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25TH ANNIVERSARY ISSUE

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Around the Laboratories

Cover photograph: On 29 October 1953, CERN Council members meeting in Geneva visited the very rural site at Meyrin which was to accommodate the proposed Laboratory of the European Organization for Nuclear Research. Earlier in the year the establishment of the Laboratory on this site had successfully passed a referendum in the Canton of Geneva by 16 539 votes to 7332. (Photo Freddy Bertrand)

This issue celebrates the 25th anniversary of CERN, which came formally into being on 29 September 1954 when sufficient ratifications of the Convention establishing the European Organization for Nuclear Research were obtained from Member States. This was the start of a great adventure in scientific research and international collaboration.

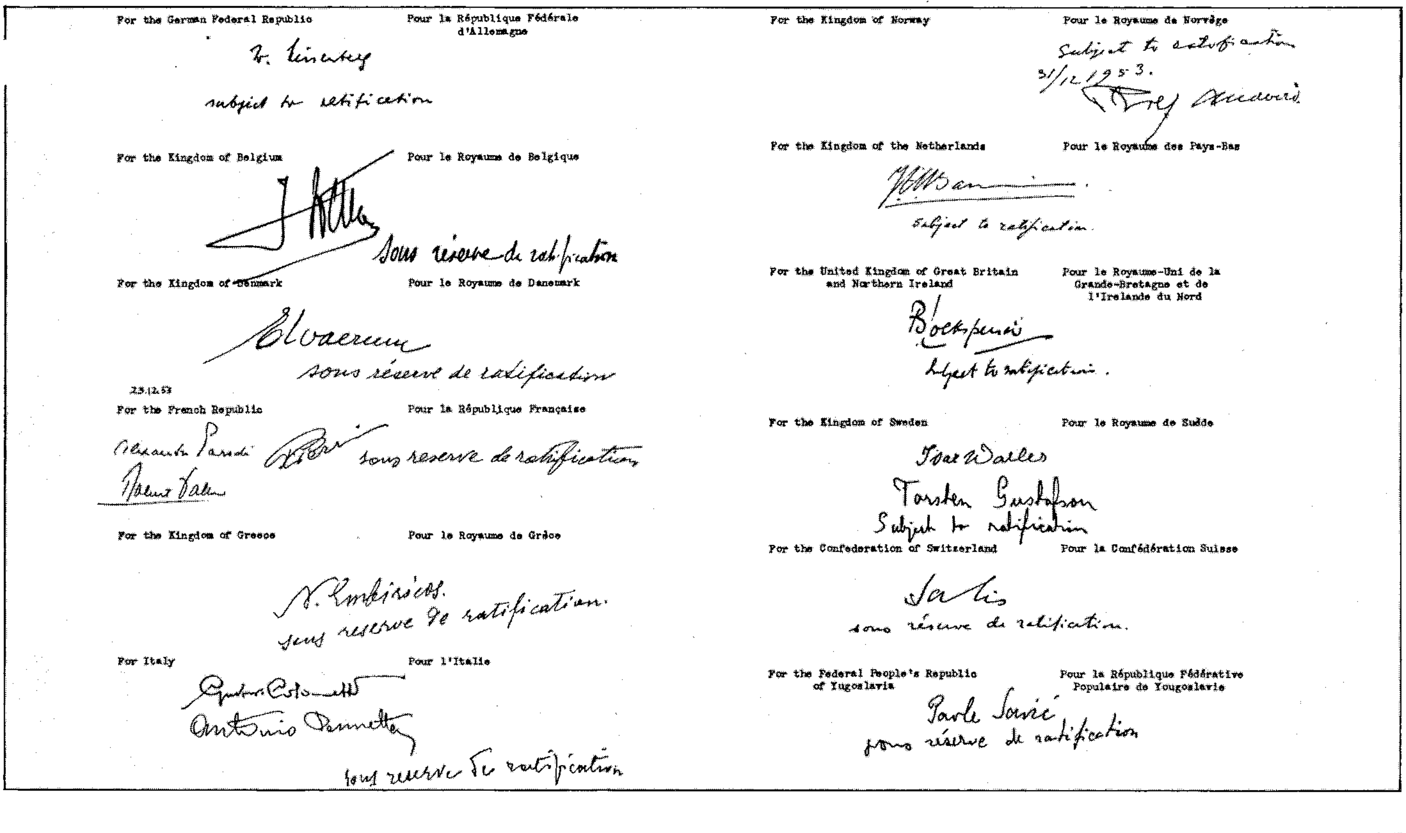
CERN was conceived to help restore the quality of European science, to provide research facilities beyond the means of individual countries and to help reunite nations, not long before torn by conflict, in the common pursuit of understanding the structure of matter.

In the past twenty-five years, these hopes have been fulfilled beyond the expectations of any of CERN's creators. From experiments at CERN's accelerators and storage rings, Europe's scientists have contributed greatly to our knowledge of the nature of matter. The CERN Laboratory now has an unequalled range of research facilities, which is able to support the experiments in which some 1500 scientists from the Member States are involved. It puts European high energy physics research on a par with that in any other region of the world.

CERN itself is held up as a shining example of international cooperation, not only with regard to collaboration within Europe itself but also in the development of excellent relations with other countries throughout the world.

Our opening article 'A brief history of CERN' concentrates particularly on the development of CERN's research facilities. The physics achievements are touched on in the second article in extracts from the talk of Professor Weisskopf at the 25th Anniversary Ceremony (page 233) and reviewed in more detail by Professor Van Hove in the third article covering the CERN Day at the European Physical Society Conference (page 239). The technological achievements were the subject of Professor Casimir's talk at the Anniversary Ceremony (page 236) and are presented in an Exhibition which is open at CERN (page 242) throughout the summer months.

The Convention establishing the European Organization for Nuclear Research was signed by the representatives of twelve European countries at a meeting in Paris in 1953. By September 1954 enough ratifications had been received for CERN to come formally into being.



For the German Federal Republic
Pour la République Fédérale d'Allemagne

subject to ratification

For the Kingdom of Belgium
Pour le Royaume de Belgique

Sous réserve de ratification

For the Kingdom of Denmark
Pour le Royaume de Danemark

sous réserve de ratification

23.12.53
For the French Republic
Pour la République Française

Alexandre Parodi
sous reserve de ratification
Robert Valeur

For the Kingdom of Greece
Pour le Royaume de Grèce

sous reserve de ratification.

For Italy
Pour l'Italie

Antonio Pennetta
sous reserve de ratification

For the Kingdom of Norway
Pour le Royaume de Norvège

Subject to ratification
31/12 1953.

For the Kingdom of the Netherlands
Pour le Royaume des Pays-Bas

Subject to ratification.

For the United Kingdom of Great Britain and Northern Ireland
Pour le Royaume-Uni de la Grande-Bretagne et de l'Irelande du Nord

Subject to ratification.

For the Kingdom of Sweden
Pour le Royaume de Suède

Torsten Gustafson
Subject to ratification

For the Confederation of Switzerland
Pour la Confédération Suisse

sous réserve de ratification.

For the Federal People's Republic of Yugoslavia
Pour la République Fédérative Populaire de Yougoslavie

Pavle Savić
sous réserve de ratification

A brief history of CERN

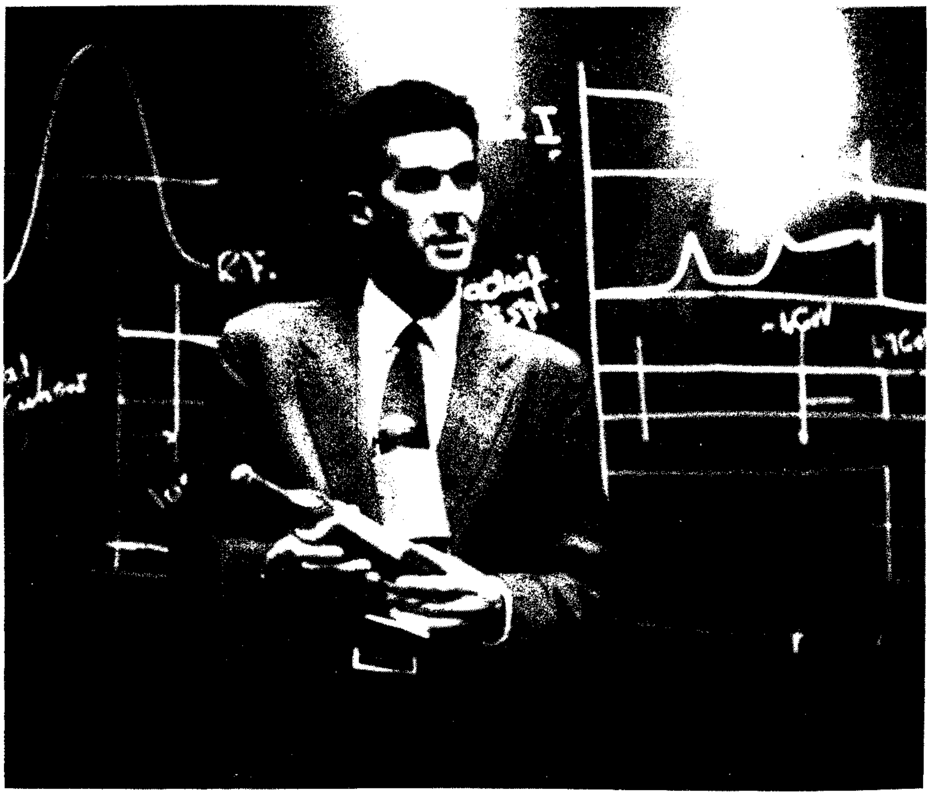
Although scientists had been discussing the possibility of a European physics laboratory for some years, the idea was first voiced publicly in a message from the French physicist Louis de Broglie to the European Cultural Conference in Lausanne in December 1949. Scientists were becoming increasingly aware that further progress in physics required resources beyond those of individual European nations, while statesmen were eager to promote worthy projects which symbolized the new spirit of European unity.

With the help of UNESCO, a series of conferences in 1950 and 1951 paved the way for the establishment of an international nuclear physics laboratory. In Geneva in February 1952, eleven governments signed an agreement setting up a provisional 'Conseil Européen pour la Recherche Nucléaire' — hence the acronym CERN, which has been retained ever since. Later in the same year, an offer from Switzerland to provide a site near Geneva for the Laboratory was accepted.

By the beginning of 1955, the Convention establishing the Organization had been ratified by twelve Member States — Belgium, Denmark, the Federal Republic of Germany, France, Greece, Italy, the Netherlands, Norway, Sweden, Switzerland, the United Kingdom and Yugoslavia. Austria joined in 1959 and Spain was temporarily a member from 1961 to 1969 but had to withdraw, as also did Yugoslavia

In June 1955 Felix Bloch, CERN's first Director General, laid the Foundation stone of the Laboratory watched by Max Petitpierre, President of the Swiss Confederation.

(Photo CERN 02.6.55)

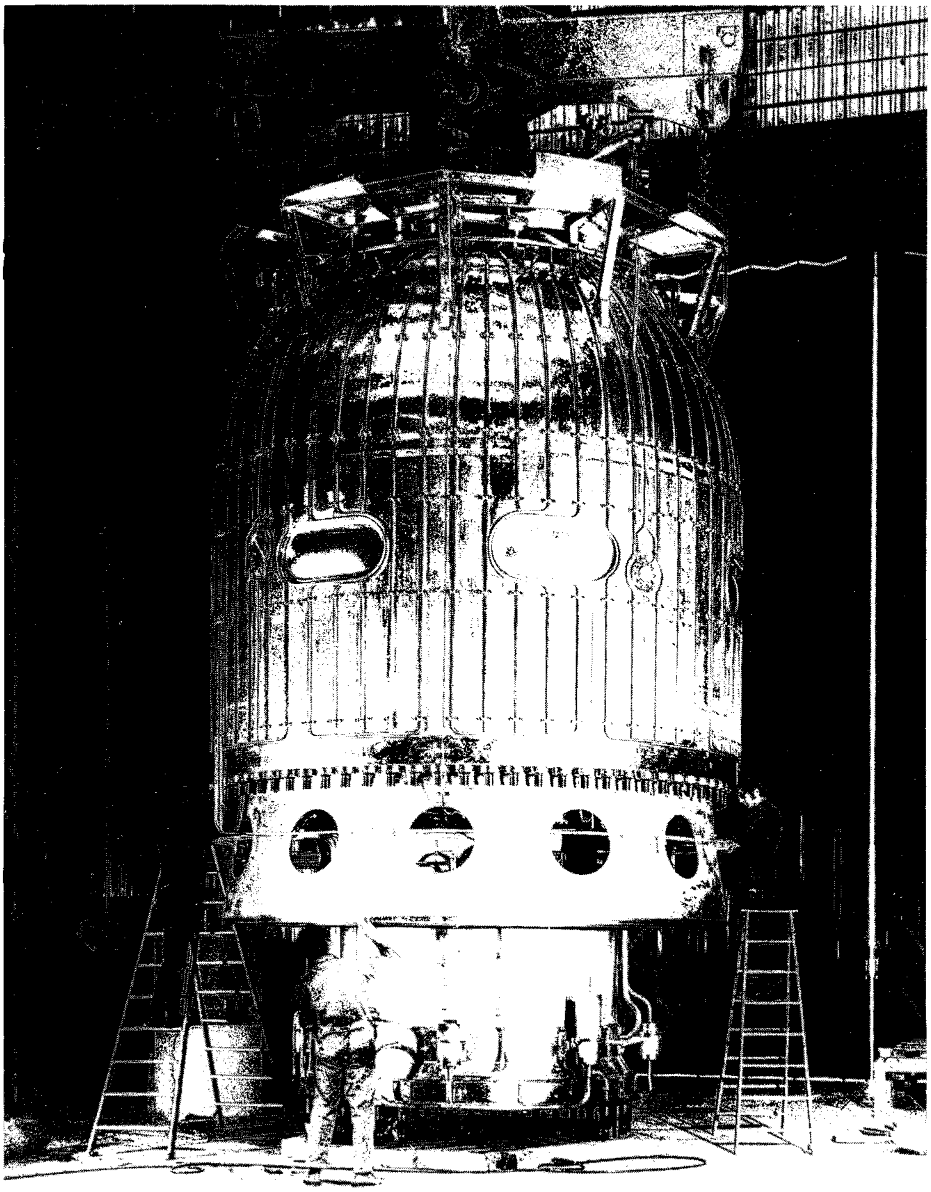


John Adams announced the first operation of the proton synchrotron in November 1959. He is holding an empty vodka bottle into which he fed a polaroid photograph of the 24 GeV pulse, to be sent to the Soviet Union. The vodka had been supplied by Dubna to be drunk when the world record energy of their 10 GeV synchro-phasotron was surpassed.

(Photo CERN 1881E)

The chamber of the 3.7 m European bubble chamber being prepared for installation in 1971.

(Photo CERN 216.12.71)



in 1962, for financial reasons. Yugoslavia, Poland and Turkey have the status of observer.

The first accelerators — the SC and PS

At an early stage, it was decided that CERN should build an ambitious proton synchrotron using the very latest developments in accelerator technology. At the same time, construction of a smaller, less powerful machine was launched to allow a research programme to get under way as soon as possible and to provide some experience of accelerator building by a European collaboration.

Excavations began on the Geneva site in May 1954, with a view to accommodating a 600 MeV synchro-cyclotron and a 25 GeV proton synchrotron with all their experimental and administrative support facilities. The synchro-cyclotron came into operation on 1 August 1957.

With construction of the proton synchrotron well under way in 1958, attention turned to the provision of adequate experimental facilities to complement the power of the big machine. Work began on the new experimental technique of bubble chambers and the first in a long line of increasingly powerful computers appeared on the CERN site.

On 24 November 1959, the proton synchrotron reached an energy of 24 GeV. This was a proud day for European science. It was the first proton machine of its type (using the strong focusing principle) to operate and was for a time the most powerful particle accelerator in the world.

In 1961 the first attempts at experiments using neutrino beams began; this field of research eventually became a speciality of the physics programme at CERN. To monitor the interactions of these elusive particles required special detectors; large arrays of spark chambers and heavy liquid bubble chambers were developed, and the first ever bubble chamber pictures of neutrino interactions were taken at CERN in 1963. The neutrino physics benefitted greatly from fast ejection of protons from the synchrotron, also achieved for the first time ever in 1963.

While the performance of the accelerators was being steadily improved and the physics programme was yielding many good results, the detection techniques used to study the behaviour of the particles and the computer power needed to analyse the collected information were advancing considerably. Several bubble chambers were in use at the proton synchrotron, and to meet its computing needs CERN had to develop one of the largest computer centres in the world.

Bubble chamber techniques were being thoroughly mastered. In 1965 an agreement was signed between CERN and the French Atomic Energy Authority to build a very large heavy liquid bubble chamber, which became known as Gargamelle. In 1967 another agreement, this time between CERN, France and the Federal Republic of Germany, covered construction of a very large hydrogen bubble chamber, which became known as BEBC — Big European Bubble Chamber. Both these detectors were initially destined for operation at the proton synchrotron.

There were also many advances in the domain of electronic detectors and the most important involving the properties of multiwire proportional chambers and drift chambers. They are able to give information about particles which traverse them with a precision and at a rate never obtainable in a single device before. Detectors of this type are now in use in high energy physics Laboratories throughout the world and are also finding extensive application in medicine, biology, solid state physics, etc.

The 600 MeV synchro-cyclotron and the 28 GeV proton synchrotron, on which the early research at CERN was based, are still in very productive use today. The synchro-cyclotron was largely rebuilt in the early 1970s to produce higher proton beam intensities so that it could remain competitive for physics experiments with other modern machines in its energy range. It is the scene of many experiments in the field of nuclear physics and, since 1967, has had one of the world's finest facilities for the study of very short-lived nuclei — the Isotope Separator On-Line (ISOLDE). In 1978 the research was further extended when helium ions were accelerated in the machine, and the use of carbon ions is planned.

The proton synchrotron has seen many modifications and additions. A four-ring 800 MeV Booster was completed in 1972 to increase the injection energy and a new 50 MeV linac started operation in 1978. The machine has exceeded its design intensity by more than a factor of a thousand. Its reliability in operation, for such a complex accelerator system, is exceptionally good. It has provided particles to hundreds of experiments in its own range of energies and it is now the source of all the protons used in the higher energy machines at CERN — the Intersecting Storage Rings and the Super Proton Synchrotron. It is also a vital component of the new project to collide proton and antiproton beams at high energies.

In January 1971, Kjell Johnsen announced in the control room of the Intersecting Storage Rings that proton-proton interactions in colliding beams had been seen for the first time.

(Photo CERN 248.1.71)

The ISR and SPS

It became evident, following the operation of the proton synchrotron, that the information gained about the nature of matter in the newly accessible energy range posed further questions which called for still higher energies to attempt to answer them. To obtain a consensus in the European community as to the best way to develop CERN's research facilities, a 'European Committee for Future Accelerators' was set up. In 1963 ECFA recommended the construction of a 300 GeV proton synchrotron and of Intersecting Storage Rings (ISR).

In 1965 CERN Council authorized a supplementary programme for the construction of the ISR to enable two 25 GeV proton beams to be brought into collision. That same year the French government agreed to make available to the Organiza-

Inauguration ceremony for the 400 GeV proton synchrotron, the SPS, in May 1977 which was held a huge experimental hall on the North Area.

(Photo CERN 4.5.77)

tion an area of land adjoining the itial CERN Laboratory in Switzerland for the construction of the new machine which was to be fed with protons from the existing proton synchrotron. Thus CERN became the first international organization which crossed a frontier physically as well as in spirit.

The Intersecting Storage Rings came into operation in 1971 with remarkable smoothness, in advance of the schedule and within the authorized budget. The machine was a daring one when it was conceived but so thoroughly was the construction executed that the ISR is widely regarded as the most perfect example to date of the accelerator builder's art.

Though the study of particles in the ISR was for a long time limited to the interaction between two protons, it has the great advantage of observing head-on collisions where the energy available to produce phenomena of interest is equivalent to that at a conventional synchrotron of 2000 GeV.

Performance of the Intersecting Storage Rings has far exceeded the design parameters. The machine is so perfect and reliable that usable proton beams can circulate for many days without need for refilling. In the future it is intended to store antiprotons in one of the rings so as to resurvey the ISR energy region, this time with proton-antiproton collisions.

Authorization to build a 300 GeV proton synchrotron took a long time to obtain, mainly because of difficulties in site selection and in cost. Finally a decision was taken in February 1971 to construct the new Laboratory alongside the existing one. Although at first administratively separate, the two Laboratories were united in January 1976.

The accelerator, which became known as the Super Proton Synchrotron or SPS, began operation in June 1976 at an energy of 400 GeV. As with the ISR, the building of the machine was completed ahead of schedule and within the authorized budget. The accelerator performance improved rapidly so that design intensity has been exceeded and at the end of 1978 the peak energy was taken to 500 GeV. The SPS thus joined the machine at the Fermi National Accelerator Laboratory as the highest energy proton synchrotron in the world.

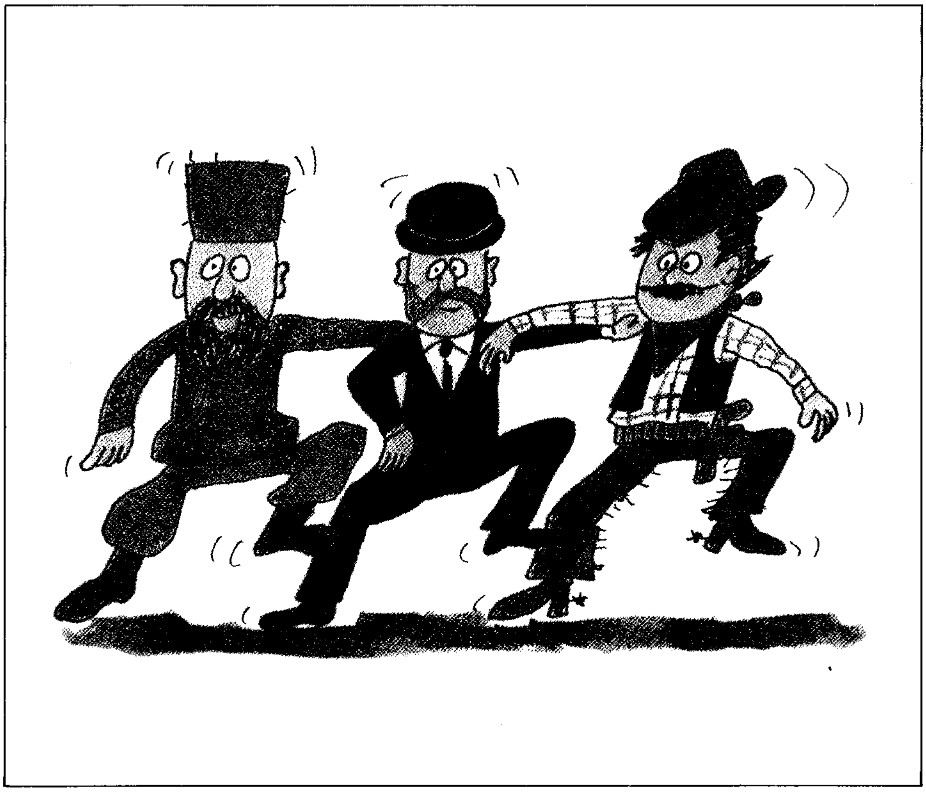
Planning for experiments at the SPS started under the auspices of ECFA in 1972 and sophisticated detection systems were ready to receive particles very soon after the machine came into operation. Careful design of the beamlines from the machine has resulted in beams of the highest energy, intensity and quality ever achieved.

Experiments at the SPS are now by far the largest part of the CERN research programme. Three large experimental halls are being supplied with beams and another is under construction to receive very intense beams, while four detection systems, including the large bubble chamber BEBC, are lined up in series to receive neutrino beams. There is every hope for a continued rich crop of results from these experiments in the coming years.

International collaboration

International collaboration is the lifeblood of CERN. The success and development of the Organization and its Laboratories over the past 25 years reflects both the need for and the usefulness of international partnership in high energy physics, where experiments require considerable resources in equipment and

Artist's view of CERN's role in international collaboration — it is taken from the cartoon album on CERN and its work 'Hunting Particles'.



manpower, and where a continual exchange of ideas provides valuable stimulus for further investigations.

From a relatively small level in the early years, the use of the CERN experimental facilities has now grown to involve some 1500 experimental physicists drawn from over 100 European universities and research institutes. It is this level of activity which makes Europe one of the main world areas for high energy physics research.

In addition to this ever-growing collaboration of European physicists, CERN, as a Laboratory of world class, attracts visitors from further afield.

