanship of Dr. G. Funke.

Progress Report

The Director General, Professor B. Gregory, singled out a few significant experimental results from the research over the past six months.

One of the most interesting, and puzzling, recent results came from an experiment on large-angle proton-proton scattering. When high energy protons are directed onto a hydrogen target, the resulting scattered and recoil protons come off from the target predominently travelling in the direction of the incident beam. Very few emerge at large angles, up to 90° to the direction of the incident beam (in the centre-of-mass system) ; in other words the cross-section for large angle scattering is very low. However, using a slow ejected proton beam has produced a sufficient number of these events to make it possible to investigate this region. At a given momentum the cross-section falls off exponentially as the angle increases and this can be characterized by a scattering parameter. This parameter was determined at 20 GeV/c and then at progressively lower momenta. It became obvious that the results would not tie up easily with results previously obtained at much lower momenta at Berkeley. The momentum region (around 9 GeV/c) in between that covered at Berkeley and that covered at CERN was therefore investigated and revealed an anomaly in the behaviour of the cross-section.

Another experiment involving groups from CERN and Liverpool University, UK, using the hydrogen bubble chambers, found two resonances (one of them possibly identical with a resonance identified in a missing mass spectrometer experiment at CERN). They used antiproton beams of momenta 3 and 2.5 GeV/c and measured the annihilations with the protons in the chambers resulting in six observed pions (three positive and three negative). They were able to show that there are two resonances, at 1717 MeV and 1832 MeV, which decay into four pions.

A missing mass spectrometer experiment, which yields high precision in the measurement of particle mass, showed a two-peak structure for the A_2 meson, indicating that there are probably two separate particles in that mass region.

CERN/PI 399.5.67

The Director General also referred to the analysis of the decay of the eta meson into two charged pions and a gamma, which gave no evidence of the violation of charge symmetry in the electromagnetic interaction. (This was covered in CERN COURIER vol. 7 p. 45.)

A Conference, organized by the Weizmann Institute and CERN, held at Rehovoth in February, showed the great interest in nuclear structure research at present. About 90 % of the experiments on the 600 MeV synchro-cyclotron at CERN are now devoted to nuclear structure problems.

Improvement Programme and ISR

The improvement programme for the existing CERN facilities can be considered in two parts — that concerned with particle detection equipment and that concerned with the 28 GeV proton synchrotron itself.

Progress has been made this year on two items of future detection equipment. One is the very large hydrogen bubble chamber project (discussed separately below) ; the other is the item for electronics experiments. A working group has been set up to draw up the specification and to design a large magnetic spark-chamber. The aim is to set-up an array of spark chambers in a magnetic field of large volume. The project is known as the 'Omega project' and it is hoped to present a report from the working group by the end of the year.

On the proton synchrotron, the first phase to increase the repetition rate of the machine, is progressing well. The motor-alternator set of the new power supply for the main magnets has arrived at CERN and work on the new accelerating cavities has reached the stage where a model cavity has been installed in the synchrotron ring for tests.

The second phase to increase the intensity of the proton beam, involves a higher injection energy into the main synchrotron ring. Various ways of achieving this have been studied and attention has moved from the initial idea of building a linear injector of 200 MeV energy to replace the existing one of 50 MeV, to the construction of a slow-cycling synchrotron with an energy possibly as high as 800 MeV. This 'booster' is now conceived as

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Page 108 : Site work for the intersecting storage rings now at an advanced stage. Many tons of earth have been removed and excavation for the beam tunnel is about on third complete.

Left : Professor E. Amaldi, Chairman of the European Committee for Future Accelerators, photographed in the CERN Council Chamber.

four rings, of 50 metres diameter, stacked vertically one on top of the other.

It has emerged in the course of these studies and their inter-relation with the ISR project, that the 'luminosity' (which can be thought of as the number of charged particles that can be packed into a given beam size) in the proton synchrotron could probably be increased by a factor over ten. This would have great advantages for conventional operation of the synchrotron itself and particularly for the intersecting storage rings where, if the factor of over ten could be achieved in each of the colliding beams, the interaction rate could be increased by over a hundred. It is hoped that a report on the booster studies will be presented to the Council in December.

Construction of the intersecting storage rings is proceeding to schedule. The excavation work for the ring tunnel has reached the stage where about one third of it is complete. Several of the main items of equipment for the rings are now out to tender.

300 GeV Project

The Council received the Report of the European Committee for Future Accelerators (summarized on page 103). It was introduced by Professor Amaldi who again underlined that work on the Report had involved scientists from throughout Europe whose hard work and enthusiasm had been most impressive.