In 1956, when the proton synchrotron was still on paper, the Ford Foundation initiated a funding programme which for the subsequent ten years enabled scientists and technologists from non-Member States, notably the US, to participate in the CERN programme. This provided valuable additional experience in those early years, and the programme has been continued and expanded with direct funding by CERN.

Also in the early years, scientific exchanges began with the Joint Institute for Nuclear Research at Dubna, near Moscow. A further important landmark was in 1967 when an agreement was signed between CERN and the USSR covering technical contributions by CERN to extracted beam facilities at the 76 GeV proton synchrotron at Serpukhov. This enabled physicists from CERN Member States to carry out experiments at this accelerator, at that time the highest energy machine in the world. This agreement was extended in 1975, enabling Soviet physicists to collaborate in experiments at the big new CERN machines. Although as yet still in its infancy, two-way contact between CERN and the People's Republic of China has been under way since 1973.

The future

In 1977, trials began to test 'stochastic cooling' — a new metho invented at CERN for concentrating particle beams. These trials were quickly successful and showed the feasibility of storing new kinds of particle beams, notably antiprotons. In the following year, antiproton beams were successfully stored for the first time ever.

As a result, ambitious plans were prepared for the SPS to take on a new role as proton-antiproton colliding beam machine, and the necessary construction work initiated. In the SPS, these colliding beams will open up a new domain of high energy physics, with collision energies equivalent to that of a 155 000 GeV conventional accelerator. Further uses of the cooled ant proton beams are foreseen at the ISR and for low energy studies at the PS.

With the full capabilities of the SPS yet to be exploited and the proton-antiproton project due to receive its first colliding beams in 1981, it is still necessary to look further ahead to the longer-term requirements for high energy physics in Europe. In 1977, these studies crystallized as an ECFA recommendation for a large electron-positron colliding beam machine. This 'LEP' project is now under detailed study for the long-range future of CERN. With such a vigorous development programme and with its tradition of international collaboration, Europe is well placed to maintain the position it has established in the forefront of high energy physics research.

The 25th Anniversary Ceremony

Jean Teillac, President of the CERN Council, opens the formal ceremony celebrating the 25th anniversary of the entry into force of the Convention establishing the European Organization for Nuclear Research.

(Photo Alain Gassmann)

On 23 June a ceremony was held at CERN to mark the 25th anniversary of the Organization. A distinguished gathering (including eight Ministers from the CERN Member States, ten Ambassadors, local Genevese and French authorities and representatives of Laboratories and Universities) participated in a most impressive and dignified day.

The ceremony was opened by Professor Jean Teillac, President of the CERN Council. Professor Victor Weisskopf spoke on 'The significance of CERN' and Professor H.B.G. Casimir on 'Big Science and Technological Progress'. We give here some extracts from these talks; the full texts will be published and will be available from CERN in the Autumn.

Professor Weisskopf: The significance of CERN

'For me the development of CERN in the last three decades is not only an impressive story of success but also a fulfilment of a dream. Our dream was to see a great and active laboratory of fundamental physics in Europe that transcends national boundaries and is a symbol of a bright future, when humanity will be united and when national pride does not refer to any specific country but refers to the whole of our great planet Earth.

I would like to consider the significance of CERN in three directions: — its Scientific impact, its European impact and its World-wide impact.

The Scientific Impact:

The object of research at CERN is to study the ultimate constituents of matter and the ultimate forces of nature, the driving forces of all natural processes.

The first step, the insight into atomic structure, was based upon the discovery of quantum mechanics, a new type of dynamics that dominates atomic processes. It led to an understanding of most phenomena that occur on the surface of the earth, chemical processes, light absorption, emission and reflection, electric and magnetic effects, and the diverse properties of materials, metals, minerals, plastics and liquids.

The second step opened up the nuclear realm and led to the discovery of phenomena such as nuclear reactions, radioactivity, fission, fusion; phenomena that are inactive or unimportant under ordinary terrestrial conditions.

The third step, the subnuclear realm, again led to the discovery of new phenomena; a large number of short-lived entities were found: mesons, antimatter, excited states of the proton and neutron and the new subnuclear fundamental particles: the quarks.

In the atomic realm, it is the electromagnetic force that holds things together and is the driving cause of events. In the nuclear realm two new forces were discovered: the nuclear force which holds the nucleus together, and the so-called weak force which causes the radioactive processes. In the subnuclear realm it is the so-called strong force that holds the quarks together. The nuclear force seems to be a derivative of the strong forces between the quarks.

Every step in this dramatic sequence of discoveries revealed new natural phenomena and new forces of nature. The deeper we penetrate, however, the higher are the energies necessary to activate the processes, the larger become the accelerators and the instruments that are needed to study the phenomena. After all, we are dealing here with processes that do not occur under ordinary conditions prevalent on earth. The nuclear realm is active only in the centre of the stars, and the subnuclear realm becomes active (apart from laboratories like CERN) only in the great cosmic cataclysms such as star explosions or the big explosion in which the universe was born (the 'big bang'). In order to study the relevant phenomena we must create conditions that do not exist on earth.

I cannot repress a certain pride as a scientist that we were able to realize such cosmic environments in our laboratories. By doing so we got nearer to the very nerve centre of nature, and closer to the answers to the questions that man has asked since he began to find his way.

CERN is devoted to the exploration of this third step and has contributed much to it.

The European Impact:

CERN was created in order to establish an opportunity for Europe to participate actively in the research of the fundamental structure of matter. In the first third of this century, Europe was leading in this field; indeed most of the fundamental discoveries and ideas originated in Europe. After the Second World War, however, this type of research took place mostly in the USA because Europe in the West and in the East was suffering from the ravages of the war and was not yet able to construct the large facilities necessary for it.

Furthermore, the size of such establishments was too large for one single country in Europe, with the exception of the Soviet Union. Therefore the only way for Western Europe to get out of the backwater in fundamental physics and to acquire again the historic leading position in this field, was to establish an All-European laboratory. This daring venture turned out to be extremely successful, although many people considered it impossible and doomed it to failure. It became a unique laboratory attracting scientists, not only from Europe, but from all over the world.

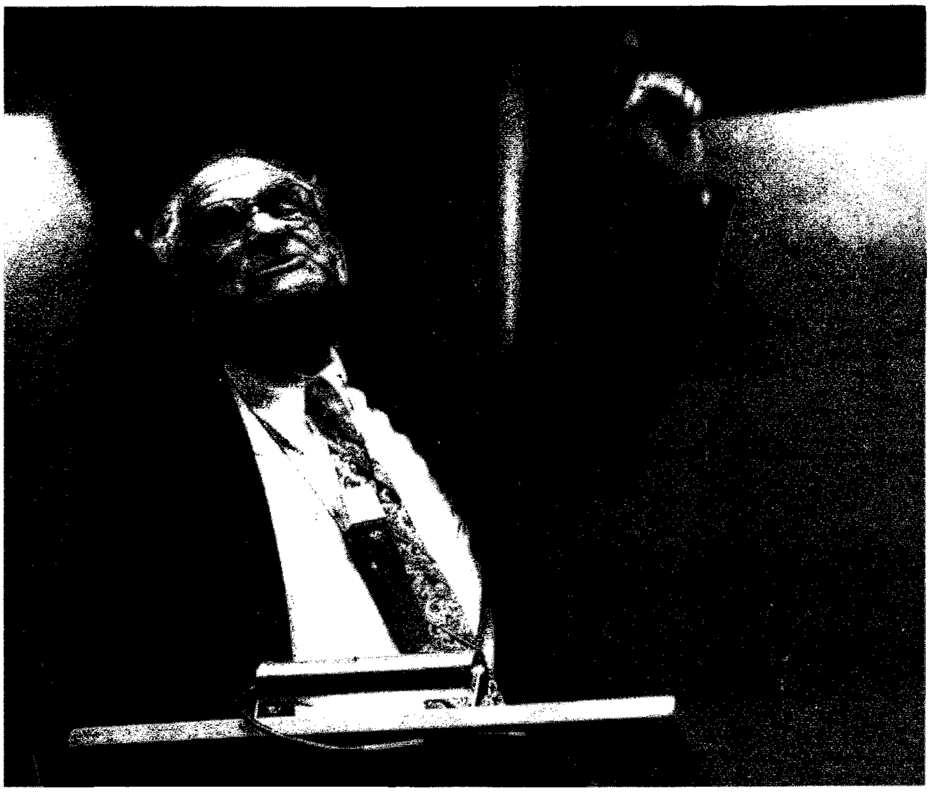
It supplied its own specifically European style. It was, as L. Kowarski expressed so succinctly, a vehicle for the re-introduction of traditionally European qualities to the world stage of advanced physics: elegance in construction, perfectionist care for precision and reliability, pioneering in invention and development of new principles of instrumentation. All this was done by a group of engineer-physicists that has no parallel in any other institution and is unique in the world. It was the result of the successful gathering of intellectual resources of many different countries.

This points to an important role of CERN. It is a place where it is possible to pool the best brains of Europe. The great success of theoretic physics at CERN is another example of the beneficial effect of pooling the intellectual capabilities of many countries. Results were achieved by direct contact and collaboration that would never have been obtained in centres distributed over the different nations. The collaboration of people of different nationality was much easier than anticipated. He who enters CERN has lost his specific nationality and becomes a scientist of the world.

The CERN idea has spread into other sciences. Since the conception of CERN, new European collaborative efforts sprang up. Some of them were directly spawned by CERN, such as EMBL (the European Molecular Biology Laboratory) and ESO (the European Southern Observatory). Others developed independently, such as ESA (the European Space

Viki Weisskopf in full flight during his talk on 'The significance of CERN'.

(Photo CERN 599.6.79)



The CERN Anniversary Ceremony in June provided a rare gathering of CERN Directors General, past and present. Left to right, John Adams, Willi Jentschke, Felix Bloch, Victor Weisskopf and Leon Van Hove.

(Photo CERN 614.6.79)

Agency) and the High Flux Neutron Reactor in Grenoble. Many other such ventures hopefully will follow these. Indeed, a European Fusion Laboratory, JET, is already in the making.

Still there are not enough of them. In particular some fields of industrial research, such as the areas of semiconductors and of computers, would greatly profit from a pooling of European resources. There does not yet exist an all-European counterpart of the Bell Laboratories, for example, or European Institute of Technology.

Because of the decisive importance of CERN for a united Europe, we must do everything in our power to keep CERN active as a centre and a spawning place of united European scientific efforts. To keep a research centre alive means a constant renewal, a replacement of older obsolete facilities by the newest and most modern ones. If CERN should remain one of the few realizations of European unity, it must stay at the forefront of research, it must constantly plan, develop and construct the most up-to-date instruments of research, it must continue to invent and use the sharpest means of penetrating into the deepest riddles of nature. This means higher energy, larger accelerators and more sophisticated instrumentation.

To keep CERN alive it also is necessary to maintain the spirit of adventure and of daring that has permeated CERN from the leading physicists to the last employee, the awareness of participation in a great and unique venture, pioneering not only in science but also in social and political innovation. It sometimes is hard to maintain this spirit over decades in a growing organization but it is a precondition for continuing success.

The World-Wide Impact:

It always was, and is, the aim of CERN to establish a wider community than the one of its Member States. Right from the beginning there was close cooperation with the United States of America; a number of American accelerator specialists participated in the construction of the proton synchrotron, and some of the experience gathered here was very useful for similar ventures in the United States. Later on, a large number of American physicists came to Geneva in order to make use of the excellent facilities here, in particular of those that had no counterpart in the USA, such as the ISR.

The doors of CERN were always open to Eastern European scientists. We had guest physicists here from Poland, Yugoslavia, Turkey, Czechoslovakia, Hungary, Rumania, and East Germany, and from Japan and India. Poland, Yugoslavia and Turkey send regular observers to the meetings of the Council. Somehow, our relations with Poland are especially close due to the most active participation of their excellent physicists in the work of CERN.

The cooperation of CERN with the physicists of the Soviet Union deserves special mention. We introduced a programme of exchange of physicists with our sister institution in Dubna and an extensive programme of collaboration was carried out in connection with the construction and exploitation of the 70 GeV proton synchrotron in Serpukhov. CERN provided help and expertise in the construction. In exchange, West-European physicists made scientific use of the then largest accelerator in the world. Many interesting results were obtained in a hitherto unexplored energy region. Since then, the collaboration with the Soviet Union continues; Russian physicists participate in many CERN experiments and also contributed some special instrumentation. Finally, the collaboration with Chinese physicists is taking shape. They plan to engage in a large high energy physics effort in their homeland. CERN offered them help, advice and training. In exchange, CERN will profit from this collaboration when new ideas and initiatives will emerge from this enormous pool of human intelligence.

Professor H.B.G. Casimir addresses the distinguished audience with Professor Leon Van Hove, Professor Victor Weisskopf, Professor Jean Teillac and Dr. John Adams on his left.

(Photo CERN 587.6.79)

These few and incomplete examples indicate how deeply CERN is involved in the world community of physicists. It came almost by itself, it could not be otherwise. After all, science is a supernational, human activity that transcends all political or ideological limits. This will be even more so in the future, when the high energy physics facilities will become so large that certain types can only be constructed at one place in the world, and other types at another place. Then the supernational outlook that the physicists have acquired in the past will be of utmost importance.

The success of CERN in pooling the intellectual capacities of Europe should be a lesson and an encouragement for similar ventures on a world scale. Many possibilities are before us, a world university, and world institutions for research into global problems. There are already some promising beginnings of such enterprises, such as the start of a world university in Tokyo, the International Institute for Applied Systems Analysis (IIASA) in Vienna, and the Centre for Theoretical Physics in Trieste. Yet, today these are only small experiments and we must hope that such global enterprises will grow and multiply.

We live in a period when many cultural values are put into doubt. There is a feeling of crisis in our civilization, a lack of direction and purpose, and a mounting fear of an ultimate catastrophe in the form of a nuclear war. However, the constant growth of our insights into the mysteries of nature, the deeper penetrations into the riddles of the Universe are some of the positive trends in our era; here we find a living tradition, development, and true progress. This is part of the reason why the CERN idea has been so fruitful; it has established a closer contact between people around the world who are engaged in these positive and constructive cultural activities.

A mere quarter of a century ago, CERN became a reality in Europe. Its influence is spreading over the whole world of physics. The lesson that we should learn from twenty-five years of supernational physics at CERN is this: it is possible, it is successful, it is inspiring. May it serve as a model for a much wider aim: a united world devoted to the well-being of all mankind and to creative activities in science, art and in all other manifestations of human culture. Let CERN be a symbol and hope for peace, for a united mankind, for an end to all destructive wars.'

Professor Casimir: Big Science and Technological Progress

'It may well be said that technology has continually been paying back its debt to basic research. Since the beginning of the last century, technological progress has become more and more dependent on science, and several of the most spectacular innovations were not only assisted but even preceded by basic scientific discoveries.

However, when looking at the installations at CERN some people may feel that here society and technology have been generously overpaying and that, for the time being, it is science that is in debt.

One may wonder whether working to produce the installations for CERN was really beneficial for industry. I am convinced that it was beneficial, since in many cases industrial firms had to meet specifications that were at the very limit of their capabilities. Meeting such specifications in collaboration with the designers at CERN must have increased the firms' general level of competence, and this has in some cases even led to new, generally applicable products. Cooperating in high level projects like CERN, like big science in general, helps to raise the level of competence of industry.

Even so, I feel that even better use might be made of the superior competence in many fields that is available at CERN. The skills in designing complex apparatus can be turned to good account in many fields. Are conditions optimal for this? I wonder. Transfer of CERN staff into industry is, as far as I know, rather limited. Does CERN often act as a consultant to industry on problems unrelated to its purchasing? I rather doubt it. At one time I toyed with the idea that CERN might be the nucleus for a very high-level graduate school of engineering. First-class teaching staff and excellent practical training facilities would be available. Degrees granted by CERN would be highly esteemed and the young CERN graduates would spread the knowledge and skill obtained at CERN in many countries and among many industries and institutions.

When I cautiously mentioned this idea in educational and governmental circles it was not well received. Industry, according to some, is not concerned with particle physics, nor with big science, and CERN's highly sophisticated and refined methods and apparatus will be of little use to industry, even to industries in the professional equipment field. In addition, it will be argued that industries mass-producing products for the general public do not need such things at all: they need engineers that have learnt to keep their feet firmly on the ground. This objection is unfounded. Time and time again we have seen that products and methods originally designed for very special purposes were later used for mass-produced articles. As for keeping one's feet on the ground: that is about the worst place for the feet of a research man to be.

A second objection is as follows. If CERN were also an educational institution it would be diverted from its main task, namely research. It would also endanger the loyal and impartial collaboration of CERN with all the universities in all the participating countries. CERN does have an educational mission, but it is best accomplished by accepting temporary collaborators sent there by those universities. These are indeed valid arguments, but I nevertheless think that the idea is a good one.

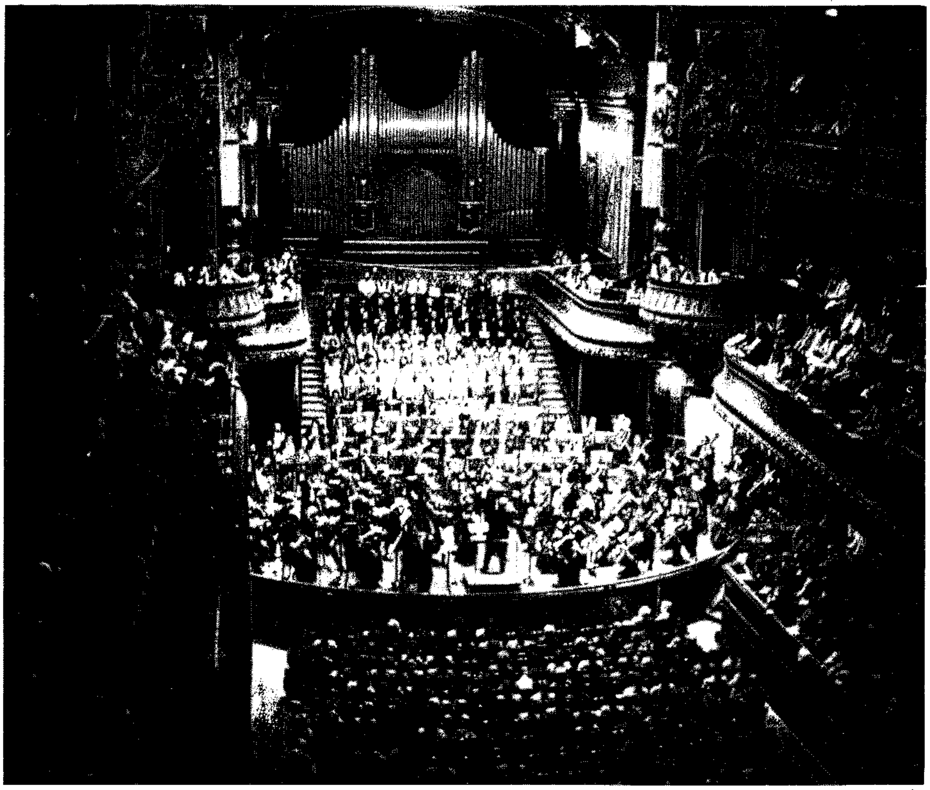
So far, I have been speaking about the technical content of the research tools designed and built at CERN. What about the real subject-matter of the research carried out here? Will it have a future impact on technology? Will the pattern of development that prevailed during the past hundred or hundred and fifty years be continued? The fact that no large-scale applications of high energy physics are in sight does not mean that such applications are forever excluded. If we were to brand particle physics as useless we should be no less obtuse than those of our predecessors who scoffed at electrons. On the other hand, it must be admitted that particle physics has now been with us for more than forty years... If practical applications finally do appear, the time delay between fundamental research and application will have been unusually long. From this I conclude that if applications turn up they will almost certainly be far outside the range of our present technology and even beyond the scope of our imagination.

I hope that the time lag will be longer still. Nuclear physics has put into the hands of mankind formidable power. We are still struggling with the problem of how to use nuclear energy efficiently and safely, we are rightly alarmed at the accumulation of nuclear weapons of annihilation. Until mankind has shown that it can deal wisely with nuclear power, it is not prepared for something entirely new. Until the last nuclear warhead has either been dispatched to outer space or quietly burnt up as fuel in an energy-producing reactor, I would not welcome an entirely new development. I have often said that I am in favour of supporting high energy physics, provided that the high energy physicists can promise not to produce applicable results within the next twenty-five years. I am usually not taken seriously when I make such remarks. I do, however, mean them very seriously.

There is of course also the possibility that there will never be any practical applications. Maybe the science-technology spiral is coming to an end and both high energy physics and astronomy are moving in realms outside the grasp of homo faber, whilst remaining accessible to the understanding of homo sapiens. In that case should society in general and industry in particular regret the investment? I have pointed out many indirect advantages. Even if we were to disregard these advantages, the industrial community should be proud of its contribution to this magnificent effort, and extends its warmest congratulations to CERN on the occasion of its Silver Jubilee.'

Professor Teillac: Concluding remarks

'... We can face the future with confidence, particularly now that physics is becoming more exciting



On 29 June, the Swiss authorities presented a memorable concert in honour of CERN's 25th Anniversary. The concert took place in Geneva's Victoria Hall and was presented by the Conseil Fédéral Suisse, the Conseil d'Etat de la République et Canton de Genève and the Conseil Administratif de la Ville de Genève. Horst Stein conducted the Orchestre de la Suisse Romande in a magnificent programme which included a Prologue for Orchestra 'Lux et Pax' specially composed in honour of CERN by Geneva composer Mathieu Vibert.

(Photo CERN 741.6.79)

than ever. From time to time physics makes its mark on history by establishing a synthesis or opening up a completely new line of thought, as in the discovery of gravity, electromagnetism, quanta, relativity, atomic structure etc. Now recent developments have indicated a possible way to another great advance.

The physicists in Europe have firmly adopted this new idea; they are almost unanimously in favour of the construction of a ring for electron-positron collisions at energies in the 150 GeV range. We have to reach these energies in order to observe spectacular new phenomena connected with the production of intermediate bosons, predicted by theoretical models which have already met with considerable success.

There is great enthusiasm for the project, particularly as the solution to a question of fundamental importance seems to be within our grasp: the unification of the weak and electromagnetic interactions. This theory was put forward in the late sixties and has already been supported by spectacular experimental results. One of its first manifestations was the discovery at CERN in 1973 of the neutral current interaction using neutrinos, then came charm, the tau lepton and the b quark. The development of high energy physics in the space of a few years has thus been exceptional, and now LEP has emerged as the ideal machine needed to make a complete study of the unification of the electromagnetic and weak interactions.

It must also be remembered that the cost of these big machines encourages complementarity rather than competition between the main research centres of the world, and the construction of LEP would be eminently suitable as a complement to the projects in the USA and the USSR. Furthermore, with PETRA in Hamburg, Europe now has a slight lead over the USA in the construction of electron-positron rings, which owe a great deal technologically to the first machines at Frascati and Orsay.

LEP will also open the door to the study of another area of modern physics which is just as spectacular and exciting — the structure of quarks. Present theories predict that the attempt to separate two quarks leads to the emission of π-mesons principally in the direction of the pair. This is comparable to the electromagnetic radiation of an antenna formed by two particles of opposite charge when suddenly separated. There is no direct manifestation of the two quarks but mesons appear, closely correlated in two jets. These events can be more precisely analysed in electron-positron collisions. LEP will therefore provide an opportunity of studying and understanding radiation by quarks and qua recombination. This analysis may even reveal a quark structure, although quarks seem at present to be as elementary as the electron and the neutrino.

Yet, in order to realize the promise that physics holds out to us, it is essential that there should be continuity in the slow and difficult acquisition of knowledge. If continuity is broken, people are soon dispersed, confidence and optimism evaporate, young people are no longer attracted. The creation of a laboratory is a long and painstaking process: it is not done by merely assembling people, any more than a forest is created by merely planting trees next to each other.

The construction of LEP needs not only the enthusiasm of the physicists but also the enthusiasm of all those who, alone, can ensure the carrying out of this project. It may seem regrettable that a machine costing approximately a thousand million Swiss francs has to be built before progress in physics can be made! Small low-cost machines were sufficient for testing Maxwell's equations and establishing the basic unity of the electric and the magnetic interactions. But in order to verify the unity of the weak and electromagnetic interactions, energies ten thousand million times greater than those peculiar to everyday electromagnetic phenomena are needed. This might seem to come low on the list of priorities of the world today.