In the discussion that followed Professor Puppi, on behalf of the Scientific Policy Committee, said that Europe could now go ahead with reinforced confidence in the 300 GeV project from the points of view of the appropriateness of the machine itself and of the great interest of the physicists. Technically, scientifically and psychologically there were now no barriers to setting up the 300 GeV Laboratory.

Dr. J. B. Adams, a former Director General of CERN, drew attention to the rise in the cost of the experimental work per physicist over the next years which emerged from the ECFA model programme. This, on average, came to approximately 4 % per year which was no more than the sophistication factor that we had come to expect in this type of work. Implicit also in Report was the question of priorities and where there was a limitation on funds, these priorities needed to be established. Support for the 300 GeV project would seem to be essential if Europe was to continue in this field, which, in turn, implied that the home support for the international Laboratories should be maintained. This meant that if financial cuts had to be imposed these would need to come first from the national programmes.

Dr. W. Francis, speaking for the United Kingdom, said that Britisch nuclear physicists regarded the 300 GeV as of the first priority. But the rates of growth of manpower and costs envisaged in the ECFA Report were greater than the rates expected in the UK. The corollary of this was that if and when the 300 GeV came into operation the UK would have to give lower priority to participation in CERN-Meyrin and in their own national laboratories.

Prof. Perrin speaking for France went further by saying that whereas in France there was a national proposal for a 45 GeV accelerator, this would only make sense if the 300 GeV project went ahead. If for some reason, Europe decided not to proceed, then there would be little point in proceeding with the 45 GeV project because the only significant research would then be done in other Continents. The priority for France was first the 300 GeV project, second the support of CERN-Meyrin and third the national programme.

In reply to a question on the future of ECFA, Professor Amaldi said that many people had expressed the view that ECFA should continue to exist in some form. It would be important to have the utilization studies for the 300 GeV machine under continual revision to keep pace with developments in physics and technology. Other work, such as examining more data on national programmes could be useful. The best way of keeping ECFA active, if it is decided that this would be beneficial, will be discussed at a meeting later this year.

New Convention

In accordance with decisions taken at the Council Meeting in December 1966, formal preparation has been going on since the beginning of this year, on a new Convention which would accommodate CERN-Meyrin and the proposed 300 GeV Laboratory. This would enable the two Laboratories to operate under one Council, with common Scientific Policy and Finance Committees to look after the scientific programmes and expenditure at the two centres. Although it is hoped to achieve substantial common membership of the two Laboratories, the new Convention needs to safeguard the interests of participants in the various projects. Nevertheless, since the existing Convention has functioned so well, as few changes as possible are being made.

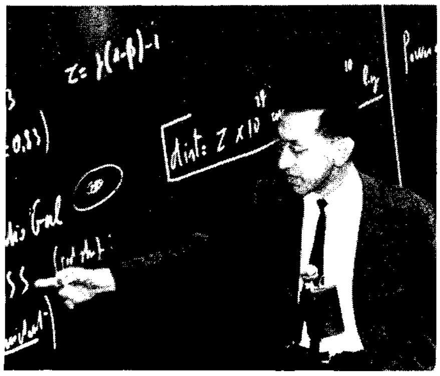
There was a long discussion on the draft new Convention and related documents. The drafting committee arranged to meet in Stockholm on 28 June to go through the Convention again taking into account the views expressed at the Council Meeting. Any Member State, wishing to do so, could send legal experts to this meeting of the drafting committee. It is hoped that a final version of the new Convention will be ready for presentation to the special Council Meeting in September, and that Governments will be able to take a decision on the Convention in December.

Sites

Further information on the studies being carried out on nine possible sites for the 300 GeV Laboratory offered by Member States were presented in two volumes 'Sites for the Proposed CERN 300 GeV Proton Synchrotron' (document CERN/644/Rev. Vol. 1 and Vol. 2). The nine sites under investigation are

Austria	Göpfritz
Belgium	Focant
Federal Republic of Germany	Drensteinfurt

1 CERN/PI 40.4.66



2 CERN/PI 183.2.67

1. Professor Wolfgang Paul who relinquishes his post as Director of the Physics I Department to return to Bonn University.

2. Professor Giuseppe Cocconi, who succeds Professor Paul, lecturing at CERN on one of his favourite topics - astrophysics.

France	Le Luc
Greece	Aspropyrgos
Italy	Doberdo
Spain	El Escorial
Sweden	Uppsala
United Kingdom	Mundford

The first volume was assembled by the CERN Study Group and contains general information and comparative tables on the various sites. It covers data such as geographical location, available area, topography, nature of terrain and seismic activity of the region, water and electricity supplies, and accessibility. The aspects which would concern personnel were also investigated, such as climate, recreation, housing, educational facilities, and proximity of nearest towns. These last are also important with regard to the availability of local man-power and industry.