In addition we must realize that the development of increasingly sophisticated technology and increasingly esoteric science brings with it growing difficulties of communication between specialists and others. This gives rise to some confusion, particularly as research is expected to benefit the economy by its discoveries. Sophisticated techology is gradually permeating our daily lives; science asks for more and more funds which governments have to make provision for in their budgets.

I believe that one of man's finest qualities is his ability, despite difficult conditions, to devote a small part of his resources to furthering his understanding of the world. I should also say on this occasion that the Member States have always supported the Organization, even though there have been times when this was difficult.

Our generation must not fail in its task. We must hand on to our successors both what has been achieved so far and the means for them to continue their research. By inspiring them with confidence we can point the way to future progress.'

CERN physics, past and future

Introducing the proceedings on CERN Day at the European Physical Society's 1979 International Conference on High Energy Physics, held in Geneva, Victor Weisskopf described the establishment of CERN 25 years ago as the fulfilment of a dream. With the creation of CERN, Europe was restored to the forefront of fundamental physics — the place it had occupied during the first decades of the century.

In a memorable presentation, CERN Research Director General Leon Van Hove painted a vivid picture of the achievements of the European high energy community at CERN over the past twenty-five years. Van Hove compared the physics panorama which has unfolded at CERN to the spectacular view of the Alps which one obtains from Meyrin on a clear day — not the only mountain landscape in the world, but a most impressive one. As well as being generally imposing, it also includes many individual mountains interesting and scenic in their own right.

Beginning with low energy nuclear physics, he mentioned the work done by the on-line isotope separator ISOLDE at the 600 MeV synchro-cyclotron (SC), taking as an example the beautiful results on the shape 'staggering' between adjacent neutron-deficient isotopes of mercury.

Another low energy highlight was the programme of work on exotic atoms, beginning with studies on muonic and pionic atoms at the SC, leading on to important discoveries with kaon, sigma and antiproton atoms at the 28 GeV Proton Synchrotron (PS).

He also mentioned the important hypernuclear physics results using kaons in flight at the PS, and recalled the discovery in 1963 of a double hyperfragment in emulsions exposed at CERN, remarking that this was an early example of the contributions of Poland, a non-member state, to the achievements at CERN.

Hadron physics at CERN had benefitted considerably by experiments using bubble chambers — first with the French 80 cm chamber and subsequently the CERN 2 m detector. An achievement of the early sixties which paved the way for the great successes of the SU(3) symmetry picture of hadron families was the determination of the relative parity of the sigma and lambda hyperons.

Work with the CERN hadron beams had played a prominent role in the discovery of many new hadronic resonances and the determination of the parameters of states previously discovered elsewhere. But Van Hove thought it 'sobering' that neither the J/psi nor the upsilon were discovered at CERN, although these new particles were both quickly confirmed by experiments at the Intersecting Storage Rings (ISR).

In the study of hadron dynamics, Van Hove highlighted the discovery of high transverse momentum collisions at the ISR in 1973, which showed that in strong interactions there were hard scattering centres deep inside protons. This discovery was the pioneer of today's hadronic jet physics, now one of the most active fields of research with hadron and lepton beams.

However these hard scattering events are only the 'outer frontier' of hadronic interactions at high energies, a domain where many important experiments were done at CERN, and at the 76 GeV Serpukhov machine in the framework of the CERN/USSR collaboration. It was at the ISR that the proton-proton cross-section was discovered to rise with increasing energy, showing that our present energies are far from asymptotic.

In the early and middle sixties, the shrinkage of the proton diffraction peak was discovered at the PS, and very important experiments on pion-nucleon charge-exchange scattering, including the use of polarized targets, were also carried out. These studies gave much stimulus to the development of the Regge pole model of hadron interactions.

Experiments at the ISR also discovered the diffraction minimum in high energy proton-proton scattering and the remarkable property of geometrical scaling of the shrinking diffraction peak.

The very first result to emerge from the 400 GeV Super Proton Synchrotron (SPS) in 1977 provided valuable information on the relative production rates of J/psi particles by different hadron beams.

In contrast to the rapid evolution of high energy physics as unexpected discoveries open the door to new areas of study, measurements of the magnetic moment of the muon (the 'g-2' experiments) spanned 20 years of activity at CERN, providing some of the most accurate measurements ever made in physics and displaying the impressive accuracy of theoretical predictions using quantum electrodynamics.

Turning to weak interactions, Van Hove described an impressive array of achievements, from the first observation of pion decay into an electron and a neutrino at the SC in 1958, through to the latest results from the neutrino experiments at the SPS.

Other early weak interaction successes included the observation of the 'beta-decay' of the pion and the measurements of the muon's helicity.

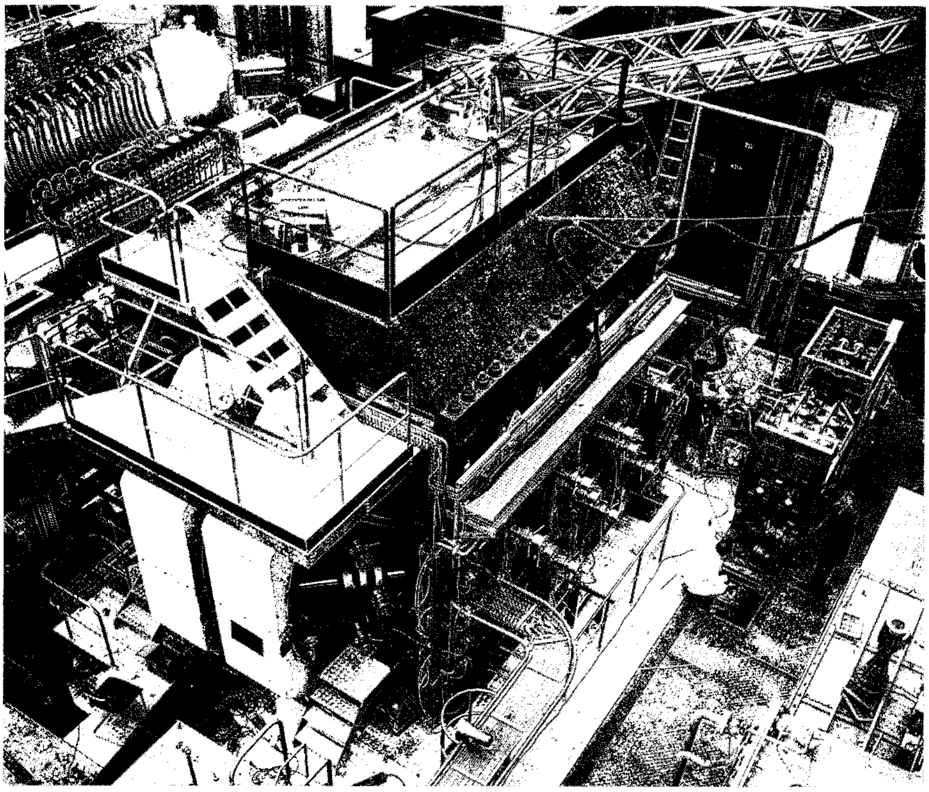
The discovery of CP violation at Brookhaven in 1964 sparked off a flurry of activity in the study of neutral kaon decays. In the search for the origin of this new asymmetry, CERN checked in 1966 that charge symmetry was obeyed in the decays of the eta meson, and 1970 experiments revealed that time reversal symmetry did not hold in the decay of the long-lived neutral kaon, while CPT could be retained as a cornerstone of field theory.

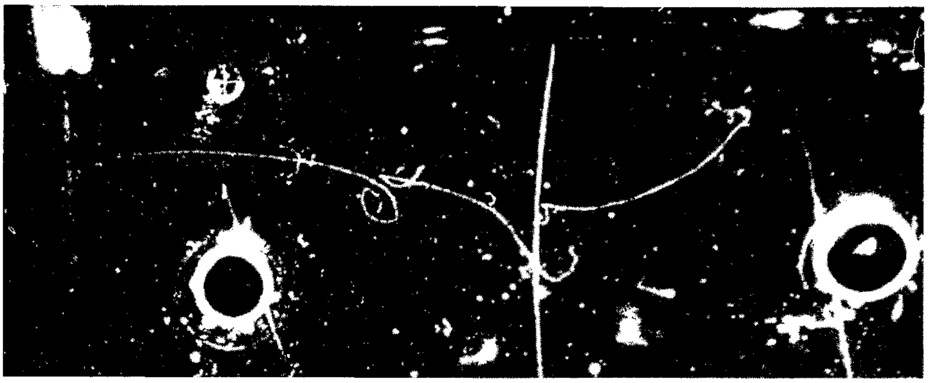
A totally fundamental discovery came in the PS neutrino beam and the Gargamelle heavy liquid bubble chamber, with the observation in 1973 of neutral current interactions involving both electrons and hadrons.

This confirmed the predictions of the Weinberg-Salam theory of the unification of weak and electromagnetic interactions, and pointed the way to a new age of theoretical and

The heavy liquid bubble chamber Gargamelle in position at the CERN 28 GeV proton synchroton where in 1973 it was the scene of the discovery of the neutral current (below). 'Gargamelle is now dead, but her discoveries remain as a crown of European achievement in physics,' declared Van Hove.

(Photo CERN 143.4.71)





experimental particle physics.

The same experiments established that there was a linear rise of the neutrino-nucleon cross-section with neutrino energy, and confirmed that the structure of nuclear matter as revealed in Gargamelle by neutrino beams was essentially the same as that seen in high energy electron experiments at SLAC. Gargamelle is now dead, but her discoveries remain as a 'crown' of Europe's high energy physics achievements of the last 30 years, said Van Hove.

Subsequent neutrino results, this time using beams from the SPS, have uncovered vital information on nucleon structure and charm production, and have measured the lifetime of charmed particles. For electronic neutrino experiments, the large detector at CERN had been 'in command' of the field since 1977, asserted Van Hove. Among many other results, it had given the first precision determination of the mix-g angle at the heart of the unified electroweak' theory.

The CERN Research Director General closed his survey of 25 years of CERN physics by pointing out that the next major task was to search for the radiation field predicted to accompany weak interactions. With a unified theory of weak and electromagnetic interactions looking so promising, the discovery of this radiation would parallel the discovery last century of the electromagnetic radiation predicted by Maxwell.

He therefore compared the new proton-antiproton collider and accompanying detectors, now being prepared at the SPS, to Heinrich Hertz' 19th century apparatus which showed the existence of electromagnetic radiation, describing the experimental programme at the collider as really 'Phase 2' of Hertz' experiments.

The Future

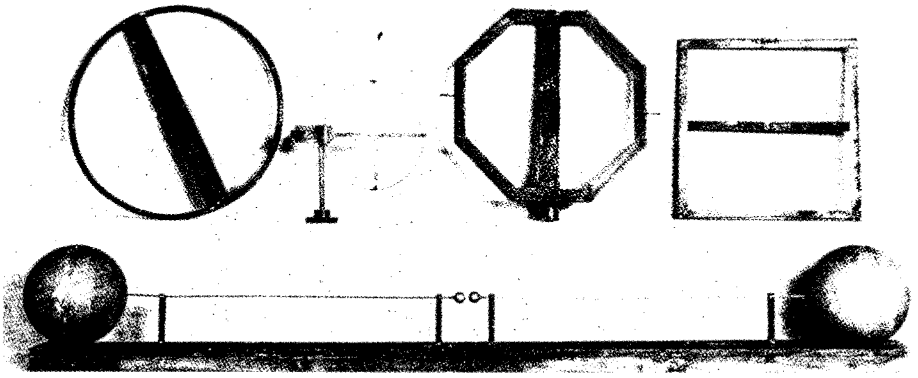
Leaving physics history to turn to prediction and speculation, the second speaker was Bjorn Wiik of DESY who outlined some of the physics possibilities of the future.

Introducing the talk, Viki Weisskopf warned that what Wiik would have to say might not necessarily be right in the end, but if he were wrong the actual observations would be all the more interesting!

Before looking into his crystal ball, Wiik also underlined that the only thing we know is what has already been seen and measured, and in view of the not infrequent contradiction between different experiments, what we know for sure is usually the result of measurements in several experiments.

Wiik sketched a physics picture based on families of quarks and leptons, with 'grand or less grand' unification schemes of the different forces of Nature pointing the way towards behaviour at higher energies. However signs of gluons, Higgs particles, intermediate weak bosons and quarks should show up, he said, before confident predictions can be made for more distant energies.

Complementary electron-positron and electron-proton machines were the ideal future armoury for Europe to continue in the forefront of physics, Wiik declared, but progress into still higher energy domains beyond might be difficult. Therefore nucleon decay, one of the important predictions of grand unification schemes, had to be checked out, and its details could provide important clues about the interrelation of Nature's fields of force at energies inaccessible by accelerators.



The apparatus used by Heinrich Hertz last century to produce and detect the electromagnetic radiation predicted by Maxwell's equations. Now that modern theory seems to have linked electromagnetic phenomena with weak interactions, a parallel experiment has to detect the radiation field of weak interactions. 'All that has to be done', says CERN Research Director General Leon Van Hove, is to replace Hertz' oscillator (below) by the proton-antiproton collider, now being constructed at the CERN SPS 400 GeV proton synchroton, and his detectors (above) by the vast underground experiments now taking shape at the SPS.

(Photo Deutsches Museum, Munich)

Technology Exhibition

Linked to the 25th Anniversary celebrations, an exhibition of some of CERN's technological achievements was opened on 22 June.

Set up in a new 600 m^2 Exhibition Hall on the CERN site, the exhibition is divided into eight technology areas — magnets, vacuum, computers and data handling, survey and alignment, radiation protection, beam monitoring and handling, detectors, and workshop techniques.

In the magnet bay the exhibits range from laminations of all the CERN accelerators through to a model of the recent invention for LEP magnets with concrete spacers in the core. Other exhibits include superconducting applications and sophisticated ejection magnets. The vacuum bay concentrates on the system developed for the Intersecting Storage Rings — the world's largest ultra-high vacuum system.

The computers and data handling bay presents the data communications developments with the CERNET computer-to-computer network, and with the STELLA experiments linking laboratories by satellite. There is also a control console of the 400 GeV proton synchrotron demonstrating the system which did so much to advance computer control of accelerators. Other computer exhibits feature ERASME, latest in the line of automated bubble chamber film measurement systems, and special purpose processors.

CERN has always had a high reputation in the field of survey and alignment and several instruments developed at CERN for automating precision measurements are shown. In the radiation protection bay there are examples of systems used on the CERN site and a selection of radiation resistant materials. Also shown is the fire warning technique used to protect cables.

Particle detector exhibits range from the CEDAR counter for particle identification through to a bank of operating spark chambers previously used in the Omega spectrometer. Components of the 3.7 m European bubble chamber are contrasted with CERN's initial 10 cm model chamber. The important techniques of multiwire proportional chambers and drift chambers are featured alongside examples of their use in positron cameras for medical applications and a spherical chamber for X-ray crystallography.

In the beam monitoring and handling bay, the stochastic cooling of charged particle beams, which emerged from work at the Intersecting Storage Rings and which has made the antiproton colliding beams feasible, is presented together with examples of monitoring systems, including the novel technique using Schottky noise. The workshop bay includes displays of many of the techniques which have been developed at CERN to respond to the stringent demands of the research programme.

The exhibition remains until the end of October and is accessible by contacting the CERN Visits Service

A view of the Technology Exhibition prepared at CERN for the 25th Anniversary events. The Exhibition is accessible on request until the end of October.

(Photo CERN 190.7.79)

Geneva High Energy Physics Conference

European Physical Society President Antonino Zichichi opens the 1979 International Conference on High Energy Physics in Geneva. Also on the podium are André Chavanne (left), Geneva's Conseiller d'Etat, who welcomed delegates on behalf of the Geneva authorities, and CERN Research Director General, Leon Van Hove.

(Photo Interpresse)

To mark CERN's 25th Anniversary, the European Physical Society's 1979 International Conference on High Energy Physics was held in Geneva from 27 June to 4 July. Greeting the participants on behalf of CERN, Research Director General Leon Van Hove pointed out that the last time CERN had hosted such an international meeting was back in 1962, but the growth of the high energy physics community since then had meant that the requirements for such a conference had outgrown what CERN could offer on site. The 800 participants therefore met at the impressive International Conference Centre in Geneva.

Introducing the proceedings, European Physical Society President Antonino Zichichi sketched some of the important results to be presented later. He warned of the danger in assuming that the present widespread agreement between experiment and theory meant that nothing new could happen in the immense energy gap between today's machines and the ultra high energy domain where there are compelling reasons to suppose that strong, weak and electromagnetic phenomena, and maybe even gravity, could merge into a single unified force.

With the Weinberg-Salam picture of unified weak and electromagnetic phenomena looking impregnable and with more and more results being found which broadly agree with the adolescent (as de Rujula described it) quantum chromodynamics theory of inter-quark forces, our understanding of particle physics seems to be in good shape. It was easy to get the impression that when the long-awaited intermediate bosons of weak interactions are discovered in the CERN proton-antiproton collider, and a few other things tidied up, particle physics will be ready for the textbooks.

Zichichi cautioned that such an approach implied a physics 'desert' at higher energies, and one had to wait for the concluding session by Abdus Salam for an indication of how this vast desert might bloom. Salam's talk probably belonged more to speculation than to theory, but counterbalanced much of the bread-and-butter physics which had gone before. It could have made many physicists think afresh on their way home from the conference.

Although not a presentation to the conference in its own right, there was a report of preliminary results from the search for new heavy particles by the Indiana/London (Imperial College) / Saclay / Southampton collaboration at CERN of an enhancement at 5.3 GeV in the mass spectrum of J/psis, kaons and pions produced by a high energy

Alvaro De Rujula's view of the relationship between experiment and theory. Experimentalists were using quantum chromodynamics in much the same way as a drunkard uses a lamp-post — for support rather than illumination.

pion beam. This enhancement is a candidate for the first sign of naked beauty (or bottom), the quark flavour hidden in upsilons (see page 249).

There was news from several experiments that the charm lifetime now seems to agree with the theoretical prediction of 5×10^{-13} s (see June issue, page 152, and this issue, page 253). The study of charm production seemed to have consolidated since the Tokyo meeting, when there was little hard data to go on. New results could soon pin down the mechanism of charm production, and other studies, for example on multilepton production, could enable the fragmentation of charmed quarks to be parametrized.

Also new at the conference were results (many of them still preliminary) from the PETRA electron-positron ring at DESY, from the North Experimental Area at CERN, and from the new detectors at SLAC — the 'Crystal Ball', and Mark II, now through with its work at SPEAR and being moved in preparation for experiments at the new PEP electron-positron ring.

Evidence for gluon production is building up, especially in the decay of upsilons recorded last year whe DORIS achieved record electron-positron storage energies before having to handle the positrons for the new PETRA machine. DESY Director Herwig Schopper indicated that now the new PIA positron ring is ready at PETRA (see page 252), DORIS will soon be able to return to physics at upsilon energies.

First data from PETRA, although still preliminary, showed little sign of a new quark flavour. Although the energy steps between different PETRA runs have been quite large, it seemed unlikely, although not impossible, that a threshold for another species of quarkonium could have been overshot.

The polarized electron data fror SLAC which last year provided vital evidence in favour of the standard Weinberg-Salam model (see July/August 1978 issue, page 245) has now been extended to give energy transfer spectra which are also in line with the standard model. With more experiments on asymmetry effects in atomic physics producing positive results, the Weinberg-Salam theory now reigns supreme, and the value for the vital mixing parameter (which relates among other things how electromagnetism is embedded in the larger theory) now seems to be settling down at about 0.23.

A minor surprise was that some charmonium levels previously reported from DESY experiments and identified as spin zero, negative parity states were not showing up as expected at SPEAR. Although substitute particles will have to be found to fill up the spectrum, theorists had been having problems with the lowest pseudoscalar candidate and would not be unhappy to see it go.

The study of baryonium and related narrow hadronic states received a setback when, instead of there being many new states to report, as predicted by theorists, experimentalists had to assign larger question marks to some of the existing candidates. This seemed puzzling, as with evidence for the colour picture of inter-quark forces looking in such good shape elsewhere, some signs of a new spectroscopy due to colour had been expected to show up (see October 1978 issue, page 349).

Theory

Many experiments seemed to be pinning their hopes on producing results on quark/gluon behaviour using a quantum chromodynamics model. Alvaro De Rujula suggested that some experimentalists might be using QCD in much the same way that a drunkard uses a lamp-post — for support rather than for illumination!

While many experiments could point to qualitative evidence for gluon effects and broad agreement with QCD predictions, some of the QCD details were a bit murky. Non-logarithmic 'twist' terms seemed to be required in some calculations, and such complications could make it difficult to extract meaningful QCD parameters from the data, or could blur any comparison of results from different types of experiment.

In his concluding talk, Abdus Salam referred to the 'delapidated house' of perturbation theory which still imprisons theorists. While these shortcomings of the perturbation approach might make quantitative QCD calculations difficult, nobody was ready to doubt that gluons were there. James D. Bjorken was insistent that bound states of gluons ('glueballs' to some) should show up soon, and Salam thought that direct evidence for gluons was not far off.

Any solution to the problem of reconciling the use of an asymptotically free quark field theory with the continual non-appearance of quarks seemed as remote as ever, although a technique based on an expansion in inverse powers of the number of colours was thought by some to hold out some hope.

Another recurrent embarrassment was the Higgs particles, no sign of which have yet been seen anywhere. With little indication of where they might be found, people have to wait patiently, although some optimists hope that light Higgs particles might soon be seen at existing accelerators.

Theorist John Iliopoulos was in confident mood and declared himself ready to negotiate bets on his predictions. As the first theorist to speak in the plenary sessions, he was the first to bring up the subject of the 'grand unification' of strong, weak and electromagnetic forces and the accompanying prediction of an unstable proton (see May issue, page 116). Iliopoulos said that the implications of an unstable proton were far too important to be left to theorists, a motto subsequently taken up by other speakers.

Weak Interactions

In his rapporteur talk on neutral currents, Friedrich Dydak of Heidelberg outlined how our knowledge of the neutral current and its couplings has now reached the stage where it opens up new opportunities to study the structure of the nucleon.

Neutral current results from different directions, including low energy neutrino data from the Savannah River reactor, the polarized electron studies at SLAC, high energy neutrino work at CERN and Fermilab, and atomic physics experiments, seem to be converging. Comparison with Weinberg-Salam predictions has now reached a level where dynamical effects producing scaling violations, etc. have to be taken into account when using the traditional quark/parton analysis.

In the charged current sector too, the emphasis seems to be on careful analysis, with data on nucleon structure functions being tidied up, quark, antiquark and gluon distributions separated, and QCD parameters being extracted. Because of the volatile state of the theory, unique prescriptions for extracting these QCD values are not easy to find.

Rene Turlay summarized the progress which has been made in charged current physics in the last few years when he pointed out how the simple analysis of a few years ago has now been replaced by detailed searches for subtle gluon effects.

In general, it was impressive, if not striking, that there is now widespread agreement between the world's big neutrino experiments, even as new detectors, such as the CHARM collaboration at CERN (see July/August issue, page 193) produce their results. This contrasts with the situation a few years ago, and indicates that neutral and charged current physics has now matured.

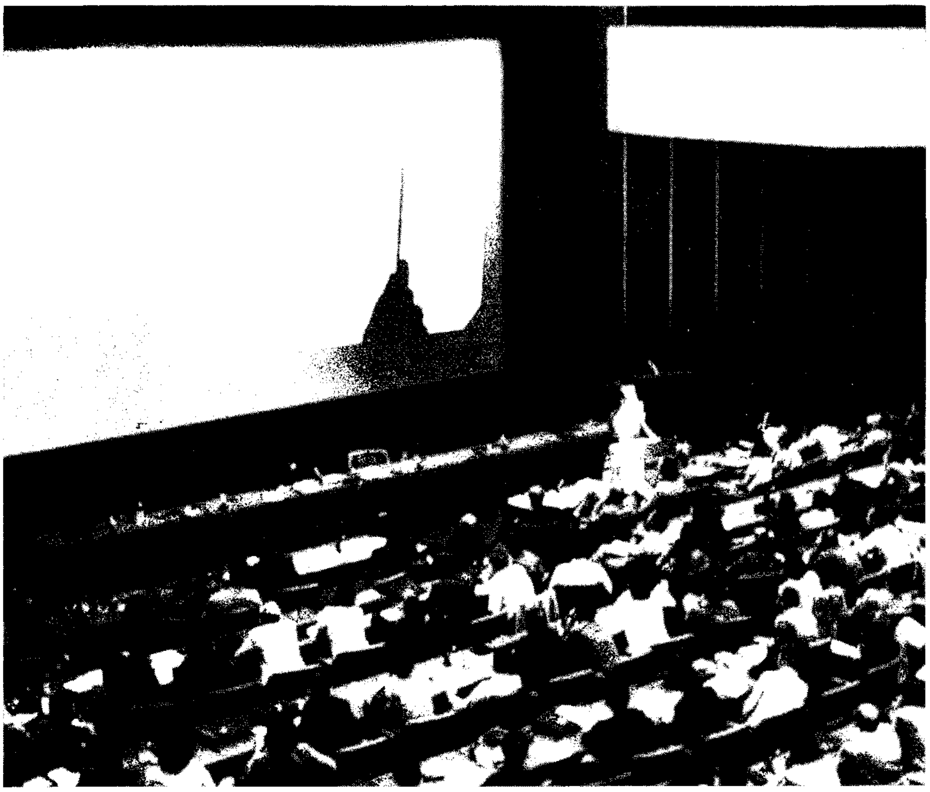
Further studies are still needed for precision measurements of nucleon structure functions and to determine the finer details of the quark/gluon content of matter. In his rapporteur talk, Lalit Sehgal of Aachen hoped that this new study of nucleon dynamics could be linked up with the static behaviour of hadrons.

Atomic physics experiments on the optical activity of thallium vapour at Berkeley now agree with Weinberg-Salam predictions, and the Novosibirsk bismuth results, according to Lev Barkov, are now more precise than ever. After the problems of a few years ago, these delicate experiments now give reproducible results.

As an interesting sideline to the neutrino physics part of the conference, Martin Rees of Cambridge presented some of the astrophysics arguments which are frequently used to indicate an upper limit to the possible number of different types of neutrino. While these arguments are useful, they are not watertight and there are many escape clauses which allow the neutrino spectrum, and hence the number of quark/lepton families, to escalate.

As ever, the ubiquitous overhead projector rivets everyone's attention.

(Photo CERN 39.7.79)



Electron-positron physics

A feature of the conference was the swathe of new high energy electron-positron data from PETRA at DESY, with PLUTO, TASSO, and Mark J all contributing and now with JADE recording its first events. Results have now been amassed at a number of PETRA energies, the highest being 27.4 GeV. Luminosity at PETRA is going well, and has now exceeded the 10^{30} mark, so that design figure of 10^{31} is well in sight.

Hadron production levels so far do not seem to indicate that a new flavour production threshold has been overrun, and any sighting of 'toponium' will have to wait at least for the installation of the remaining r.f. cavities at PETRA.

Sophisticated techniques for the analysis of hadron jets have now been developed, and these too do not reveal any signs of a new flavour. One new thing which is seen is that the multiplicity of produced charged particles increases at PETRA energies and does not follow an extrapolation from lower energies.

The hadron jets seen at PETRA also show signs of broadening, possibly due to gluon emission, and description of the observed behaviour in terms of the simple Feynman-Field picture of quark fragmentation seems to be insufficient. More detailed models including gluon effects seem to be called for.

PLUTO at its new site in PETRA has some results on two-photon processes, and quantitative details should follow soon. The quantum numbers of two-photon exchange allow direct access to quark-antiquark bound states which is excluded by a single photon mechanism.

Sigmund Brandt from the PLUTO collaboration described the result obtained from 1250 upsilon decays seen with the detector last year at DORIS. The jet analysis of these events is in good agreement with what would be expected for the production of three gluons, and a simple phase space description can be ruled out, although more elaborate phase space models cannot.

It is now clear that energy flow diagrams showing the hadronization of the gluons are not a good indicator of gluon production, as other mechanisms, including phase space, can easily reproduce the three-pronged pattern.

New results from SPEAR, including data from the Mark II and Crystal Ball detectors, threw some doubt on the previously-reported 3590, 3455 and 2820 MeV levels attributed to pseudoscalar charmonium states. In particular, the high gamma detection

The organizers and staff of the conference take a welcome break.

(Photo CERN 16.7.79)

capabilities of the Crystal Ball makes it an ideal instrument for studying the decay of J/psis into three gammas. While most of the Crystal Ball data was preliminary, all the J/psi into three gamma data has been analysed, and no sign of the 2820 has been seen.

Elsewhere in the charmonium spectrum, and in the study of the tau heavy lepton, experiments are convergent. The low energy electron-positron region, exploited by Adone in Italy, VEPP-2M in the USSR and DCI in France, still seems to be a good resonance hunting ground, and according to J.-E. Augustin of Orsay more work on specific exclusive channels could turn up evidence for new resonances.

Lepton production

Multilepton production by neutrinos seems to have progressed only slowly since last year. Although signs of exotic new phenomena might be difficult to spot, people have not yet given up hope. There are now consistent reports of a low level of production for muons of like sign. The steady accumulation of multimuon data from different types of experiment now means that the idea of what is meant by a 'rare' multimuon event has now changed. However only a few events with five outgoing muons have been seen.

Giorgio Matthiae presented new data from the CERN / Collège de France / Ecole Polytechnique / Orsay / Saclay collaboration studying the production of muon pairs by pions, kaons, protons and antiprotons at the SPS (see also page 257). This experiment gives an insight into the pion structure function and the results agree with the Fermilab data (see June issue, page 150). The comparison of both upsilon and background muon pair production by different beams gives useful information.

The Frascati / Harvard / MIT / Naples / Pisa collaboration studying the production of muon pairs at the CERN ISR has a few interesting events where energetic muon pairs (above about 16 GeV effective mass) are associated with unexpectedly large numbers of charged hadrons, the hadrons also being more directional than at lower dimuon energies.

Production of single photons from a study of high energy collisions in the ISR by an Athens / Brookhaven / CERN / Syracuse collaboration was reported by Chris Fabjan (see June issue, page 153). This study could be extended to probe the distribution of gluons in nuclear matter.

Erwin Gabathuler reported on experiments using high energy muon beams, where preliminary data is now available from Berkeley / Princeton / Fermilab and Bologna / CERN / Dubna / Munich / Saclay teams, as well as from the large European Muon Collaboration at CERN. These initial muon results are in broad agreement with each other and with data from the CERN / Dortmund / Heidelberg / Saclay neutrino experiment (see also page 256).

A bump in the squared momentum transfer dependence of the F_2 nucleon structure function (which describes the momentum distribution of the component quarks) previously reported by a Michigan / Fermilab experiment is not reproduced in the latest (but still preliminary) muon data. This bump, which showed up at high values of the energy of the produced hadrons, had led to speculation about possible new threshold effects.

Daniel Treille reported on charm production, indicating that results from a new CERN beam dump experiment agreed with previous beam dump data from the CERN / Dortmund / Heidelberg / Saclay detector (see March 1978 issue, page 80), the discrepancy between bubble chamber and counter statistics now having been ironed out.

Evidence for charm production has now been seen in a variety of experiments at the ISR, including diffractive production of charmed baryons by the Aachen / CERN / Harvard / Munich / Northwestern / Riverside group. Other signs of charmed baryons at the ISR come from old data from a Los Angeles / Saclay collaboration and more recently a CERN / Collège de France / Heidelberg / Karlsruhe group working at the Split Field Magnet.

This latter group has also reported charmed meson production (see April issue, page 76). These results are dependent on selection of events

Abdus Salam winds up the conference. He pointed out that higher energies from future machines could uncover whole new tribes of particles.

(Photo CERN 25.7.79)

with an intermediate K*, as previous experiments at electron-positron storage rings indicated that this provided the significant proportion of D meson decays. Treille hinted that this assumption might have to be reexamined.

A controversial spot was Bogdan Povh's report on the experimental status of baryonium. Povh said that he had hoped to be able to clear up the baryonium picture, but instead had to report that the situation was even more vague. Far from finding new states predicted by theorists, latest results assigned a bigger question mark to the 1940 MeV proton-antiproton narrow resonance candidate, now of some five years standing. Some preliminary reports did not confirm heavier baryonium candidates.

Clearly much more work is required from new experiments to sort out this potentially interesting spectroscopy. If future experiments do uncover a series of baryonium states, the 1979 Geneva Conference will certainly mark a nadir in the fortunes of baryonium.

Maurice Jacob gave a comprehensive review of hadronic jet physics. Different experiments are producing convergent results and the basic features of non-gluon jets seem to be well known. When searches are made for more subtle effects due to gluons, the experimental data seems to respond quite well. However the subject is not yet a closed book and there is still work to be done on understanding jet production mechanisms at today's energies before embarking on studies of jets from high energy proton-antiproton colliders.

Peter Weilhammer presented some nice results from the Amsterdam / CERN / Cracow / Munich / Oxford / Rutherford collaboration studying pion production by high energy beams at the SPS. This work has given the variation with energy of the pion-pion cross-section, always interesting to compare with other hadron cross-sections.

The Argonne data on polarized proton scattering (see October 1978 issue, page 347) has been extended to cover large scattering angles. These results have still to be explained, and to keep things on the boil there is now a hint of something new in neutron-proton data extracted from similar Argonne experiments using deuterium targets. Unfortunately these investigations will soon come to an end when the Argonne machine switches off.

Keith Barnham described new results from bubble chamber experiments at CERN using kaon beams from the SPS. This data gives a new handle on the low transverse momentum aspects of the quark model, indicating that pre-charm physics still has something to offer. Barnham warned that bubble chamber statistics were fast being submerged by spectrometer results.

In another corner of hadron physics, the A_1 meson is still the subject of debate after all these years, although some new phase-shift analysis from the Amsterdam /CERN / Cracow / Munich / Oxford / Rutherford pion studies seemed to be helping the dust to settle.

Tony Hey of Southampton gave a systematic review of the methodology of hadron spectroscopy. Although it cannot be described as a proper QCD mechanism, a scheme using single gluon exchange contributions seemed to offer an attractive explanation for the shortage of some baryons.

The Future

The final afternoon of the conference was given over to future developments. Carlo Rubbia reviewed the major project under way to convert the SPS proton synchrotron at CERN for use as a storage ring to collide protons and antiprotons (see September 1978 issue, page 291 and March 1979 issue, page 16). Rubbia was confident that the luminosities in the new collider would produce ample supplies of intermediate vector bosons.

Looking further ahead, Marcel Vivargent painted a picture of Europe's requirement for high energy machines in about ten years' time. He hoped that firm recommendations would soon emerge for complementary electron-positron and electron-proton machines.

And so to Salam's concluding talk. He hinted that increasing energies could uncover whole new families of quark/lepton multiplets, responsible for as yet unseen 'tribes' of new particles. Perhaps the particles we now know are just those confined in a small corner of Nature's energy scale.

Such an explosion in the numbers of 'elementary' particles might mean that even the quarks are not the basic layer in the structure of matter, and there might be a further stratum of 'pre-quarks' underneath. If so, then future generations of physics experiments might try to measure the pre-quark structure of quarks in much the same way that today's experiments study the quark structure of hadrons.

While some people might not relish the idea of so many particles still to be discovered, Salam maintained that Nature shows no economy in structures, only in principles, and much more ground will have to be covered before we unearth the most economic set of basic principles to describe the structure of matter.

Beauty uncovered?

Ever since the discovery of the upsilon at Fermilab in 1977, physicists have been hoping for a sign of naked beauty, the fifth quark flavour.

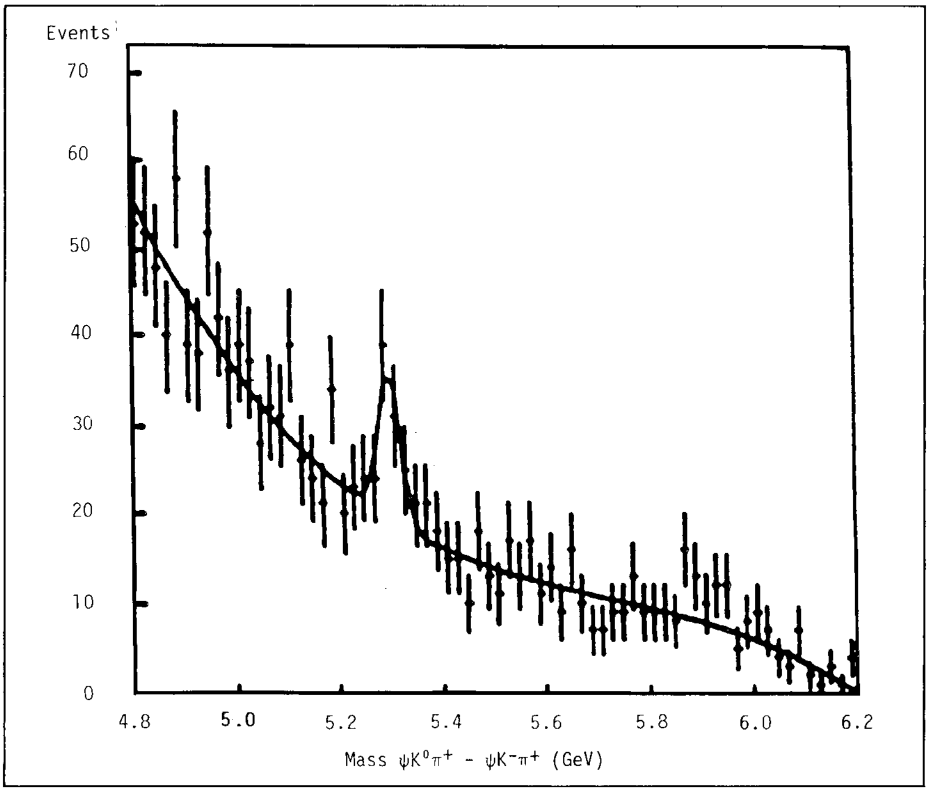
Just as the J/psi, a bound state of a charmed quark and its antiquark, heralded the charm age, so the upsilon indicated that a fifth dimension in hadron spectroscopy was there to be discovered.

Now a CEN-Saclay / Imperial College London / Indiana / Southampton collaboration working at the CERN SPS 400 GeV proton synchrotron has seen preliminary evidence for a resonance at 5.3 GeV in the mass spectra of the J/psi plus kaon plus pion combination produced by high energy pion beams. More data has to be taken, but the candidate beauty signal is in line with theoretical predictions.

The experiment analyses the hadrons produced along with J/psis. It triggers on high energy muon pairs, and the J/psis are separated off-line. So far some 10 000 J/psis have been found in these muonic triggers, but this data sample is to be considerably increased.

Muons and hadrons are produced when a high energy negative pion beam hits a beryllium target. The vertex spectrometer consists of the 2 m-diameter Goliath magnet equipped with proportional chambers containing some 40 000 wires.

The momentum of the energetic positive and negative muon pairs is analysed in an 8 m gap before the downstream muon filter. This gives a high resolution (1–2 per cent at the J/psi mass), enabling the J/psi and the neighbouring psi prime (590 MeV heavier) to be separated. Usually in hadronic experiments the psi prime appears as a shoulder on the high energy side of the J/psi signal.



Preliminary data from an experiment at the CERN SPS showing an enhancement at 5.3 GeV in the mass spectrum of the J/psi plus kaon plus pion combination produced by high energy pion beams. This could be the first evidence for bare beauty, the fifth quark flavour.

Originally, the experiment was designed to look for naked charm mesons produced in association with J/psis. Although some evidence for associated charm has been seen, this initial aim has been put to one side while the search concentrates on naked beauty.

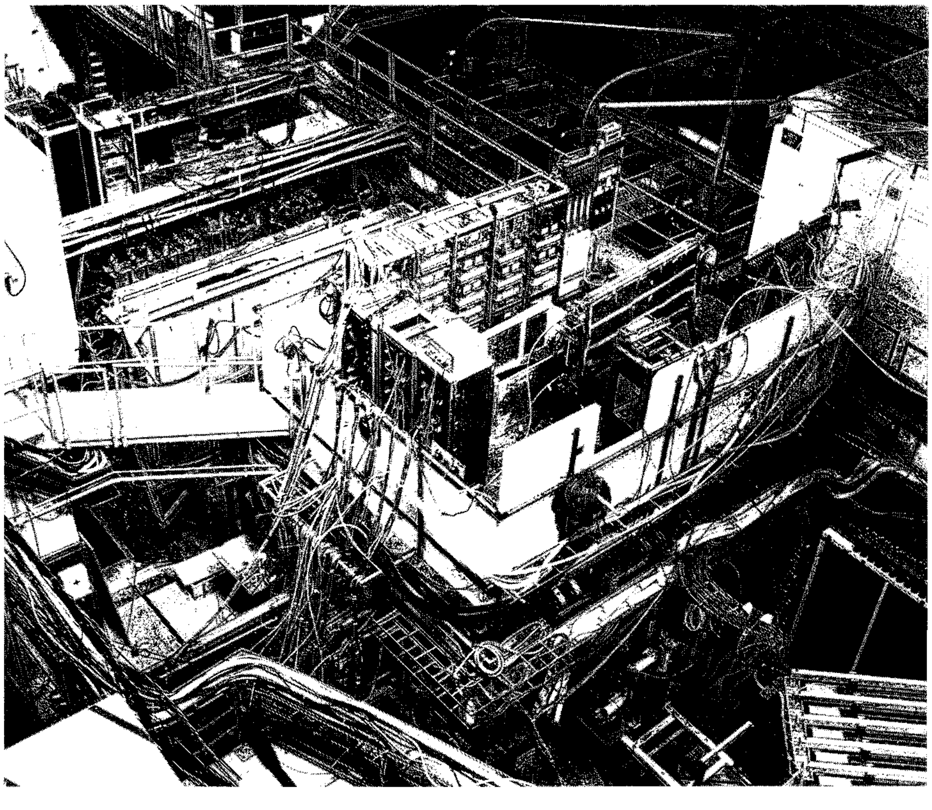
Studying hadrons produced in association with J/psis is potentially a good way of looking for beauty. The hidden charm of the psi is provided by the weak decay of the beauty quark, while the heavy mass of the psi restricts the number of additional hadrons which can be produced, favouring simple final states.

A sample of 6700 J/psis collected using 140 and 150 GeV negative pion beams showed some early signs of an enhancement near 5.3 GeV in the J/psi plus kaon plus pion spectra. Interest in this signal began to grow when theoreticians predicted that the decay of a beauty meson could produce an enhancement in the J/psi plus kaon spectrum.

While the experiment sees no enhancement in the psi plus kaon mass spectra, something is seen in the psi plus kaon plus an additional pion. Recent theoretical arguments have proposed that the energy of the hadronic system recoiling against the J/psi favours the production of a kaon and a pion, rather than a single kaon.

Adding new data at 175 GeV, the 5.3 GeV signal shows up clearly in psi plus neutral kaon plus positive or negative pion, and in psi plus negative kaon plus positive pion charge modes. Spectra with positive kaons do not show the enhancement, but the experimenters think that this is due to problems of positive kaon contamination by protons.

If further data confirms that this is the beauty meson, there should be plenty more of them waiting to be discovered higher in the mass spectra. Because it is the J/psi which unlocks the door to this new spectrum, hadronic experiments producing high energy lepton pairs will be in the forefront of this new search.



View of the CEN-Saclay / Imperial College London / Indiana / Southampton experiment studying J/psi plus hadron combinations using the Goliath spectrometer (centre). The 8 m gap between the target and the downstream muon filter (top left) gives high resolution (about 1–2 per cent at the J/psi mass).

(Photo CERN 200.7.79)

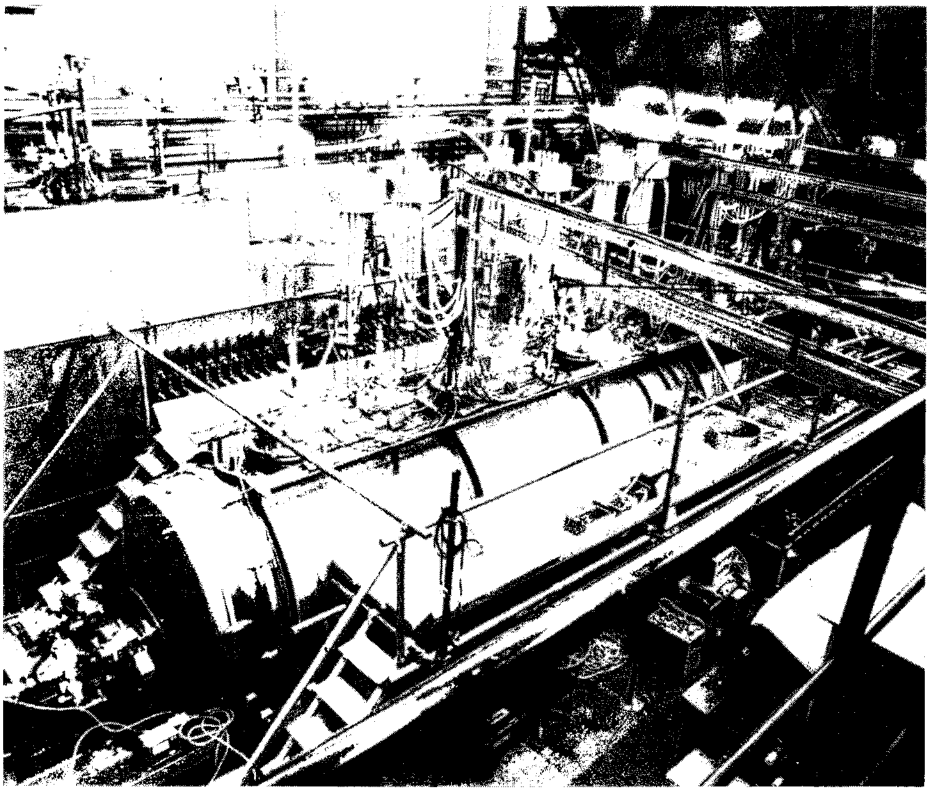
Around the Laboratories

KARLSRUHE
Superconducting accelerator completed

A superconducting proton test linac, prototype for accelerators with low particle velocities, has been completed at Karlsruhe. An energy of 4.5 MeV with a beam current of 150 μA (100% duty cycle) was obtained, and there have been more than 1000 hours of high field operation of the superconducting resonators and more than 3000 hours operation of the cryogenic system. Energy gradients of 1 to 2 MeV/m have been obtained reproducibly for several years without any degradation and without demounting resonators for additional surface treatment.

The linac project started under A. Citron in 1970, and M. Kuntze became project leader. The linac uses a 750 kV Cockcroft-Walton for njection, and the beam is chopped and tightly bunched at 90 MHz with less than 1% loss of particles. The bunches have a length of 0.7 ns and a total energy spread of 3.8% up to beam currents of 400 μA.

The accelerator has a helical structure operating at 90 MHz, selected to avoid large dimensions at low energies, and an Alvarez structure at 4 MeV to study the problem of medium-energy structures and the frequency jump. The system is subdivided into nine helix resonators with a modular length of 0.5 m and a diameter of 0.2 m and one Alvarez resonator 0.25 m long with a diameter of 0.29 m. The resonators are made of niobium sheet, and the helices of niobium tubing. With the exception of the first three, all the helix resonators have been built identically and are interchangeable. The helix design was made in such a way as to keep the peak electric fields at the helix below 16 MV/m corresponding to energy gradients of 1 to 2 MeV/m.



General view of the superconducting proton test linac at Karlsruhe. The cryostat is 8 m long and has a diameter of 1.5 m. The tuners for each helical resonator are mounted on top of the cryostat. Beam enters from the injector on the right and emerges into the energy analyser on the left.