The second volume was compiled by geological and geotechnical experts from the respective Member States and gives technical details of the sites.

Several speakers at the Council Meeting emphasized that it is still too early to make judgements at this stage on the respective merits of the sites. The Working Group (Mr. J. H. Bannier, Mr. A. Chavanne and Professor J. K. Bøggild, all from countries not offering a site) set up at the last Council Meeting to study the Site Reports and the problem of site selection, will give their views on the various proposals probably at the Council Meeting in December, at the same time presenting the report of Dr. Bjerrum, the consultant geologist. The final decision on the site will therefore not be taken until 1968.

Serpukhov collaboration

The Council authorized the Director General to sign an agreement with the USSR State Committee for the Utilization of Atomic Energy along the lines of a draft Convention which has been prepared by representatives of CERN and the Soviet Union. Some points of detail have still to be cleared with the Soviet authorities but it is hoped that the agreement can be signed in the very near future.

The agreement concerns collaboration at the 70 GeV proton synchrotron which is nearing completion at the Serpukhov Laboratory. It will give European scientists access to what will be for several years the highest energy accelerator in the world. More information about this collaboration will be given probably in the July issue of CERN COURIER.

Large Hydrogen Chamber

An agreement concerning the construction of a very large hydrogen bubble chamber was authorized by the Council. The chamber which has a diameter of 3.5 metres, will be built as a joint project by CERN, France and the Federal Republic of Germany. It is scheduled to cost 84 million Swiss Francs, the finance being provided equally by the three partners. A steering committee with one representative from each party will supervise the project.

This new chamber is one of the major elements of the improvements programme at the CERN proton synchrotron. It will be described in detail in an article in the August issue of CERN COURIER.

The Council expressed its gratitude to France and Germany for their willingness to make this extra, important contribution to the future of European physics at CERN.

Appointments

Professor G. Cocconi was appointed Director of the Physics I Department for the next three years in succession to Professor W. Paul.

Professor Wolfgang Paul had expressed the wish to return to the Federal Republic of Germany to direct the Physics Institute at Bonn University. He has been at CERN since 1964, first as joint Head of the Nuclear Physics Division and then, following the internal reorganization in June 1966, as Director of the Physics I Department. He will remain in close contact with CERN by virtue of his position as Chairman of the Electronic Experiments Committee (the committee which prepares the programme of experiments using counters and spark chambers for the proton synchrotron).

The Council expressed its thanks to Professor Paul for the contribution he has made to the work of CERN during the past three years. During this time the programme of electronics experiments has greatly increased in importance and has involved, for the first time, extensive collaboration with other Laboratories and universities throughout Europe.

Wolfgang Paul has been Professor at Bonn University since 1952. It was there that in 1958, he lead the work on a small electron synchrotron (500 MeV) which was the first machine in Europe to operate using the strong focusing or alternating gradient principle to achieve beam focusing. He has also played a leading role in the project for a 2.5 GeV electron synchrotron at Bonn which came into operation in March of this year.

Professor Giuseppe Cocconi joined CERN in 1963, though he was here previously for two years in 1959-60. He has been active in sub-nuclear physics research for many years, both in Europe and in the United States. His particular interest is the study of strong interactions and, for example, he led the team which carried out the important experiment on large-angle proton-proton scattering referred to in the Director General's progress report to the Council.

CERN News

Quark hunt continues

A further search for the hypothetical particles, called quarks, whose existence could be the underlying reason for the regularities in the list of particles we have now identified, was reported by a team from CERN in Nuovo Cimento on 1 May. The CERN-Bologna team consisted of A. Buhler-Broglin, G. Fortunato, T. Massam and A. Zichichi.

The significant feature of the quarks, whereby it could be possible to pluck them out from the rest of matter, is that they carry fractional electric charges — less than the unit of elementary charge, the charge on the electron, e. The three types of quark needed to build up the observed particles have charges + 2/3, — 1/3 and — 1/3 e. The same experimental team have already set upper limits for the existence of quarks in the cosmic radiation with charge ± 1/3 and ± 2/3 e (see CERN COURIER vol. 6 p. 178).

Combinations of any two quarks might have mass-values considerably lower than a single quark. The nucleon is considered to be made of three quarks and is very light. These two-quark states would have charge values of + 1/3, + 1/3, — 2/3 and + 4/3 e. Limits for the first three possibilites have therefore already been checked by the previous experiment and the latest experiment was concerned with the search for the combination carrying charge 4/3 e. As in their first search, the team used a vertical telescope consisting of six plastic scintillation counters and two spark chambers, with the addition of an iron shield 0.8 m thick over the top of the telescope in an attempt to filter out other charged particles. The electronics were arranged to distinguish particles of charge 4/3 e and the limitation in the experiment came primarily from the pulse-height resolution of the counter electronics system.

Four counts were recorded which was consistent with the expected background (where a particle with unit charge simulates a particle with charge 4/3 e in the counters) and the upper limit for the existence of charges ± 4/3 e in the cosmic radiation was calculated as 1.6 ± 0.8 x 10^{-7}/cm^2/steradian/second.

Another paper on the search for quarks originating in the cosmic radiation appeared in Nature, 15 April, entitled 'A quark albedo' by M.R.C. McDowell (Durham) and J. B. Halstead (University College London). They maintain that quarks from the cosmic radiation are likely to combine with heavy elements on land or oxygen in the sea. The resulting charged atoms would tend to collect either in the ionosphere (drawn there by the electric fields) or on the continental shelf (where the top few metres of the earth's surface, which catches the quarks, is comparatively rapidly deposited). They therefore suggest that the search for quarks from the cosmic radiation should concentrate in these regions, using rockets to bring down samples of air from a height of 50 km or more and digging samples from the sea-bed. These samples could then be analysed by a mass-spectrometer.

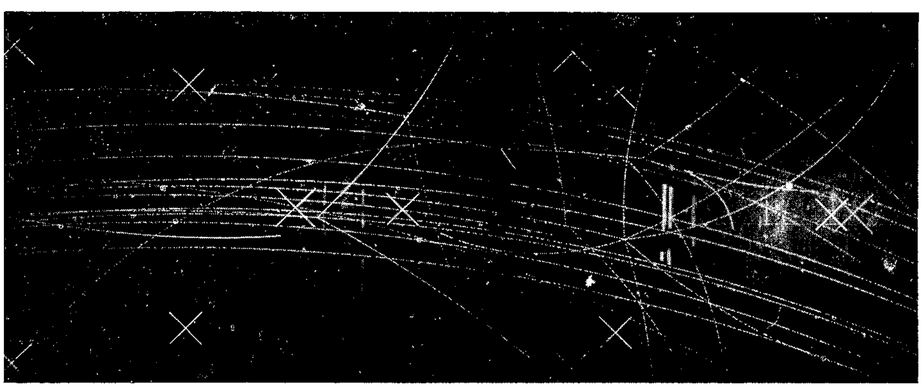
A scientist has remarked that quarks may be found inside oysters because they concentrate heavy elements from seawater. This presents the possibility of a very interesting experiment for the gourmet physicist.

Further culinary comment on quarks appeared in letters in 'Science' a few months ago. It was pointed out that quark is German for 'a somewhat gluey cottage cheese'. In Goethe's 'Faust', Mephistopheles commented on man's insatiable curiosity 'In jeden Quark begräbt er seine Nase' (He sticks his nose in every quark).

Bubble Chamber Conference

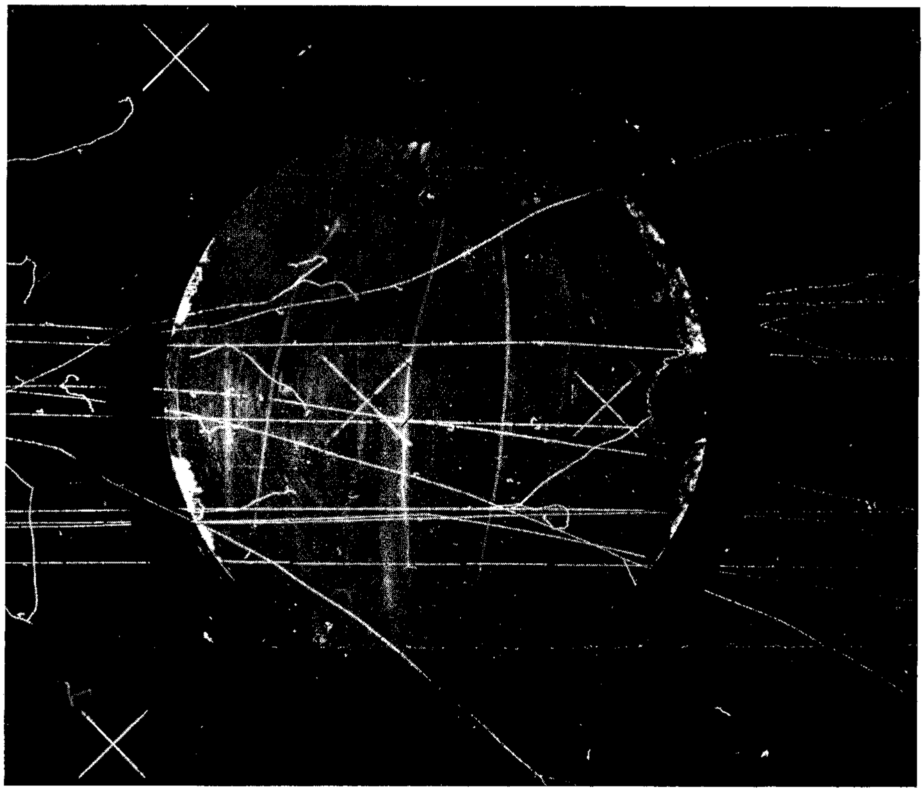
An international conference on the technical problems associated with the construction of large bubble chambers was held at Heidelberg, Federal Republic of Germany, on 13 -16 April. More than 150 scientists and engineers working with bubble chambers in the Soviet Union, United States and Europe attended the Conference which was organized by the Institut für Hochenergiephysik der Universität Heidelberg and the Study Group for the large hydrogen chamber at CERN. It was the first international conference ever held devoted entirely to bubble chambers.