(Photo Karlsruhe)

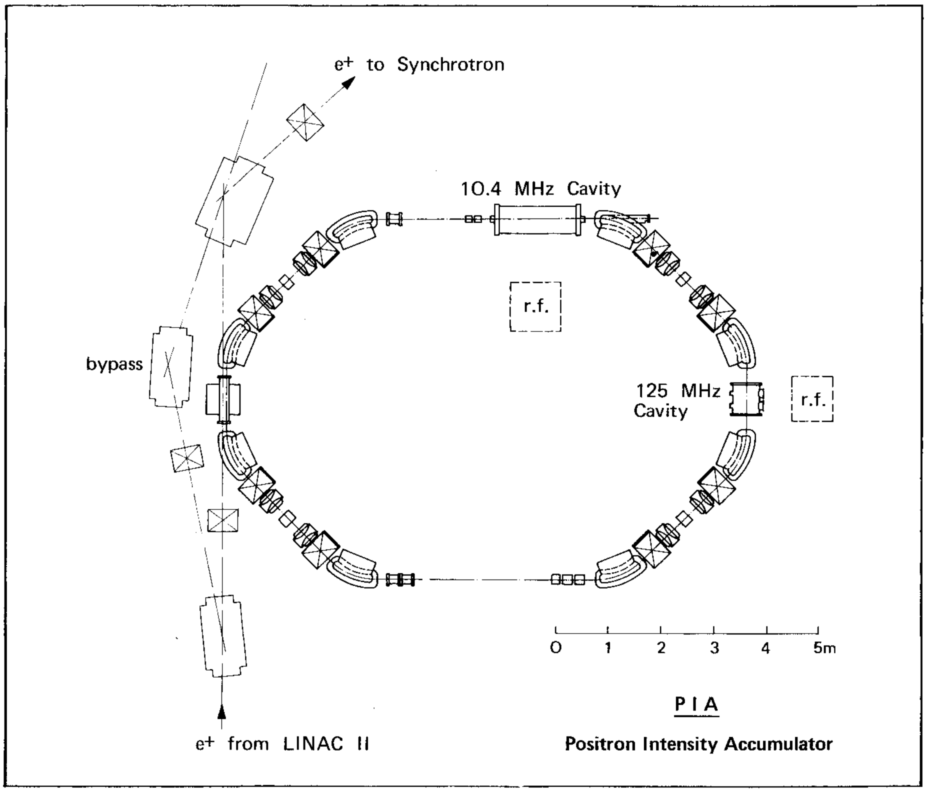
Several technological problems had to be overcome. The most difficult was taming the structure, particularly from the point of view of stabilizing frequencies with several helices, which have a tendency to vibrate in various mechanical modes. This was surmounted in 1975 by carefully isolating from environmental oscillations and by adding a fast feedback system. Another problem was to achieve surfaces of adequate quality and to obtain high accelerating fields. For that purpose several surface treatments were applied to each helix resonator and, as the surface treatment techniques improved, the obtainable field values were progressively raised well above design values. Helix resonator 1 has been used since November 1975 without any significant degradation of the superconducting properties. Helix resonators 2 and 3 have been used since February 1977 showing the same reliability over long periods. In April 1978 the last helix resonators were completed and measurements of the accelerator performance began.

The proton beam is guided through the accelerator by six small superconducting quadrupole doublets (0.3 m long). They operate in the persistent current mode (10^4 hours time constant) at gradients up to 30 T/m. Stray fields are avoided by superconducting lead shields.

The linac was connected to a 300 W refrigerator allowing operation at a temperature of 1.8 K with superfluid helium. The cooling time of the linac (2 tons of stainless steel and 0.5 tons of niobium) from room temperature to 1.8 K with a subse-

1. Plan of the new positron storage ring PIA at DESY, where it is now working as positron accumulator for PETRA.
2. Photograph taken during the installation of PIA, showing the magnet structure. The piece of vacuum pipe in the foreground had still to be substituted by the 125 MHz r.f. cavity.

(Photo DESY)



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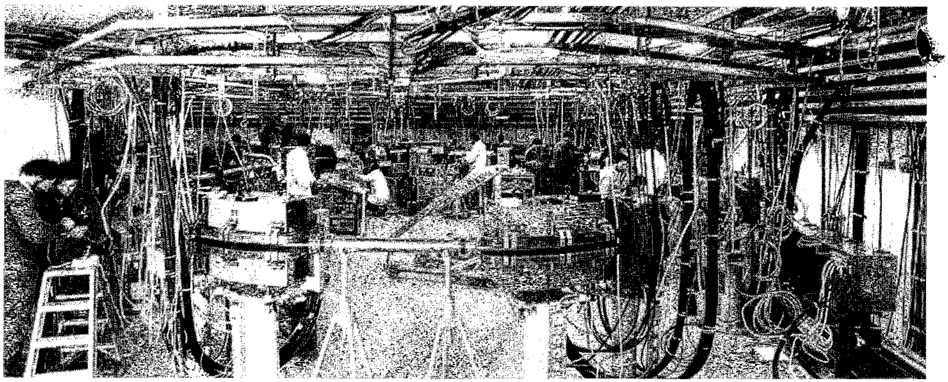


2.

quent filling with 500 l of helium was about 60 hours. In May the complete linac was brought into operation and the proton beam was accelerated and analysed. These measurements were repeated in August 1978 and at the end of the year. The linac project was then terminated with the experience of more than 3000 hours cryogenic operation and more than 1000 hours of high-field operation of the superconducting resonators.

The design energy gradients were obtained after clearing low-level multipactoring. By measuring the energy of the beam, the energy gradients of successive resonators were obtained. The maximum energy gain was achieved by adjusting the phase between the r.f. field in the resonator and the reference phase. A maximum beam energy of 4.5 MeV was obtained, which is extremely close to the calculated value.

Establishing the right velocity profile gave minimal energy spread of the beam; it was measured to be 114 keV or 2.5%. Operation of the focusing system was as expected, with the exception that it was only possible to extract 85% of the input beam. Beam current is lost at known positions along the linac, but no time was spent improving the alignment of the complex system. Finally it was possible to accelerate and extract a beam current of 150 μA from a 176 μA input beam. The stability of the linac was excellent; the machine could be shut down for long periods and the beam reappeared at the target, without any adjustments, when the accelerator was turned on again.

The linac project has been a basic research and development programme on the applicability and feasibility of r.f. superconductivity. It gave rise to several other projects in this field, such as the superconducting r.f. separator in the beamline to the Omega spectrometer at CERN and a test section of a superconducting post-accelerator for the Heidelberg tandem.

The application of superconducting accelerating cavities for large electron-positron storage rings is now being investigated. A first step is the construction of a cavity (a joint CERN/DESY/Karlsruhe project) to be installed at the end of this year in the DORIS ring at DESY.

DESY
PIA taking over

For about twelve months the DORIS storage ring at DESY has been used as a positron accumulator every time the PETRA electron-positron ring had to be filled. Now the Positron Intensity Accumulator ring PIA (see October 1977 issue, page 326), has taken over this task, leaving DORIS once more completely free for high energy and synchrotron radiation research.

PIA was designed in 1977 and most components were built in 1978. During a four-week shutdown in February of this year ring components were installed in a new small hall at the end of Linac II. After installation of the r.f. systems in May, positrons were successfully stored in PIA on 9 June. On 4 July PETRA was filled for the first time from PIA via the synchrotron. Since then PIA has run routinely for PETRA.

Linac II has been slightly modified to provide 450 MeV positron pulses about 100 ns long at a rate of 50 Hz. Present operation consists of injecting and accumulating nine Linac pulse trains in PIA, where they are captured by a 10.4 MHz first-harmonic r.f. system. Longitudinal damping forms a bunch of about 80 cm length containing up to 10^{10} positrons. At the end of the accumulation sequence, a second r.f. system at 125 MHz is powered, reducing the bunch length to 25 cm. At this point the bunch is injected into the synchrotron where it is accelerated to the PETRA injection energy of 6 GeV. This procedure is repeated four times per second.

PIA has been built by a team led by Arno Febel and Günter Hemmie. It is an excellent example of the state of the art of electron storage rings. The small ring (11 × 7 m) consists of eight of each of the usual bending, quadrupole and sextupole magnets. The bending magnets are of the combined function type including a defocusing gradient. The radius is extremely small in order to provide fast radiation damping. These magnets were specially designed for PIA.

Some machine parameters surpass practical requirements. The vacuum provides a beam life of several minutes while the beam is only stored for a quarter of a second. The maximum number of positrons which have been stably accumulated in a single bunch was 8.4×10^{10}. This corresponds to an average circulating current of 140 mA and exceeds by far the requirements for PETRA injection. At present PETRA is running at 2×15.8 GeV with peak currents of about 10 mA per beam (5 mA per bunch and 2 bunches per beam). Thanks to PIA, the total time needed to reach this current has been reduced to less than five minutes.

FERMILAB

Charm decay visible in big bubble chamber

In recent months evidence has been accumulating from emulsion experiments that the measured lifetime of charmed particles must be in the vicinity of a few times 10^{-13} seconds (see June issue, page 152). The excellent spatial resolution of the emulsion technique has been exploited to measure accurately decay distances much shorter than a millimetre.

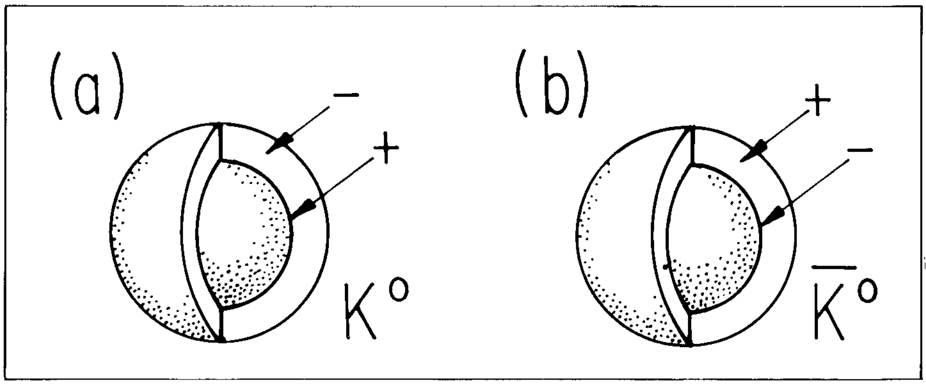
Most of the emulsion events have involved charged particles decaying into three charged secondaries, since neutral decays involve difficult volume scans rather than track-following. Emulsion techniques involve the use of auxiliary detectors such as bubble chambers and electronic detectors to help locate events in the emulsion stacks and to determine the momenta and identities of the secondary particles. The total number of neutrino-induced events located to date in emulsions is less than a thousand and the reported number of charmed decay candidates is small, although larger numbers are expected in the near future.

Neutral decay of a charmed particle observed in a Fermilab bubble chamber experiment by a Berkeley / Fermilab / Hawaii / Seattle / Wisconsin collaboration. The decay is consistent with a D^0 meson decaying into a positron and a negative kaon, where tracks 7 and 8 are a positron and a negative kaon respectively. The decay distance is 6.7 mm. The positron does not project back to the primary vertex. Track 2 is not associated with the decay. The neutrino enters the picture from below.

Much larger neutrino event samples are available in bubble chamber experiments, but until recently it was considered unlikely that the very short decay distances of charmed particles could be detected in bubble chambers of the size used for neutrino experiments. In these large chambers the bubble size employed is about 500 microns, comparable with the decay paths so far observed in emulsion events from the low energy neutrinos (horn-focused spectra) used for exposures.

Furthermore, the high multiplicity of forward tracks tends to obscure close-in interactions or decays occurring within about 5 mm of the primary vertex. Thus until now the best that bubble chamber experimenters have been able to do is to

Charge distributions of (a) a neutral kaon, and (b) its antiparticle, according to the quark model. The heavier strange quarks are confined to smaller radii, giving an inner charged core. Because the neutral kaons are spinless, the charge distributions are spherically symmetric.



place upper limits on charmed decay lifetimes.

Now two different groups working with the Fermilab 15 foot bubble chamber have been able to detect visible decays of charmed particles, both charged and neutral, by selecting for close examination only those dilepton events expected to consist almost entirely of semi-leptonic decays of charmed particles. In particular, the negative muon plus positron dilepton events induced by neutrinos should result from charged current interactions accompanied by either charmed meson decay or charmed baryon decay.

The kinematics of these decays means that the light positron is occasionally emitted at a large angle, especially for positrons with low laboratory momentum. Background processes simulating such dilepton events are rare. The more energetic charmed particles will have time-dilated laboratory decay distances and may be observable.

The first definitely established bubble chamber charmed particle visible decay was observed by members of the Berkeley / Fermilab / Hawaii / Seattle / Wisconsin collaboration during routine checking of 35 negative muon plus positron dilepton events, part of a subsample of 11 000 charged current neutrino events already located in a neon-hydrogen exposure. This first event, consistent with the decay of a D^0 meson, includes a negative kaon/positron vee some 7 mm from the primary vertex. The neutral kaon decay background is excluded by the high value of the negative pion/positron invariant mass. The positron track does not extrapolate back to the primary vertex, the distance of closest approach being 1200 ± 300 microns.

Three other charmed decay events have been observed in this same sample: one more neutral meson decay, one charged decay, and one 'uncertain' event where the track obscures the decay path and the charge of the particle cannot be established. All events are of high visible neutrino energy and charmed particle energy.

A unique feature of this experiment was the high value of the mean neutrino energy (90 GeV), which increases the probability of decay distances greater than the resolvable 5 mm. A maximum likelihood method has been used to determine lifetime values for D^0 and D^+ mesons, assuming equal populations, utilizing the observed decay distances plus the distribution of minimum resolvable distances from events where no decay was observed. The result for both lifetimes was about 3×10^{-13} seconds, within a factor of 2.

In another Fermilab bubble chamber experiment, a Brookhaven / Columbia collaboration has obtained a large negative muon plus positron dilepton sample with a series of wide-band horn-focused neutrino exposures in a neon-hydrogen mixture, yielding over 100 000 charged current neutrino events.

This sample is large enough to produce a D bump in the $K^0\pi^+\pi^-$ mass spectrum corresponding to about 60 events of the hadronic decay $D^0 \rightarrow K^0\pi^+\pi^-$ where there are no missing particles. Thus this experiment has a unique advantage of knowing the distribution of D^0 momenta in the exposure, and for any given lifetime experimenters can predict the number of D decays which should be observable in their dilepton sample of 250 events. In fact, they observe one event, which is consistent with a lifetime of 5×10^{-13} seconds.

Neutral kaon charge structure

A Chicago/Wisconsin/ETH Zurich team has recently isolated the electromagnetic structure of the neutral kaon. The experiment, using an idea proposed by Zel'dovich many years ago, had greater sensitivity and was less prone to systematic uncertainties than several earlier attempts (see May 1977 issue, page 145).

Feinberg first pointed out that the K^0 may have a charge structure. The K^0, unlike some neutral particles, for instance the pion, differs from its antiparticle. If a particle and its antiparticle are truly identical, the charge distribution must vanish everywhere since conjugate charge distributions are required. Thus the π^0 is truly neutral while the K^0 need not be.

In the framework of the quark model, the K^0 consists of an anti-strange quark of charge $+1/3$ $(\bar{s})$ and a normal quark of charge −1/3 (d). Since an $\bar{s}$ is thought to be more massive than a d, the $\bar{s}$ will be confined to smaller radii and thus give the K^0 a positively charged core. Because the K^0 is spinless, its constituent charge distributions are spherically symmetric so that the quark mass splitting results only in a radial distribution for the charge. The $\bar{K}^0$ antiparticle will have the opposite distribution.

Because of the spherical symmetry, there will be no force between a K^0 and an electron unless the electron is inside the K^0, in which case there will be an attractive force. In effect, a measurement of the magnitude of this force yields a determination of the mean square charge radius of the K^0.

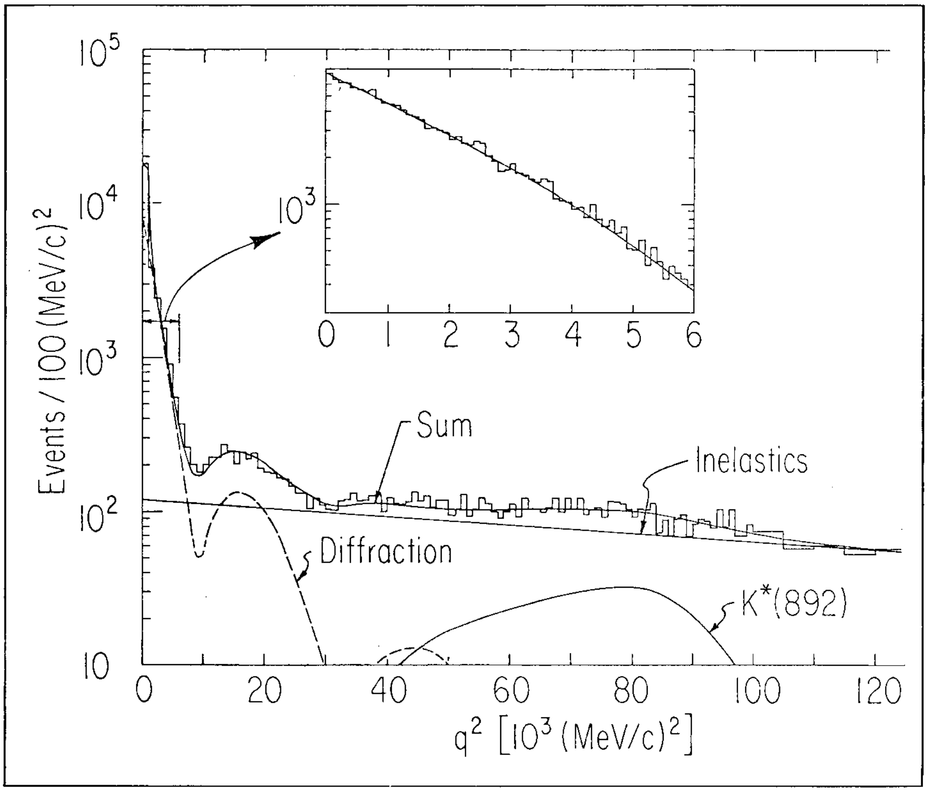
The measurement is accomplished by noting that since the force will be repulsive for $\bar{K}^0$, the interaction of long-lived K_L mesons (which are almost equal mixtures of K^0 and $\bar{K}^0$) with electrons will 'regenerate' short-lived K_S mesons.

The experiment consisted of a detailed study of the angular distribution of K_S regeneration from a lead target. The strong force regenerates much more copiously than the electron scattering. In the exact forward direction, the regeneration from the atomic electrons is coherent with that from the nucleus so that an interference term between the two processes is present. Away from the forward direction, the processes are incoherent and there is essentially pure 'nuclear' regeneration, since the electron contribution can be neglected. A comparison of the rate exactly at zero degrees with that extrapolated to zero degrees from larger angles yields a measurement of the interference term, expected to be about 3 per cent in the energy range of the experiment.

The measurement was carried out in the M4 neutral beamline at Fermilab. The forward and finite angle regeneration were studied independently and simultaneously with two optimized targets situated in two sharply separated neutral beams viewed by the same spectrometer. The roles of the beams were interchanged every pulse by alternating the targets about two hundred thousand times. This procedure allowed the minimization (or elimination) of corrections due to multiple scattering in the targets, CP violation in the K^0 decay, and relative normalization between the two targets.

Over forty million events were recorded. Two diffraction minima are seen and a signal due to Primakoff production of neutral K*(892)s has been isolated.

The magnitude of the mean square charge radius was determined in each of seven momentum bins. An important check of the result is that it be independent of kaon momentum. The result is a constant, independent of momentum, and negative. The inclusion of all systematic uncertainties results in the value $-0.054 \pm .026 \times 10^{-26}$ cm^2. The value is in good agreement with recent theoretical estimates, and is in fact negative as the naive quark model would suggest.



Results from a Chicago/Wisconsin/ETH Zurich team studying the electromagnetic structure of neutral kaons. An analysis of over forty million events gives this angular distribution for the regeneration of short-lived kaons. Two diffraction minima are seen and a signal due to Primakoff production of neutral K (892)s has been isolated. The results enable the interference between regeneration from atomic electrons and target nuclei to be determined. The expanded view shows the way the results are extrapolated to zero degrees.*

CERN
Data from the North

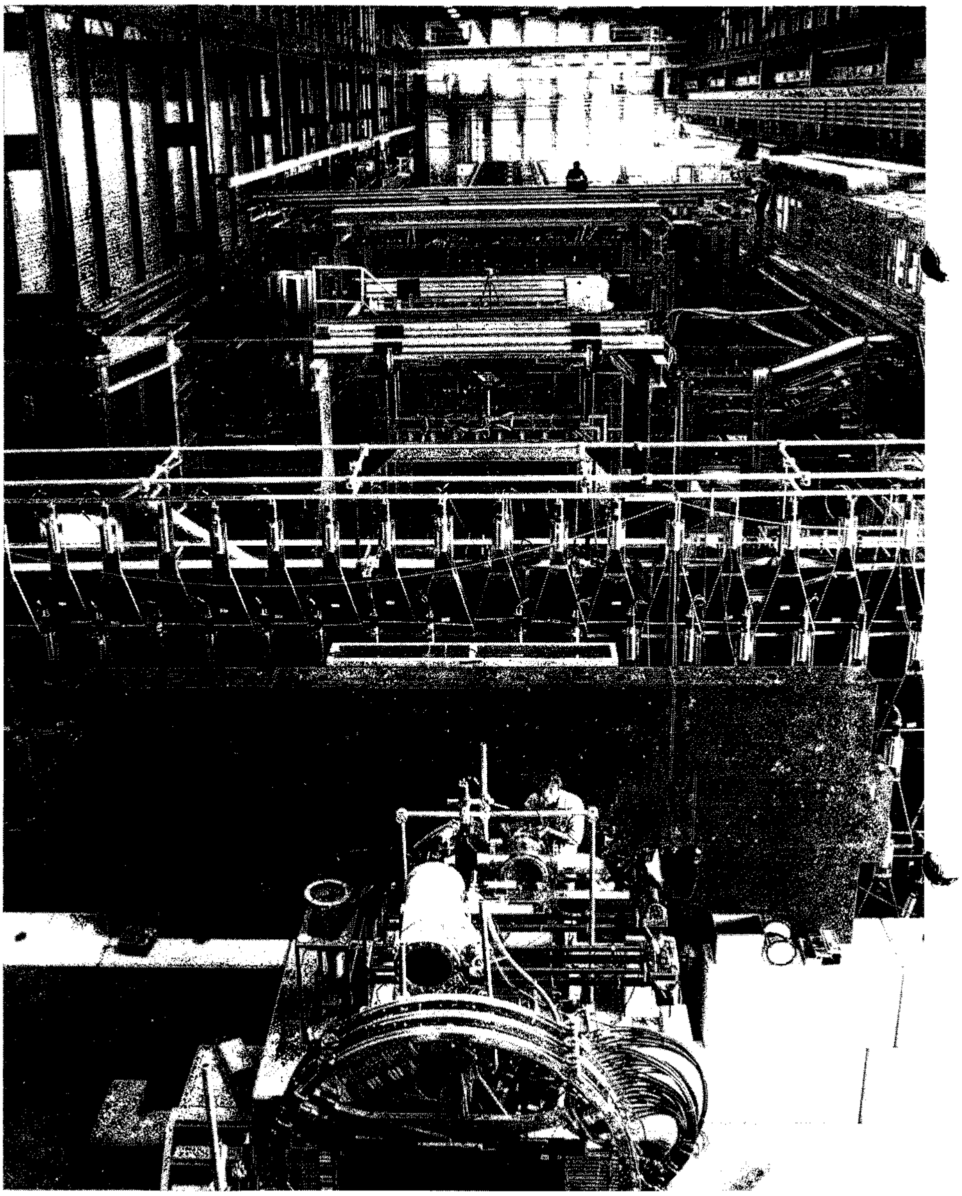
One of the features of the Geneva High Energy Physics Conference (see page 243) was the new data coming in from the North Experimental Area at the CERN SPS 400 GeV proton synchrotron. These results nicely complement the studies which have been under way at the SPS West Experimental Area since 1977.

Although much of the data is still preliminary, these results are likely to be the first of a new batch of physics which will extend the already significant contributions from the SPS.

The North Experimental Area is situated on CERN's Prevessin site, separated from the main (Meyrin) CERN site by several kilometres and wholly on French territory. As well as being the scene of physics with high energy extracted beams from the SPS, the Prevessin site is also the home of the SPS control centre and power supplies.

Two experimental halls are now in action in the North Area. Hall EHN1 houses several hadronic experiments, while Hall EHN2 is the home of two large detectors using muon beams. A third underground hall is under construction and will enable experiments to be carried out using high intensity beams without interfering with neighbouring physics.

The first North Area experiments to report results are a CERN / Collège de France / Ecole Polytechnique / Saclay collaboration studying muon pair production by different high energy hadron beams (see next page), and the two big detectors using muon beams — the European Muon Collaboration and the Bologna / CERN / Dubna / Munich / Saclay team.



View of the EHN2 muon hall in the North Experimental Area of the CERN SPS. The high energy muon beam enters at the bottom of the picture and passes through two large experiments — first the European Muon Collaboration, and subsequently the 50-metre magnetized iron spectometer of a Bologna/CERN/Dubna/Munich/Saclay team.

(Photo CERN 30.7.78)

Already these three experiments have contributed a great deal to our knowledge of the structure functions of nucleons and pions and will go on to provide more precision information on the structure of hadrons.

The European Muon Collaboration is certainly an easy way to describe a CERN / DESY / Freiburg / Kiel / Lancaster / LAPP (Annecy) / Liverpool / Oxford / Rutherford / Sheffield / Turin / Wuppertal collaboration comprising over some 70 physicists. It uses a forward spectrometer consisting of a wide aperture magnet together with drift and proportional chambers to measure the momentum of the muons and hadrons.

Triggering on scattered muons is provided by three planes of scintillation counters before and after a magnetized iron block, which are able to eliminate slow muons coming from pion decay.