The purpose of the conference was to pool the thinking of the many accelerator Laboratories who are now concerning themselves with the problems of the next generation of bubble chambers. More than forty papers were presented on the physics requirements and technical problems in five sessions : physics aspects (including consideration of what would be needed when accelerators of energies up to 300 GeV are available), present and future projects, optical and magnet systems, thermodynamics, and engineering and instrumentation.



The 81 centimetre hydrogen bubble chamber took its 9 millionth photograph (right) on 19 June. The photograph is of antiprotons of momenta 700 MeV/c being annihilated in the chamber.

A photograph taken on the 85 centimetre bubble chamber at DESY on 23 May. Tracks inside the ring are in pure hydrogen photographed through a thin Mylar window ; tracks outside are in a more dense hydrogen-neon mixture.



Advance in bubble chamber technique

One of the ideas discussed at the Heidelberg conference was the use of a 'bubble chamber within a bubble chamber'. This idea which may overcome some of the limitations of existing chambers is being tested at DESY and at CERN with every indication of success.

The most common bubble chamber liquid is hydrogen. It presents the simplest possible target, the isolated protons at the nuclei of the hydrogen atoms, to the incoming beams which greatly simplifies the analysis of the resulting interactions. However, in hydrogen, the path-lengths of gammas which emerge from the inter-troublesome for the detection of neutral pions which themselves leave no track in the chamber liquid and gammas arising from their decay can often escape from the chamber volume before converting to electron-positron pairs which make it possible to identify them. In chambers filled with heavy liquids (such as propane or freon), the path-lengths are much shorter but the target nucleus is then complex and Coulomb scattering of the particles emerging from an interaction by the multi-charged nuclei results in less preci semomentum measurements.

A fairly obvious compromise would be to set up a hydrogen filled target surrounded by a more dense liquid to retain the simple target and, overall, to reduce path-lengths. The problem was to find some way of doing this without the complication of having effectively two bubble chambers with separate expansion systems, etc...

In March 1966, H. Leutz, working at CERN in the study group for the large hydrogen chamber suggested a scheme whereby a target volume of hydrogen would be set up, separately enclosed, inside a chamber filled with a mixture of neon and hydrogen. Thin, transparent Mylar windows would make it possible to photograph both volumes with the same optical system and, more importantly, make it possible to transmit the pressure changes in the main volume to the hydrogen via the Mylar windows.

In cooperation with DESY, simple enclosures to provide the hydrogen target have been built. Some pictures were taken at CERN in the 81 cm. chamber filled with hydrogen early in April using a radioactive source to provide the incoming particles. The first pictures with a beam were taken at DESY on 23 May in the 85 cm chamber, with hydrogen in the target and a hydrogen — neon mixture in the main chamber volume.

The implications of this development for the big chambers, which are now on the drawing boards, are under consideration. For example, for the very large hydrogen chamber of 3.5 metres diameter, which was authorized at the June Council Meeting as a joint project between CERN, France and the Federal Republic of Germany, it may be decided to have a facility for installing a 1 metre diameter hydrogen target volume. This could replace the initial proposal to introduce thin lead plates into the chamber to convert neutral particles into charged particles.

Much work remains to be done to perfect the idea in practice but the work at CERN and DESY gives good reason far believing that the scheme will work.

Computers

An IBM 360/30 computer arrived at CERN in June to be used in administrative services. The use of this computer is seen as a long-term solution covering foreseeable requirements into the 1970s. It has become known as the ADP project (Administrative Data Processing).

An IBM 360/44 as an on-line computer for physics experiments is scheduled to be delivered in July. It is capable of accepting large quantities of data at high speed, and performing a considerable amount of computation to pass results immediately to experimentors or to store them for future reference. This computer is particularly appropriate for the increasing number of experiments likely to use large wire spark chamber arrays, which are capable of collecting a great deal of information during one pulse of the accelerator.