Data has been taken using 280 and 250 GeV positive muon beams using both iron and hydrogen targets, and about 15 per cent of the raw data has been analysed.

A clear signal of J/psi production was soon revealed in the forward spectrometer, indicating that this spectrometer is a valuable tool for studying the virtual photoproduction of J/psis.

The Bologna / CERN / Dubna / Munich / Saclay collaboration has large toroidal iron spectrometers, 2.7 m in diameter, surrounding a 50 metre-long target. Proportional counters and liquid scintillators are inserted into the iron to record the trajectories of the muons as they pass through the iron. The experiment is downstream of the European Muon Collaboration and uses the same muon beam.

Iron for the spectrometer was supplied by the Soviet Union, and the properties of the long magnet are such that muons are trapped inside the torus, making for high detection efficiency. Some 20 per cent of the data amassed so far has been analysed.

Details of the nucleon structure functions extracted from preliminary data samples of both muon experiments are in good agreement with each other, with a Berkeley / Princeton / Fermilab muon beam experiment and with data from the CERN / Dortmund / Heidelberg / Saclay neutrino counter experiment.

The European Muon Collaboration results show that the F_2 structure function (which gives the quark momentum distribution inside the proton) varies with the squared momentum transfer in the way predicted by quantum chromodynamics over a wide range of energy transfer to the produced hadronic system.

Previous results from a Michigan / Fermilab experiment had reported signs of a bump in the squared momentum transfer dependence of the structure function at higher masses of the hadronic system, W. This 'high-W' anomaly had led to speculation about the onset of new threshold effects such as 'colour brightening', in a way which brings to mind the 'high-y' anomaly reported several years ago in neutrino experiments, and which was subsequently erased by better statistics (see July/August 1977 issue, page 244). The high-W anomaly is not seen in the new muon data.

While the main thrust of these experiments will continue to be in precision measurements of structure functions, surprise behaviour by hadrons produced by high energy muon beams cannot be ruled out.

Looking inside hadrons

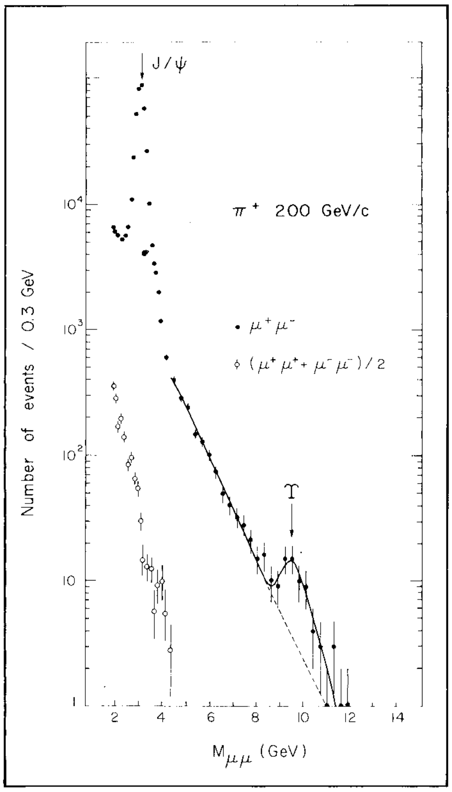
One of the first experiments in the North Experimental Area of the SPS to produce data is a CERN / Collège de France / Ecole Polytechnique (Palaiseau) / Orsay / Saclay collaboration studying the production of muon pairs by different types of hadrons.

This gives a window on the dynamical quark structure of unstable hadrons, such as pions and kaons, which cannot be studied in the same way as nucleons through deep inelastic lepton scattering.

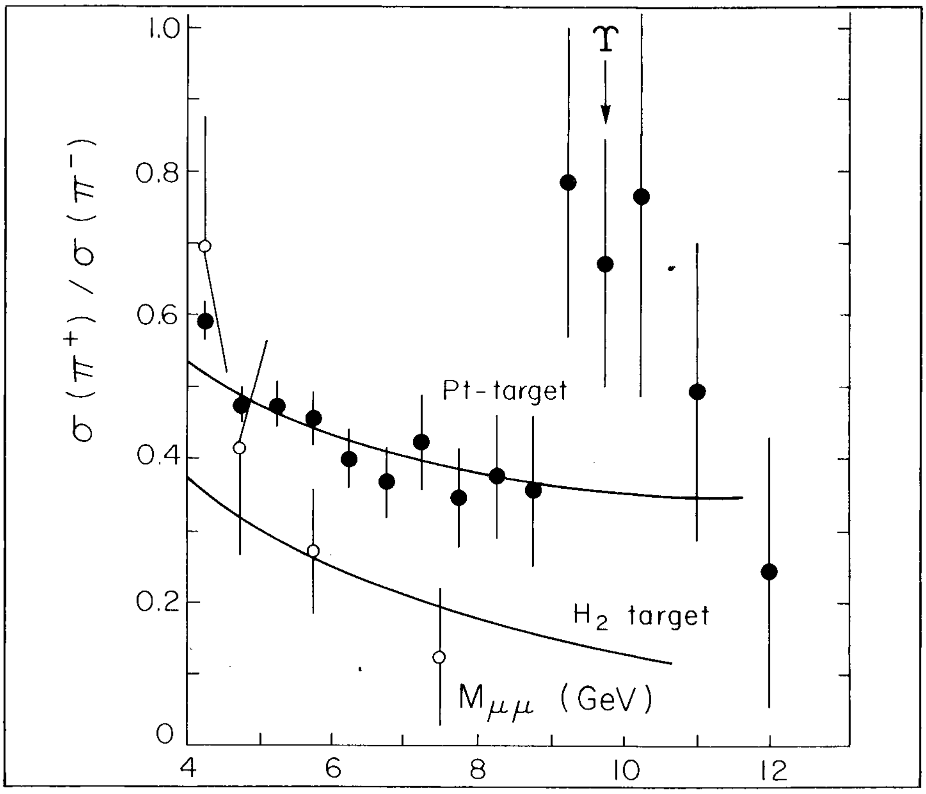
The incident particles come from an unseparated secondary beam. Antiprotons and kaons are tagged by differential Cherenkov counters, and positive pions by threshold Cherenkovs.

Muon pairs produced at 200 and 280 GeV in a platinum target are analysed in a large acceptance spectrometer. The apparatus consists of a superconducting magnet of 1.6 m bore and 31 planes of multiwire proportional chambers containing a total of 26 000 wires (the largest measuring 20 m^2) together with muon filters. Use also of a liquid hydrogen target allows the atomic number dependence of muon pair production to be measured.

Data from a CERN/Collège de France/Ecole Polytechnique/Orsay/Saclay collaboration studying the production of muon pairs by 200 GeV positive pions, showing clear J/psi and upsilon signals. This is the first time that upsilons have been produced by pion beams.



For the first time the upsilon particle, discovered by the Lederman team at Fermilab in 1977 using a 400 GeV proton beam, has been produced by pions. The pion-produced upsilons are seen at an average mass of 9.7 GeV with a very clean signal-to-background ratio of about 4 to 1. However the experiment cannot resolve the three separate upsilon resonances. The upsilon is also seen in the negative pion data, but with more muon pair continuum background due to the charge asymmetry of the production mechanism.



More data from a CERN/Collège de France/Ecole Polytechnique/Orsay/Saclay collaboration showing the relative production of muon pairs by positive and negative pions for platinum and hydrogen targets. Away from the upsilon resonance, the continuum production levels are proportional to the square of the electric charges on the participating quarks, so that the ratio of positive to negative pion data converges to an asymptotic value. At the upsilon, the ratio jumps to unity.

Upsilons are produced about thirty times more copiously by pions than by protons. This is because pions contain an energetic antiquark, which fuses hadronically with one of the target proton quarks to form an upsilon. With protons, the production depends on rare virtual antiquarks.

The experiment has also provided valuable information on the production of the J/psi by different types of incident hadrons. Subtracting the effects due to the J/psi and upsilon resonances gives the continuum muon pair spectrum, attributed to the 'Drell-Yan mechanism' where a quark and an antiquark from the colliding hadrons annihilate electromagnetically into a heavy photon, which subsequently decays into a characteristic muon pair.

The continuum muon pair production cross-section is proportional to the square of the (fractional) electric charge of the annihilating quarks. Therefore the ratio of cross-sections for incident positive and negative pions is expected to converge at large muon pair masses to an asymptotic value of 1/4 for an isoscalar target. The corresponding value in platinum is about 1/3 because of the neutron excess, and the value in hydrogen is 1/8.

Assuming this production mechanism, measurements of the effective mass and longitudinal momentum of the muon pair determine the fractional momenta carried by the annihilating quarks.

Using the Drell-Yan model as input allows extraction of the hadron structure functions, which describe the dynamics of the hadron constituents. These results can then be compared with structure functions from other experiments.

The pion structure function follows similar behaviour as that measured by a Chicago/Princeton experiment at Fermilab (see June issue, page 150). The experiment at CERN has obtained data from positive as well as negative incident pions, which enables the contribution of the 'sea' of virtual quarks and antiquarks to be fixed. The fractions of the pion momentum carried by the valence and sea quarks agree with quark model predictions.

Quantum chromodynamics calculations predict corrections due to gluon effects which increase the muon pair production level to about twice that of the simple Drell-Yan model. These predictions can be checked directly by using incident antiprotons whose structure functions are the same as those of protons, known from deep inelastic lepton scattering experiments.

The experiment is now collecting antiproton data at 150 GeV and the results will be an important test of our understanding of muon pair production. Muon pairs produced by negative kaons are also being studied, and will provide the first measurements of the kaon structure function.

Little bubble chamber

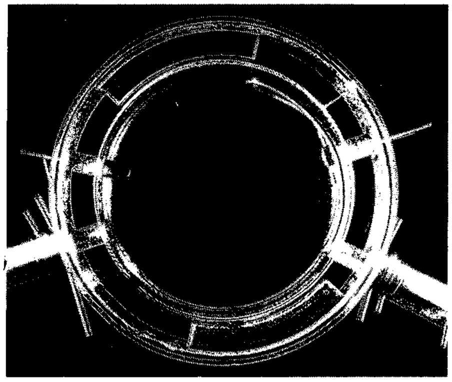
What is probably one of the smallest bubble chambers ever to operate for physics, and certainly the smallest rapid-cycling chamber, recently completed its first data taking run in a high energy pion beam in the North Experimental Area of the CERN 400 GeV proton synchrotron.

Only twenty centimetres in diameter and containing just one litre of liquid hydrogen, the rapid-cycling chamber is designed to achieve the high resolution required to directly detect the production and decay of charmed particles in high energy hadronic interactions. This refine-

1. A view of the new 20 cm-diameter high resolution rapid-cycling bubble chamber built at CERN to search for charm production in hadron collisions.

(Photo CERN 20.9.78)

2. The little chamber has already produced a strong candidate for the first example of the production of a pair of charmed particles by a hadron beam. A decay occurs about 0.5 mm from the main vertex, and a second decay vertex (arrowed) is seen 1.3 cm downstream. The strange particle vee decay (top right) comes from the production vertex or the first decay vertex. This pattern is what would be expected for the production and decay of a charmed particle pair. The coarse-grained horizontal tracks are due to high energy pions passing through the chamber early in the expansion cycle. The circle under the scale shows for comparison the size of a single bubble in the 3.7 m BEBC chamber.



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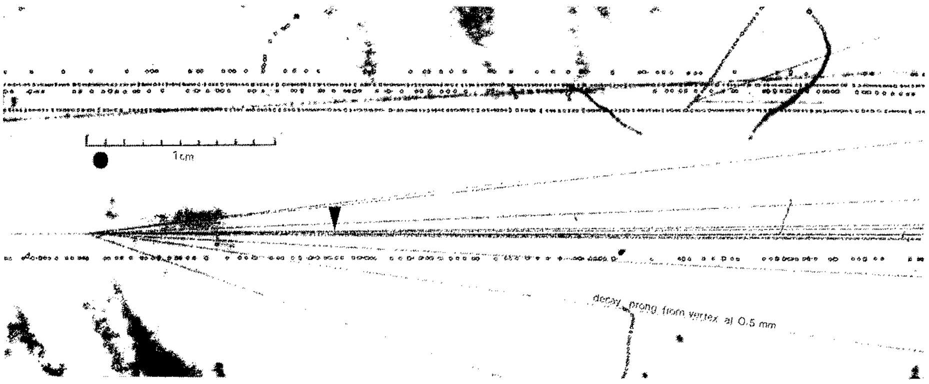


2.

ment of the bubble chamber technique was suggested by Colin Fisher of the Rutherford Laboratory and Heinrich Leutz at CERN. The aim is to obtain high resolution information more easily and rapidly than in emulsion experiments, while the use of hydrogen gives the added advantage of a clean proton target.

The tiny detector has earned the name LEBC — Little European Bubble Chamber — to distinguish it from the mighty 3.7 m diameter BEBC — Big European Bubble Chamber — in the West Experimental Area. The first LEBC pictures are very promising and display clearly how the chamber records the fine details of hadronic collisions.

The theoretically predicted charm lifetime of about 5×10^{-13} s now looks in good shape from neutrino experiments using emulsion targets (see June issue, page 152). This means that high energy charm decays could take place on about the same scale as a single 500 micron-diameter bubble in BEBC, so that there is difficulty in seeing the details of these interactions in a big chamber. (However BEBC can see the subsequent decay products, see for example June issue, page 154, and encouraging new results have come from the Fermilab 15 foot chamber – see page 253.)

Recent indirect evidence on charm production at SPS energies indicated that one or two hadronic interactions per thousand could contain a pair of charmed particles. A detailed Monte Carlo study at Rutherford (see October 1976 edition, page 346) showed that a chamber which could work with a bubble diameter of 50 microns should enable particles with lifetimes in the 5×10^{-13} s region to be efficiently detected by simple scanning.

Built for a Brussels / CERN / Oxford / Padova / Rome / Rutherford / Trieste collaboration, the chamber, cryogenics system, expansion system and optics have been constructed at CERN in record time by a collaboration of several bubble chamber groups. The first high resolution pictures were taken less than six months after the start of the project and the collaboration successfully concluded a data taking run a short while later in July.

The small chamber is made of Lexan, using the techniques developed for the Track Sensitive Target (TST) at BEBC (see April 1978 issue, page 120). It is perfectly clean with no seals or rough edges to produce unwanted spurious boiling. This, coupled with the need to allow only small bubbles to develop, provides excellent conditions for fast cycling.

Expansion is by means of a hydraulically-driven piston pushing against a membrane, the stroke of the piston being just 1.2 mm. The expansion system is a miniature version of that under construction for the 80 cm rapid-cycling chamber for the European Hybrid Spectrometer. During its first run, LEBC achieved cycling rates of up to 50 Hz.

Photographing bubbles 50 microns across is not easy, so that the optics form a critical part of the design. One consequence of high optical resolution is small depth of field, and under the required operating conditions the depth of field is only 4.5 mm, so that events must be selected where the beam is confined in a narrow slice.

Operating conditions are chosen to give a high bubble density and slow bubble growth, however the small size of the bubbles means that the photographic flash delay is only 200 μs, compared with the BEBC figure of some 10 ms.

Because of its small size, the probability of interaction in the LEBC hydrogen is small, and triggering is essential. More than 1.1 million expansions were made during the ten day run, from which LEBC produced 110 000 triggered pictures, containing about 70 000 interactions of the 340 GeV negative pion beam. The collaboration is busily scanning the sample for examples of charmed events. Already several candidate events have been found.

Momentum measurements and identification of secondary particles would require the addition of a downstream spectrometer. As well as being a tailor-made tool for charm physics, LEBC could also go on to discover evidence for the production and decay of additional flavours.

Low energy antiproton source

Following the recent workshop on low energy antiproton physics at Karlsruhe (see June issue, page 148), approval has now been given in principle for the construction at CERN of the first phase of a Low Energy Antiproton Ring (LEAR).

Detailed proposals are now to be prepared for a stretcher ring as the first phase of the project. A second stage using colliding beams could follow later.

LEAR is another outcome of the beam cooling technique pioneered at CERN. While the success of stochastic cooling has enabled the high energy proton-antiproton colliding beam project at the SPS to get under way in record time, it also offers the prospect of low energy antiproton beams over a thousand times more intense than existing sources, and with momentum resolution and beam stability comparable to the levels attainable with a Van der Graaff machine.

The first phase of LEAR will be a stretcher ring to be built in the South Hall of the CERN 28 GeV Proton Synchrotron (PS). Cooled antiproton beams of 3.5 GeV from the Antiproton Accumulator now under construction for the SPS proton-antiproton project will be decelerated in the PS before being passed to the LEAR ring to produce high quality beams in the 0.1– 2 GeV range.

The physics possibilities of such a new source include low energy particle-antiparticle annihilation — as yet a relatively unexplored field, the search for proton-antiproton resonances, and studies on exotic atoms.

One immediate objective for LEAR experiments will be the search for baryonium states, as the present experimental situation seems to be confused and contradictory (see page 248).

Subsequent LEAR developments could include a gas jet target, formation of antiprotonic atoms in flight, and low energy colliding beams of protons and antiprotons. However these must await further technical improvements.

Originating from a paper submitted to the 1977 Serpukhov accelerator conference, LEAR has been nurtured by many enthusiastic and devoted proponents, including Ugo Gastaldi, Kurt Kilian, Dieter Möhl and Gunther Plass. The hope is that the small LEAR ring, with its modest needs, will go on to produce a rich crop of physics results.

People and things

Lew Kowarski

On 27 July Lew Kowarski, a founder member of CERN and one of its greatest personalities, died at the age of 72. Lew Kowarski became involved in the first informal discussions about CERN as a leading scientist in France who had already an established reputation in the field of nuclear power. In 1939 he had participated with F. Joliot and H. von Halban in the first experiments to demonstrate uranium fission and nuclear chain reactions. With von Halban he took the world's entire stock of heavy water into England at the beginning of the war to continue research at Cambridge where he obtained the first strong evidence for the feasibility of a controlled nuclear reactor. A few years later Kowarski led the construction of reactors in Canada and in France.

In 1952 he was chosen as Director of the Laboratory Group planning the CERN site, administrative methods, finance, workshops, etc. and when CERN moved to Geneva in 1954 he became Director of the Scientific and Technical Services Division. He decribed these early years in a CERN report 'An Account of the Origins and Beginnings of CERN' which remains the most complete account of CERN's early history. He later led the Data Handling Division, promoting the use of computers.

Lew Kowarski was an impressive character — big in physical stature, gifted with a prodigious memory, clear in thought and articulate in expression. It was very moving that, despite several months of severe illness, he was able to attend the ceremony on 23 June to mark the 25th Anniversary of the Organization he helped to create.

Sin-itiro Tomonaga

(Photo S. Kikuchi)

Sin-itiro Tomonaga died of esophageal cancer on 8 July. Professor Tomonaga was awarded the Nobel Prize in 1965 together with R. Feynman and J. Schwinger for his fundamental work on quantum mechanics and the theory of the interaction of charged particles with the electromagnetic field. He had a distinguished career in physics mainly based at Tokyo University. He was a member of the Japanese Academy and was awarded the Japanese Order of Culture. He played an important role in establishing the Institute for Nuclear Study at Tokyo and the KEK Laboratory where he was a Member of the Board of Councillors.

Seventieth birthday of Bogolyubov

Nikolaj Nikolaevitch Bogolyubov, Member of the Soviet Academy of Sciences and an outstanding theoretical physicist, celebrated his 70th birthday on 21 August.

Non-linear mechanics, problems of statistical physics, the theory of superconductivity, quantum field theory, elementary particle interaction symmetries, are but a few of the topics linked with the name of Bogolyubov.

In the theory of imperfect quantum macrosystems, he introduced a mathematical scheme (the Bogolyubov transformation) which was subsequently used to describe the energy spectrum of superfluid and superconducting systems. A deeper knowledge of superconductivity and superfluidity of Fermi systems led him to discover a fundamental effect — the superfluidity of nuclear matter — which is one of the cornerstones of current nuclear theory.

N. N. Bogolyubov

At the beginning of the fifties, he turned his attention to axiomatic formulations of quantum field theory. This work subsequently exerted a strong influence on thinking in physics and it became clear that new standards of mathematical support and more convincing models would be required to develop quantum field theory further.

N.N. Bogolyubov is also a talented teacher and organizer. Many well-known physicists acknowledge him as their mentor with pride and respect. He established Schools of Theoretical Physics and Non-linear Mechanics in Kiev, and Schools of Theoretical and Mathematical Physics in Moscow and Dubna.

He has been presented with many awards, including the Lenin Prize and State Prizes in the USSR, the M.V. Lomonosov Prize and various international prizes. He is also an *honorary member of many foreign academies. His creative power continues to flourish as he enters his seventieth year, and for his many friends, 21 August was a day for celebration.*

On people

USA Laboratory Directors: Leon Lederman took over from Phil Livdahl as Director of the Fermi Laboratory on 1 June. He set the pace of his reign of office on the first day with an early morning run around the accelerator ring. Don Kerr has been appointed Director of Los Alamos in succession to Harold Agnew. He worked for ten years at Los Alamos on various positions of responsibility until joining the Department of Energy in 1976. His appointment took effect on 1 August. Walter Massey has been appointed Director of Argonne in succession to Bob Sachs and took up his appointment on 9 July. Walter Massey worked at the Laboratory from 1966 to 1968 and was consultant until 1975. He moved to the Laboratory from the position of Dean at Brown University.

Ron Martin has asked to concentrate on the heavy ion fusion programme at Argonne, becoming Research Program Manager for Heavy Ion Fusion. Bob Kustom will succeed him as Director of the Accelerator Research Facilities. Another Argonne appointment we missed earlier in the year was that of Bob Diebold as Associate Laboratory Director for High Energy Physics. He succeeded Gerry Smith who has returned to Michigan State University.

Some of the Nobel Laureates at this year's Lindau reunion. Left to right, front row: L. Esaki, J.S. Schwinger, P. Kapitza, I.M. Frank, behind: W.E. Lamb Jnr, E.P. Wigner, I.I. Rabi, S.C.C. Ting, P.A.M. Dirac, L.V. Kantorovich (Economics, 1975), N.G. Basov, W.H. Brattain.

(Photo W.S. Newman)

1\.

2\.

1. Rich Muller and daughter.

2. Sir Geoffrey Allen.

Donald Glaser, who invented the bubble chamber technique with work on centimetre scale models, photographed while visiting the CERN Technology Exhibition in front of a large picture of the 3.7 m European bubble chamber, BEBC.

(Photo CERN 36.7.79)

On 9 July, Piotr Kapitza visited CERN on the occasion of his 85th birthday. Seen here raising their glasses to the future are (left to right) CERN Directorate Members Robert Lévy-Mandel and Italo Mannelli, Kapitza and Research Director General Leon Van Hove. Paying tribute to someone whose life spans the entire history of particle physics, CERN Executive Director General John Adams described Kapitza as a man who combines the talents of a scientist with the ingenuity of an engineer.

(Photo CERN 98.7.79)

Richard Muller from Berkeley has received the 1978 Alan I. Waterman Award of the National Science Foundation. It carries a grant of $50 000 to finance research of his choosing over the next three years. It followed closely another award of $35 000 — the Founder's Prize of the Texas Instruments Foundation. Richard Muller has led a very inventive and original life in science following in the footsteps of his mentor Luis Alvarez. His contributions include the new accelerator technique of radioactive dating, the measurement of the earth's motion through the cosmic ray background radiation and the invention of a rubber telescope to minimize distortions in astronomical observations.

Geoffrey Allen, Chairman of the Science Research Council in the UK, has received a Knighthood from the Queen. Sir Geoffrey succeeded Sir Sam Edwards in 1977 and has been a regular UK delegate at the meetings of the CERN Council.

Hermann Grunder has received a Humboldt US Scientist Award from the West German government to work at the GSI Laboratory, Darmstadt, home of the Unilac heavy ion linac, for a year. Grunder is associate director of the Accelerator and Fusion Research Division at Lawrence Berkeley Laboratory where he has played a major role in the development of LBL's heavy ion accelerators.

Peter Koehler from the Tevatron Department at Fermilab is another recipient of a Humboldt Award. He has moved for a year to the DESY Laboratory to work on experiments at the PETRA electron-positron storage ring.

Nobel physicists meet

At the end of June in Lindau, the island town on Lake Constance, Nobel prizewinners met for their annual reunion. This year it was the turn of the physicists, the three-year cycle covering also medicine and chemistry. The reunions started modestly in 1951, when six Nobel Prize winners in medicine met aspiring students and researchers. Under the presidency of Count Bernadotte, their reunions have now grown to attract over 20 laureates and 500 students and staff from German and other European universities.