1. Professor Linus Pauling, holder of the Nobel Prize for Chemistry and the Nobel Prize for Peace, gave a colloquium at CERN, on 1 June.

2. Science journalists visiting the site of the intersecting storage rings during a Press Day on 2 June.

3. A group of lecturers and students at the 1967 CERN School. Left to right N.C. Mukherjee, Professor B. Gregory (Director General of CERN), D. Lê, Miss L. Bergamasco, Prof. G. Ekspong (Chairman of the organizing committee of the School), Dr. G. Funke (President of the CERN Council), P. Kitching. (Photo : K. G. Svensson)

1 CERN/PI 414.5.67

2 CERN/PI 405.5.67

The CDC 6400, the second large general-purpose computer which arrived at the end of March, is being used for development of the next operating system prior to gradually being brought into full operation. Brookhaven National Laboratory, USA, received its second CDC 6600 in April and their two big computers will eventually be linked with a million-word core store which is scheduled to be delivered later this year. The Laboratory is also developing a 'Brookhaven Digital Communications Network' to give direct access to the main computers from a number of remote access points. A similar development project, called FOCUS, has been started at CERN.

CERN School

The 1967 CERN School of Physics was held from 21 May to 3 June at Rattvik, Sweden, on the shores of Lake Siljan. It was attended by 83 students from 20 countries.

The School was opened by Dr. G. Funke, the President of the CERN Council who is also Secretary General of the Swedish Atomic Research Council. The main lecture courses were given by Professor G. Goldhaber (Berkeley), Professor M. Veltmann (Utrecht), Professor J. Nilsson (Gothenberg) and Professor B. Svensson (Lund). Professor B. Gregory, Director General of CERN attended the opening ceremony and gave an evening seminar on the experimental programme at the CERN proton synchrotron. Other speakers from CERN were Dr. M. Vivargent and Dr. M. Jacob.

3

Visit

On 13 June several senior politicians from Belgium visited CERN, including Mr. J. Van Offelen (Minister for Economic Affairs), Mr. M. Toussaint (Minister for Education) and Mr. R. Gruslin (Governor of the Province of Namur). They were welcomed by Mr. J. Willems, Belgian representative at the CERN Council, and by Professor L. Van Hove, Director of the Theoretical Physics Department.
After a talk on the work of CERN by Professor Van Hove, the visitors toured the site. The visit concluded with a discussion of the implications for a country if the 300-GeV Laboratory is set up on its territory. Belgium has put forward a site at Focant in the Province of Namur.

Conferences

The International School of Physics 'Ettore Majorana' is being held at Erice in Sicily from 1 - 14 July. The theme of the school this year is 'Advances in Particles Physics'. More than 100 physicists from 39 countries are enrolled. A. Zichichi from Bologna University and CERN, is Director of the School and the lecturers include N. Cabbibo, C. Franzinetti and B. Gregory from CERN.

The second International Conference on Magnet Technology will be held in Oxford, UK, from 11 - 13 July. The Conference is being organized by the Rutherford Laboratory. Nearly 300 participants from 19 countries will attend including many scientists and engineers from CERN.

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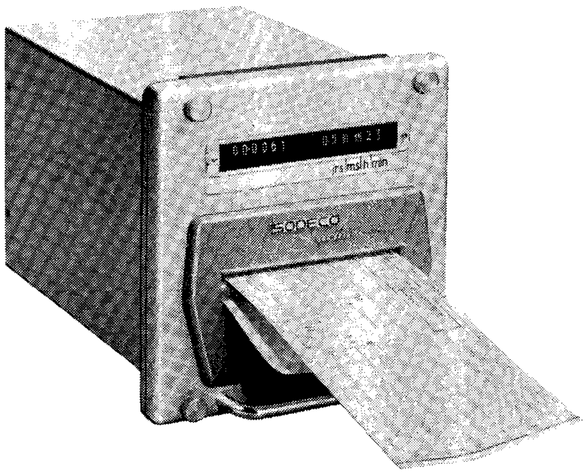