This year's Nobel lecturers included such 'old-timers' as Paul Dirac (1933 prize) speaking on the variation of the gravitational constant, Eugene Wigner (1963) on causality, Hannes Alfvén (1970) on cosmology. Rudolf Mössbauer (1961) spoke on neutrino stability, Sam Ting (1976) on photons and new particles, and the 'new boy' of the Nobel clan, 85 year-old Piotr Kapitza (1978) lectured on high-temperature plasmas.

The trend of physicists towards other fields was exemplified by Leon Cooper (1972) talking on the visual cortex, Donald Glaser (1960) on a physicist's view of biology and Ivar Giaever (1973) on biology and solid surfaces.

But even more interesting than these formal lectures were the social occasions. One evening, in a large hall at long tables each hosted by a laureate, young students met the physics élite to chat over Bavarian food and drink until some hours later the band and dancing stopped all verbal communications. One afternoon was devoted to an extended scientific discussion, and on the last day there was a steamer trip to Bernadotte's garden island of Mainau.

On 1 June, his first day as Fermilab Director, Leon Lederman set the pace by inviting everyone to join him in a jog around the main ring. More than fifty people took up his invitation.

(Photo Fermilab)

Fermilab Energy Saver

The start of construction of the Fermilab Energy Saver project has now been authorized by the US Department of Energy. The construction phase is authorized for $46.6 million of which $12 million will be available before 1 October. The balance of the funding will come over the next two years. Approval for the project had been granted by the US Congress last December. Since that time the project has been under intensive technical review both by panels appointed from within Fermilab and by the Department of Energy. Authorization of the construction phase signals the successful completion of the reviews.

The construction timetable calls for the completion of $2\frac{1}{2}$ superconducting magnets every week until October. Then the production rate will be scaled up to five a week. Installation will take place in specially scheduled shutdowns over the next several years.

PEP progress

Our latest news on the construction of the Berkeley/Stanford electron-positron storage ring PEP is that considerably progress has been made on the crucially important r.f. system. All eleven klystrons and the twenty-two cavities have been completed, tested and cleared for installation. Construction of the quadrupoles and sextupoles is complete ahead of schedule but various Acts of God are interfering with the production of the bending magnets. There are no basic problems but bringing things together on schedule is a struggle. It is still expected that particles will be brought into PEP when the linac comes back on the air in October.

Workshop on Neutrino Bubble Chamber Physics at Tevatron Energies

Physicists interested in doing Tevatron-energy neutrino bubble chamber physics are invited to attend a pair of Workshops to be held this Fall/Winter. The first Workshop will be held 29/30 October near Fermilab. It is planned to form "working parties" at this first Workshop who will report back at a second meeting to be held in early January 1980. A goal is to prepare a coherent plan for upgrading the 15 foot bubble chamber hybrid system which could facilitate proposals to do significant neutrino physics when Tevatron neutrino beams are available. A preliminary agenda is being prepared by Professor V. Peterson (University of Hawaii), Workshop organizer.

ICFA Workshop

A second Workshop organized by the International Committee for Future Accelerators will be held at Les Diablerets in Switzerland from 4 to 10 October. The subject will be 'Accelerator and Detector Possibilities and Limitations'. Sub-groups have been set up on Electron-positron colliders (convener A.N. Skrinsky), Proton accelerators and proton-antiproton colliders (Lee Teng), Extraction and external beams (Bas de Raad), Electron-proton interaction regions and experiments (Gus Weber), Experiments at electron-positron and proton-antiproton colliders (Barry Barish), Deep inelastic experiments with lepton beams (G. Barbiellini), Hadron and photon experiments at fixed target machines (Yu.D. Prokoshkin), Detectors and data handling (George Trilling). On 10 October the conveners will present the results of their work at an open meeting in CERN.

Healthy beams for fusion

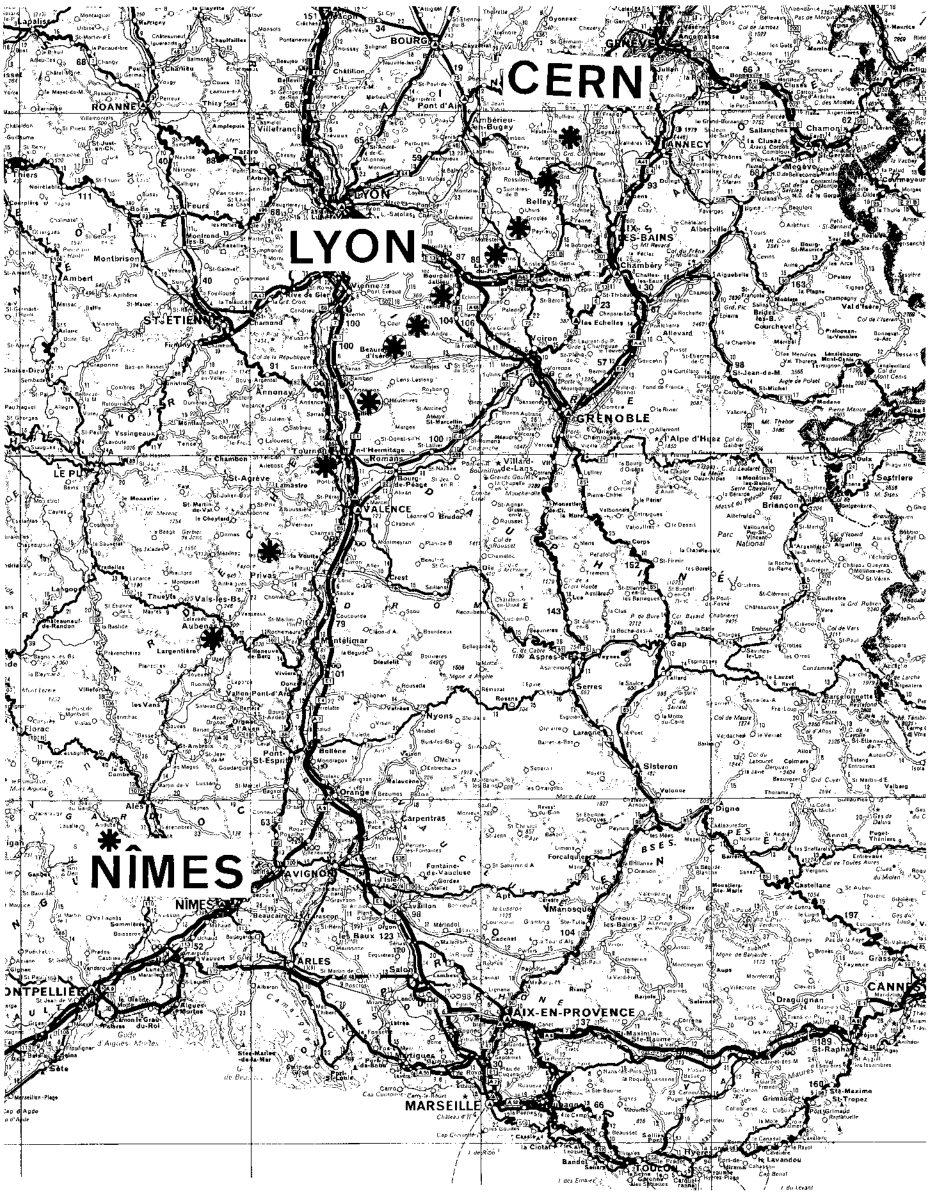
An important step towards demonstrating the feasibility of nuclear fusion using heavy ion beams has been taken at the Argonne Laboratory with tests on a pre-accelerator to produce beams of xenon ions.

Beams of 50 mA of singly charged ions at 1.1 MeV have been achieved. These early results are regarded as showing that the pre-accelerator is a convincing prototype of what will be needed in a heavy ion fusion reactor. (For more details on the reactor requirements, see November 1978 issue, page 384.)

The preferred concept of such a reactor at Argonne goes under the name of Hearthfire. The Laboratory has recently learned that its research programme in this field will *receive additional support next year with funding from the Department of Energy, probably in the region of $6 million. The work is being led by Ron Martin, Bob Burke, Jerry Watson and Rick Arnold.*

ZGS Symposium

On 1 October the 12.5 GeV Zero Gradient Synchrotron at the Argonne National Laboratory will close down after sixteen years of operation for high energy physics experiments. To mark the occasion a Symposium on the History of the ZGS is being organized at Argonne on 13–14 September. It will cover the conception, construction and operation of the accelerator and the physics programme it has supported, conveying the crucial role the machine has played in developing high energy physics in the mid-West USA. Further information on the Symposium may be obtained from Beverly Marzec at Argonne. The ZGS is the largest high energy physics facility ever to be closed down and the American Institute of Physics Center for the History of Physics will follow the Symposium. CERN COURIER hopes to pay tribute to the machine and its achievements in a forthcoming issue.



A good time was had by all at the CERN Experimental Physics Division's Summer fete. 1500 physicists, family and friends turned up to enjoy the fun. Seen here is Jack Steinberger leading the WA1 experiment team to victory in the obstacle race. Another feature of the afternoon was the release of 500 helium-filled balloons. The map above shows where some of the balloons were subsequently picked up, one having travelled some 300 km.

(Map copyright 1979, Hallwag)

TRIUMF
Safety Group

has a position available for a Health Physicist. The successful applicant will be required to establish a safety program for all radiochemistry operations at TRIUMF. This person will supervise technicians who will perform routine radioactivity surveys, and decontamination procedures, and maintain radioisotope inventories.

Applicants with a Degree in Chemistry or Physics and experience in radiochemistry operations will be given first consideration.

Applications, including curriculum vitae, should be forwarded by October 1, 1979, to:

Mr. W.J. Bryan, Administrator,
Management & Technical Services
TRIUMF
University of British Columbia
Vancouver, B.C.
Canada V6T 1W5

TRIUMF

Cyclotron development and Beam development Groups

Junior Research Scientist

A joint appointment to the above groups is available for a physicist, engineer, or engineering physicist, to collaborate in the program to upgrade the 520 MeV H^- cyclotron to provide beams of very high intensity ($>100\mu A$), and also of high energy resolution (100keV) with separated turns. The successful candidate will be expected to work on both the experimental apparatus and the ion optics of the cyclotron.

Candidates should have a degree (preferably M.Sc. or Ph.D.) in Physics, Engineering or Engineering Physics. Salary negotiable depending on qualifications and experience.

Applications, including curriculum vitae, should be forwarded by October 1, 1979, to:

Dr. J. T. Sample, Director
TRIUMF
University of British Columbia
Vancouver, Canada V6T 1W5

PHYSICISTS

Fermilab, a major accelerator facility for research in particle physics, has a number of staff positions available for experienced Physicists.

Staff members contribute to the laboratory program in the following areas:

Operation and advanced developments of our existing accelerators, experimental areas and facilities.

Work on new projects, including the 1000 GeV superconducting Tevatron and the $\bar{p}p$ colliding beams facility.

We welcome inquiries from Physicists whose experience is not specifically in the above areas, to work in the advanced technology environment characteristic of particle physics research.

Staff members have the opportunity to devote some of their time to individual high energy physics research. Salary and term of appointment will depend on qualifications, ability and experience.

Research associate positions in high energy and accelerator physics are also available.

Applicants should submit a resume, list of publications and the names of three referees whom you have asked to send letters of recommendation to:

Dr. Roy Rubinstein, Secretary
Fermilab Committee on Scientific Appointments
Fermi National Accelerator Laboratory
P. O. Box 500
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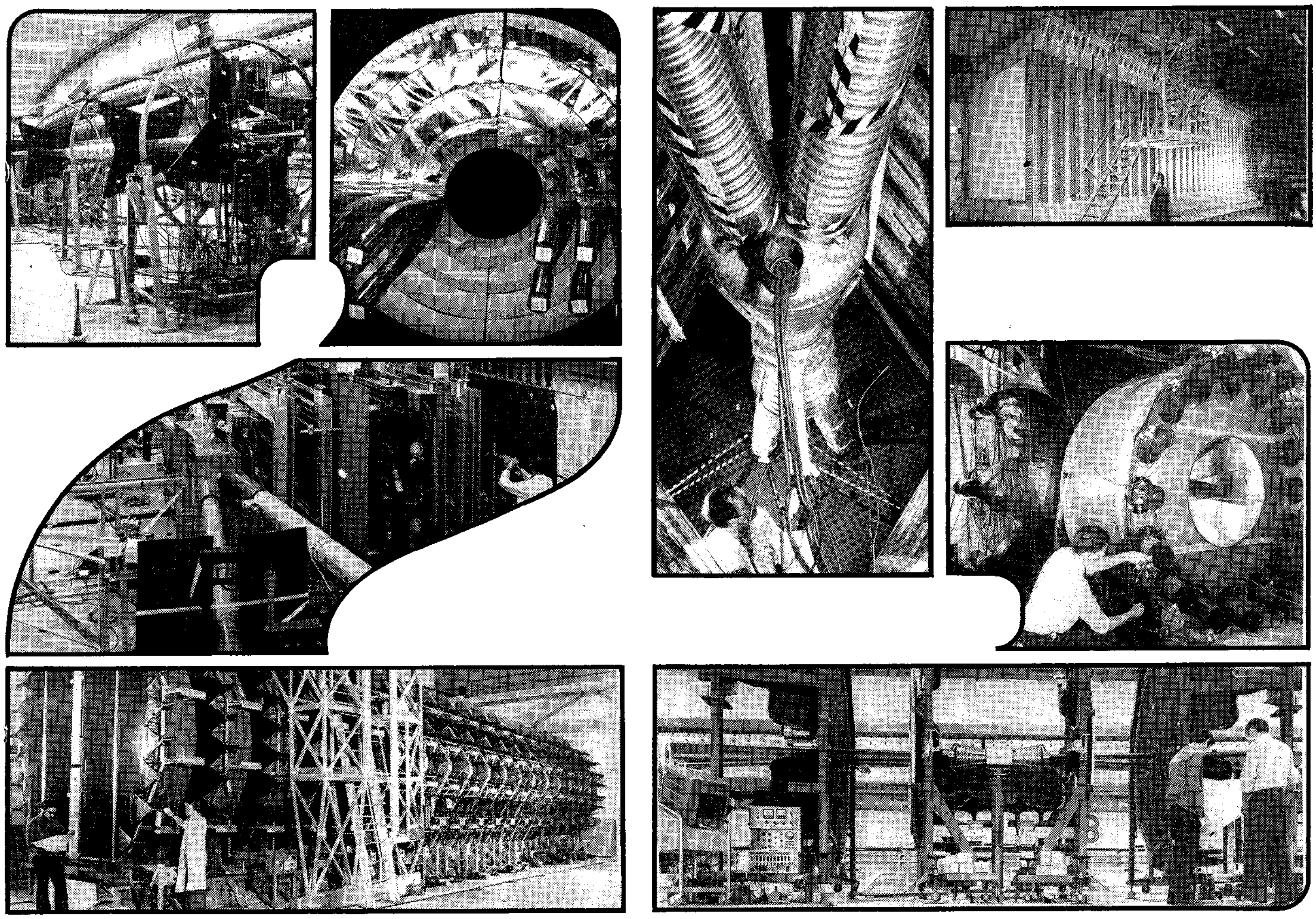

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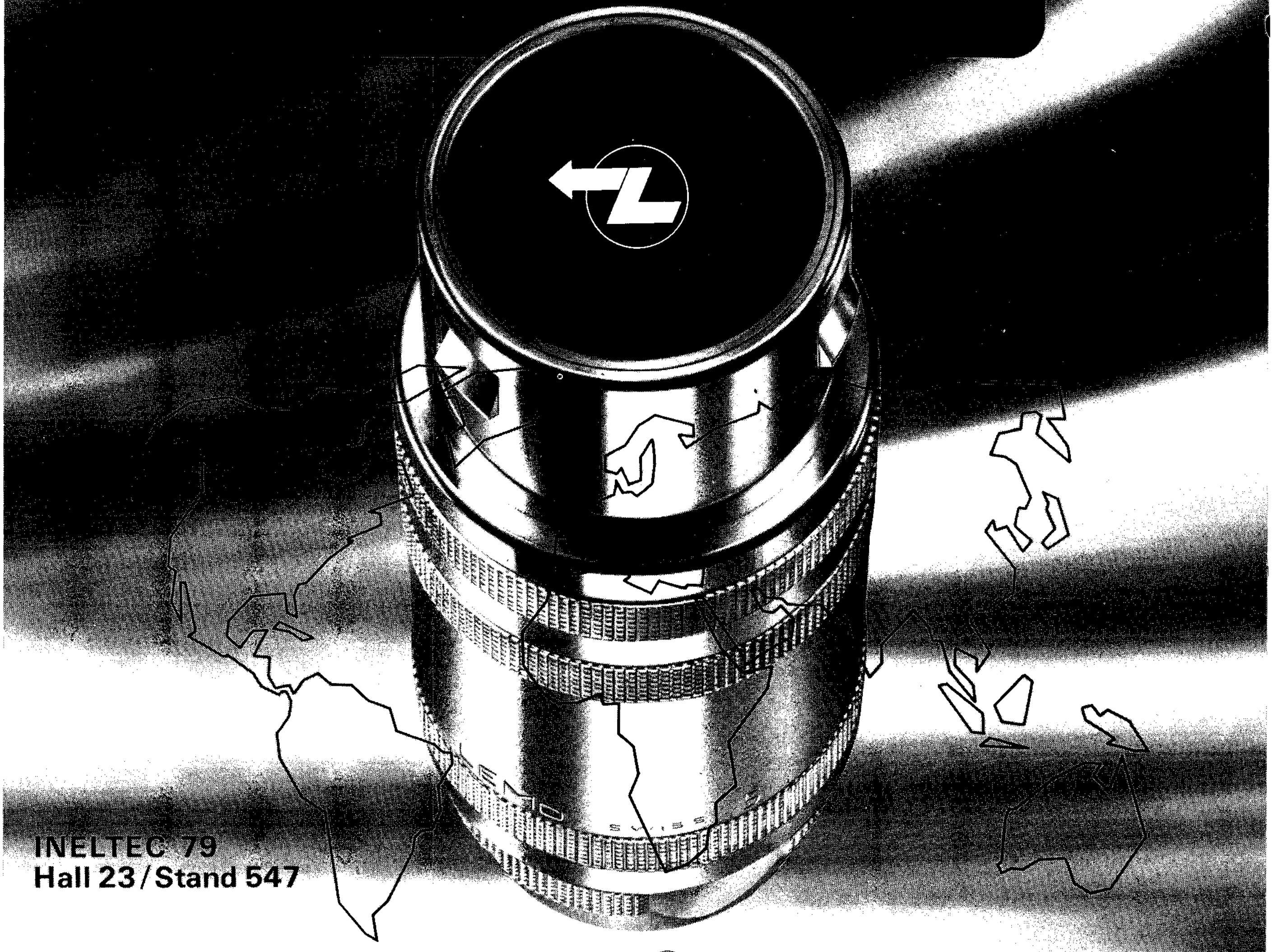

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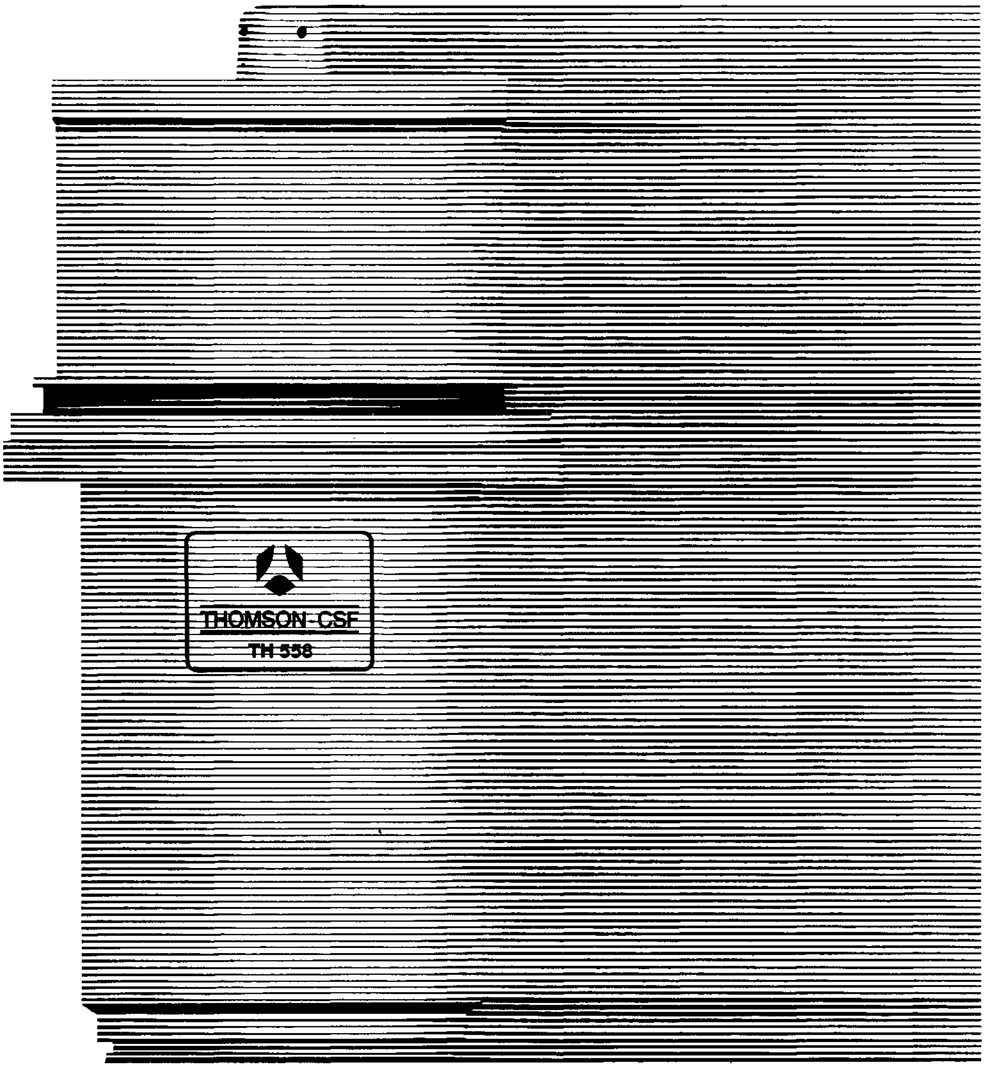
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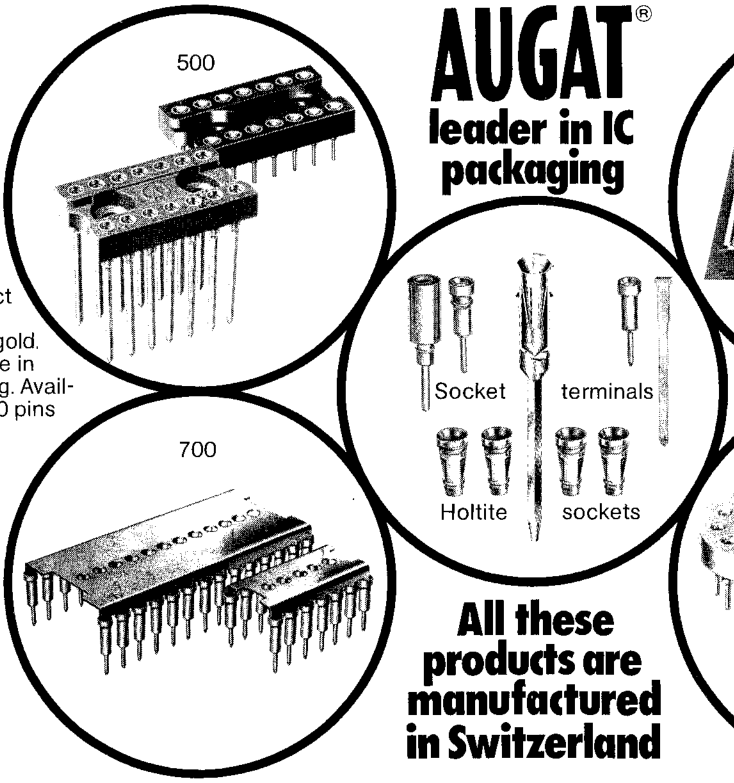
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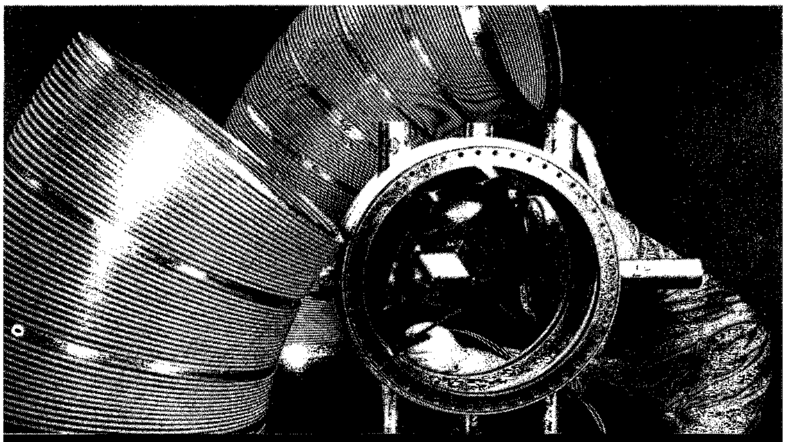