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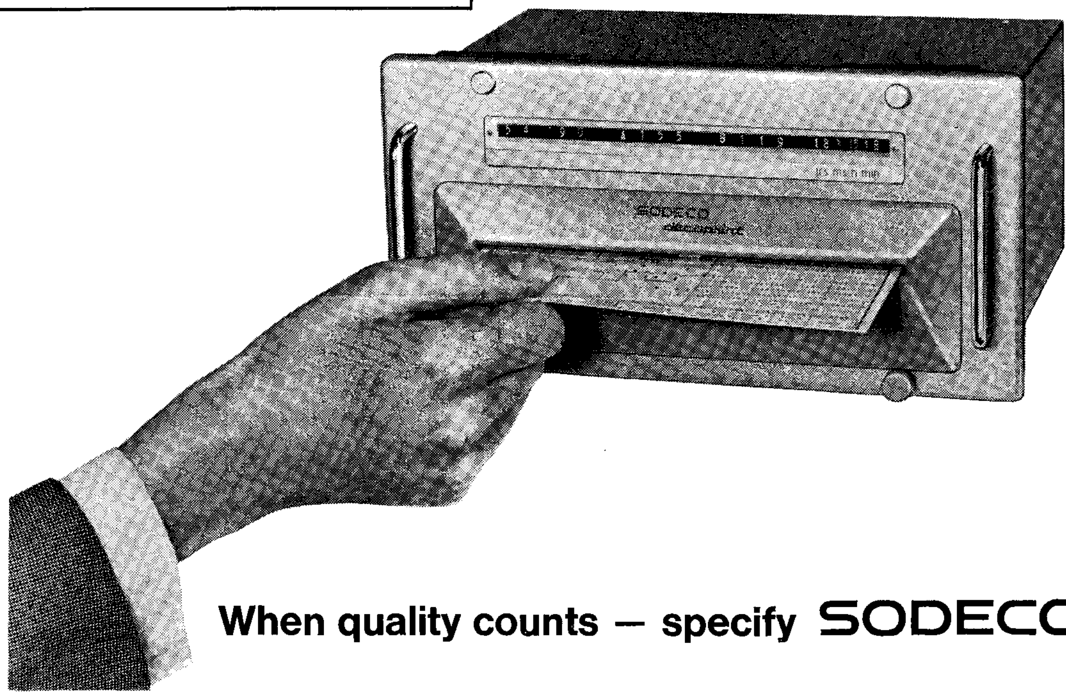

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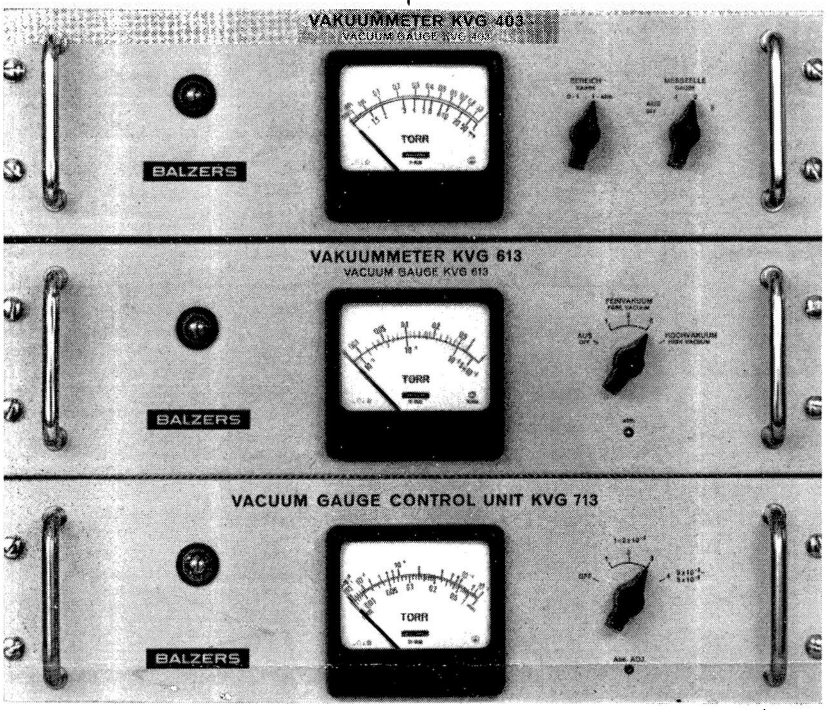

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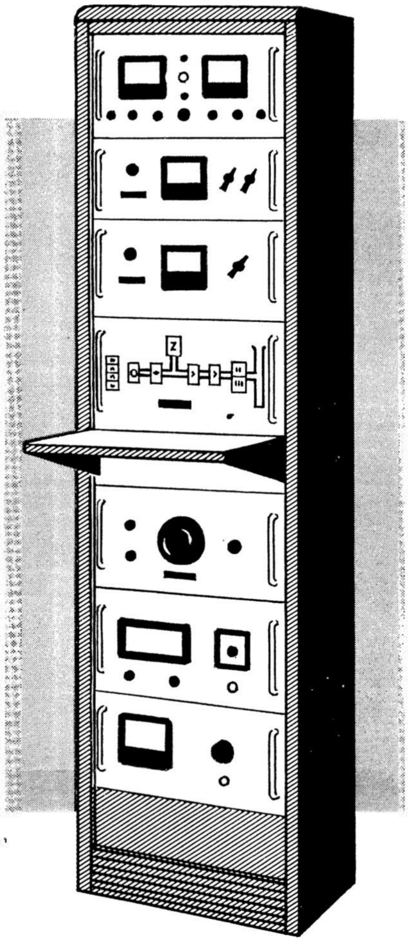

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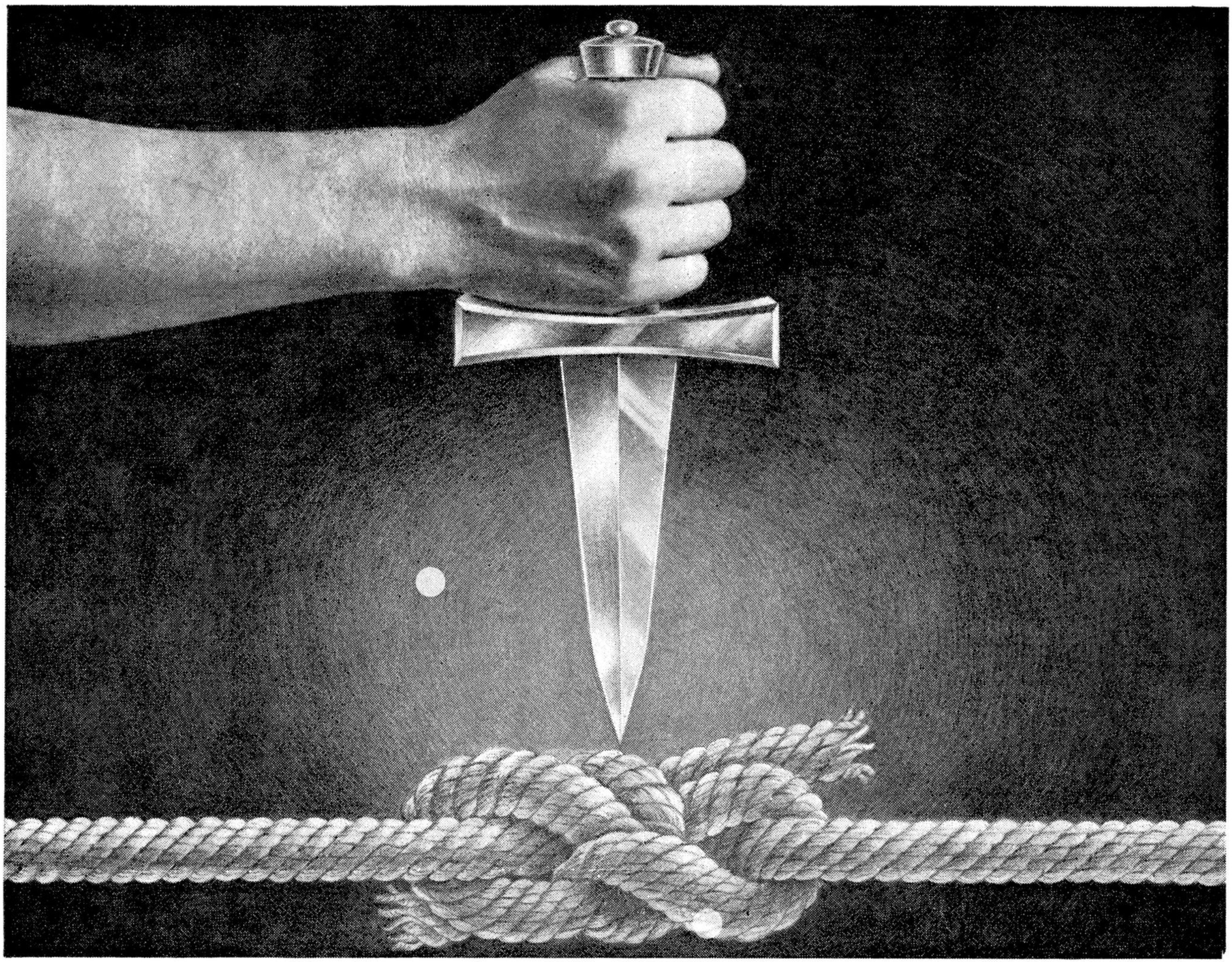

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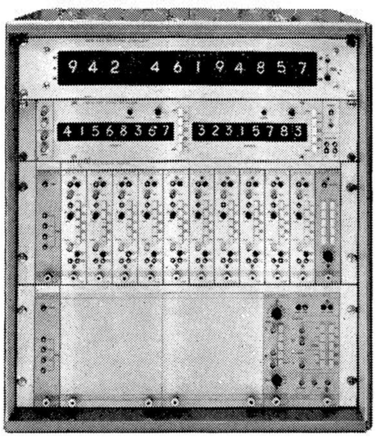

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