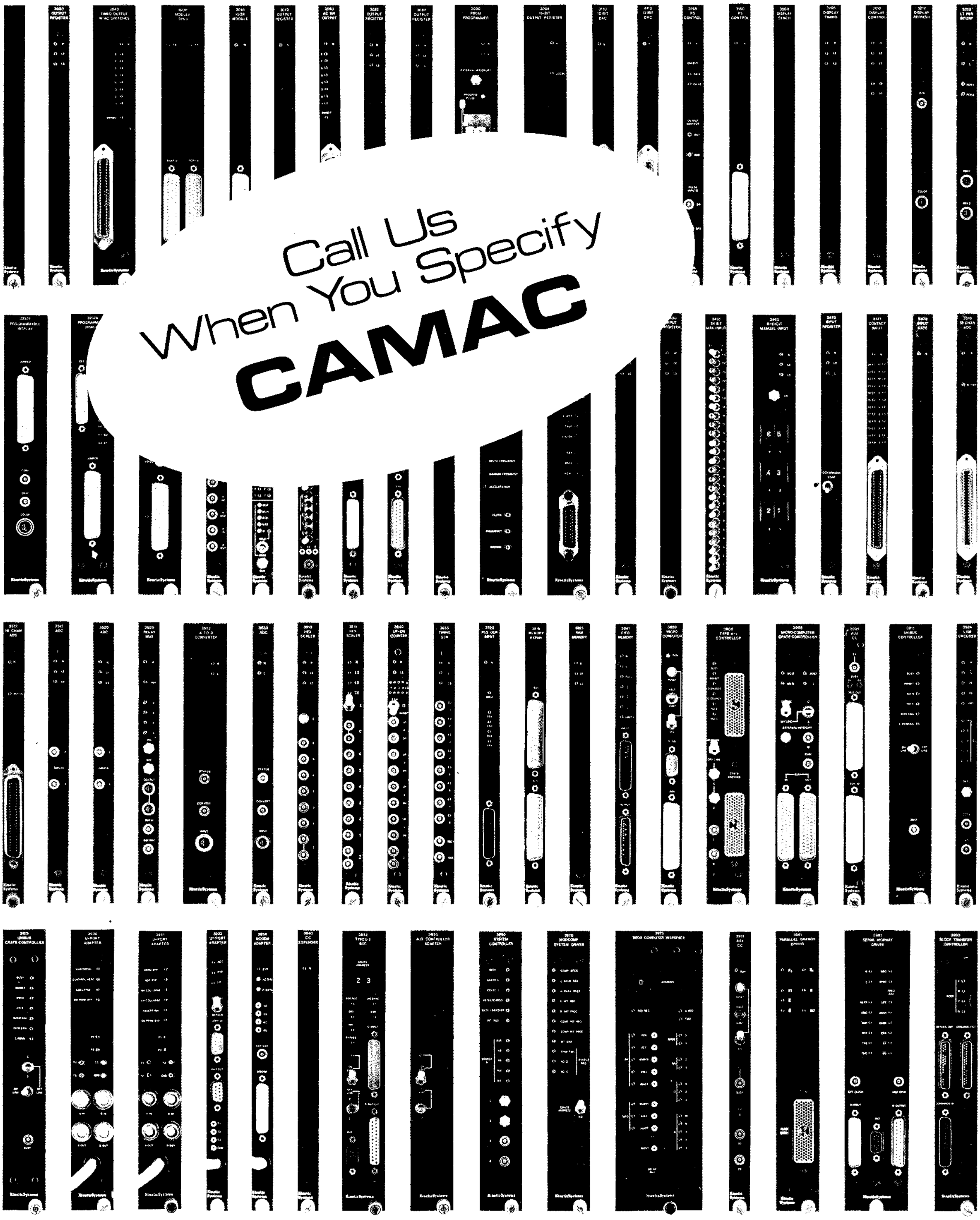
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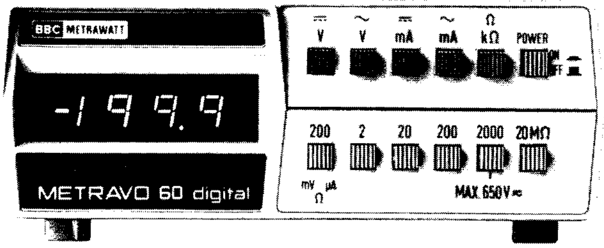
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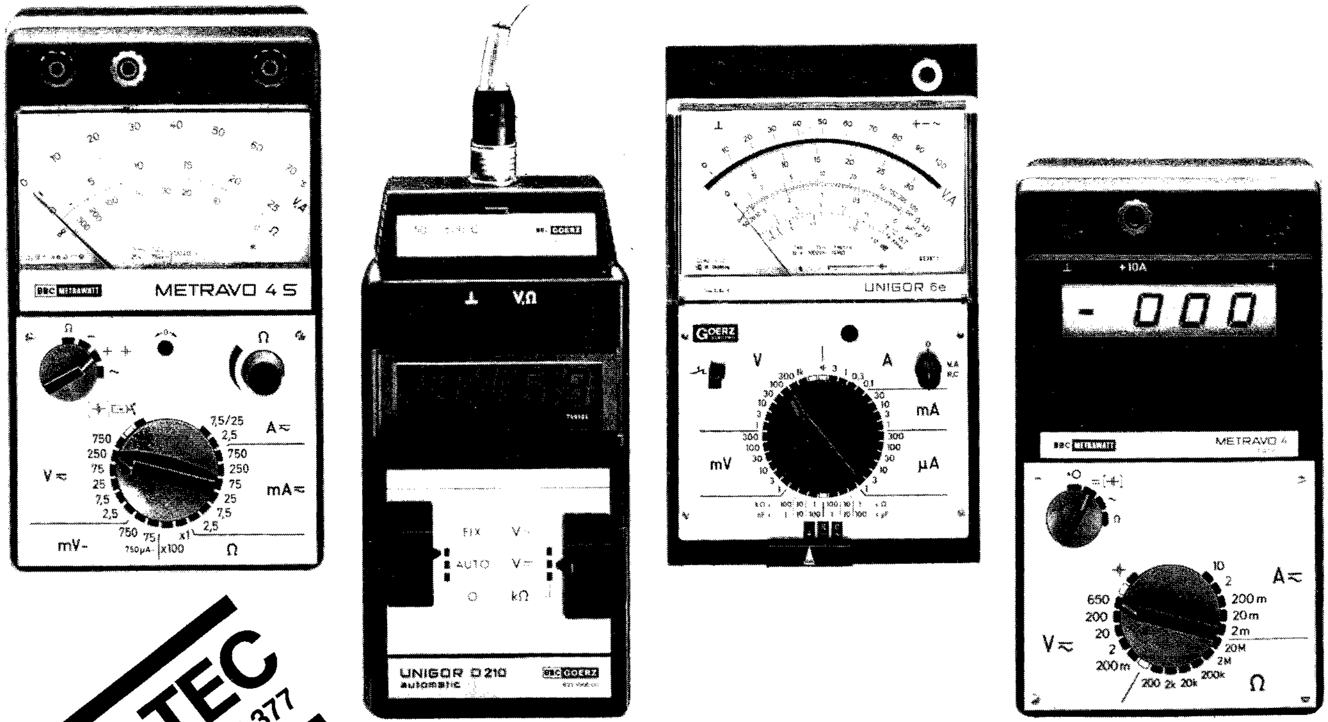
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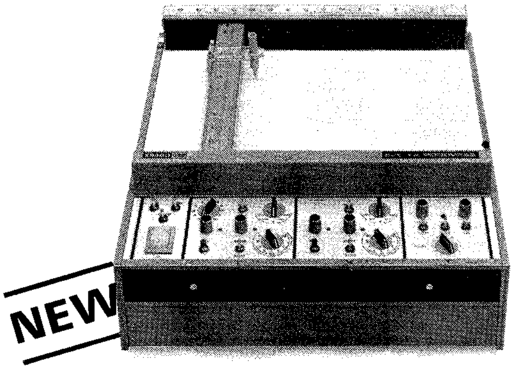
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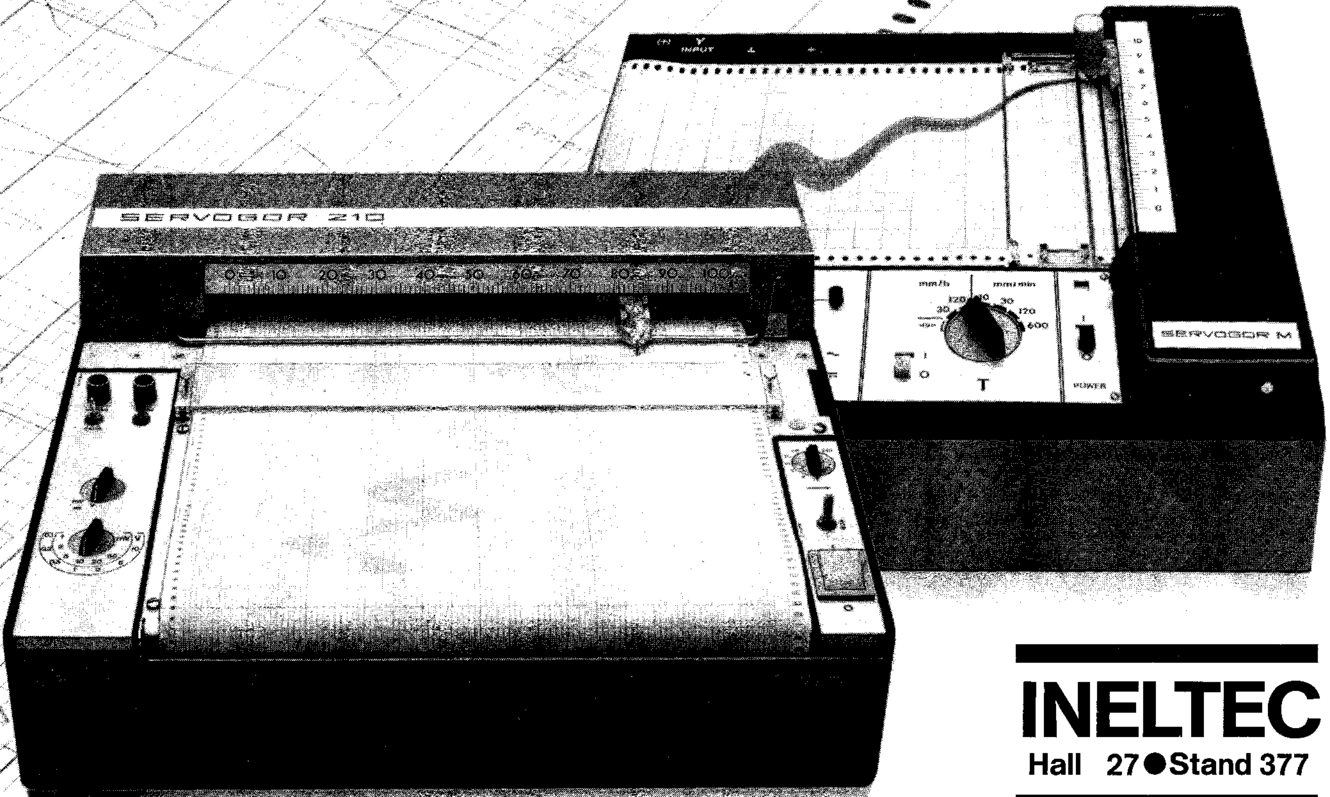
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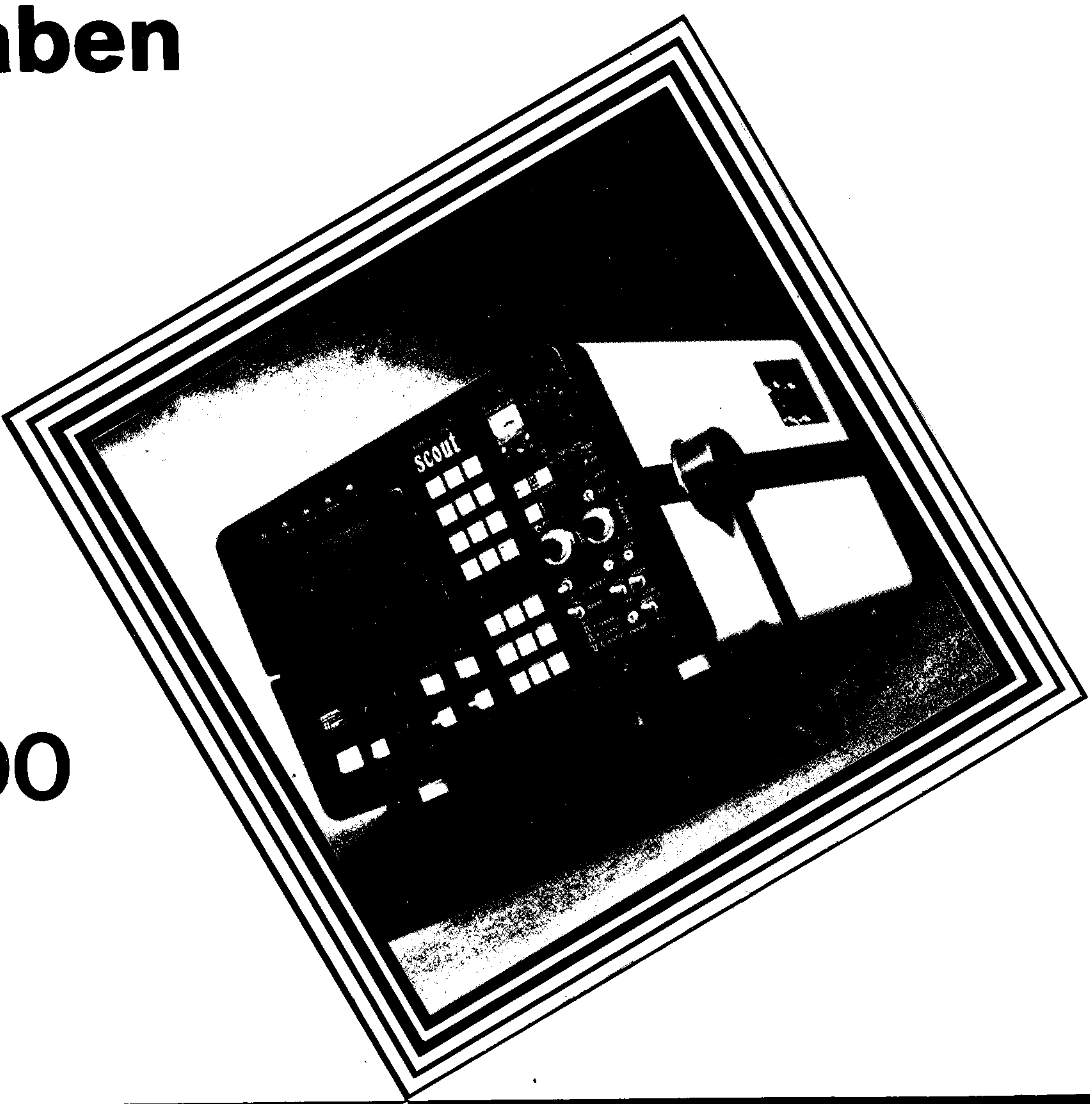
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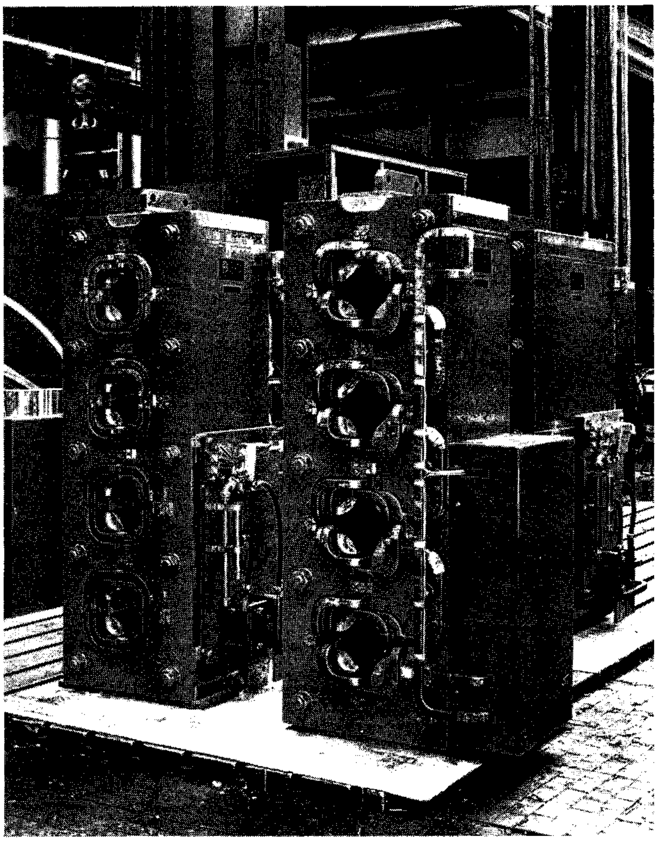

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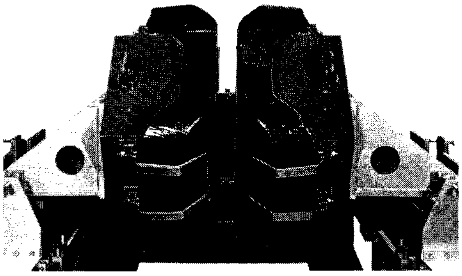

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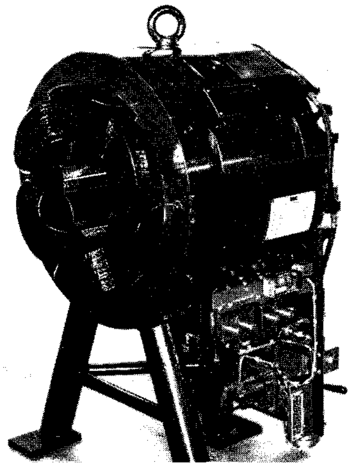

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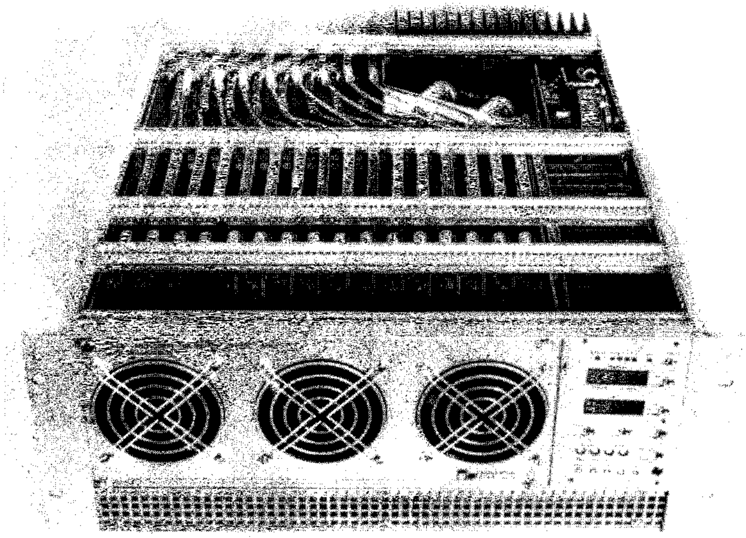

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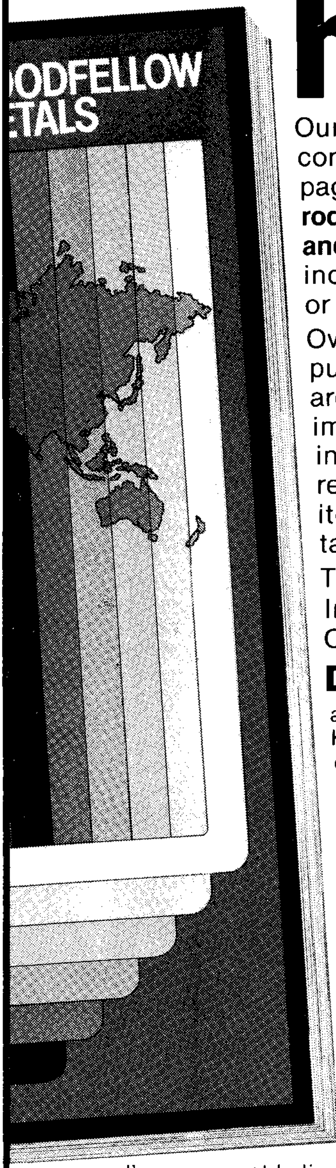

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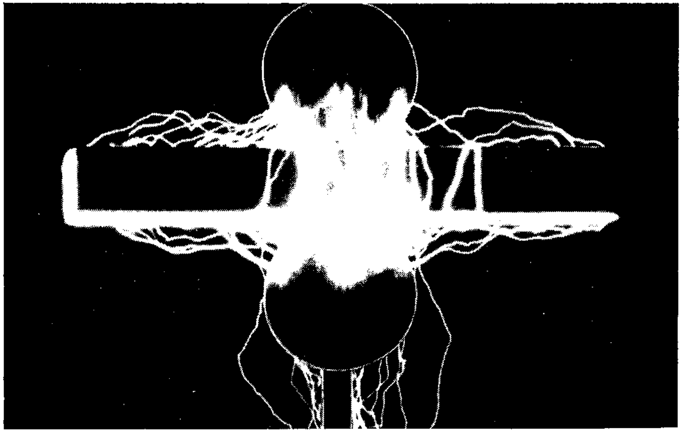

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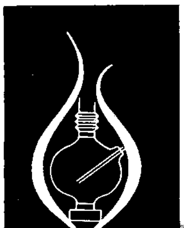

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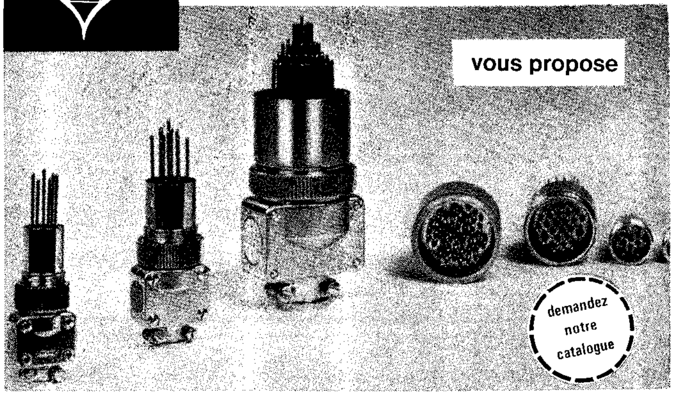

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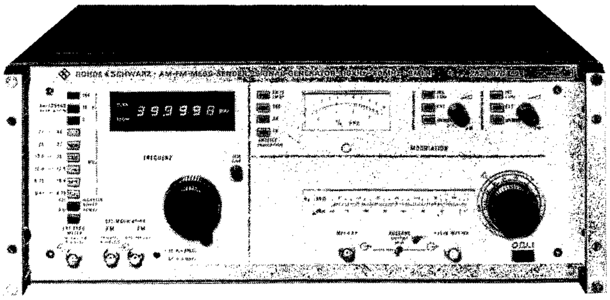

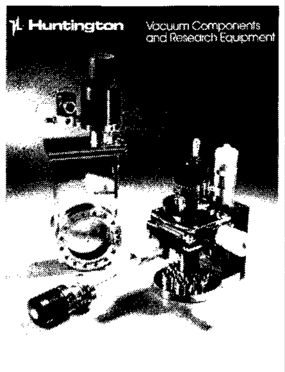
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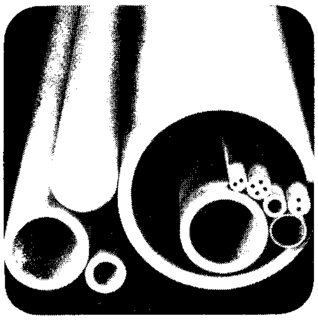

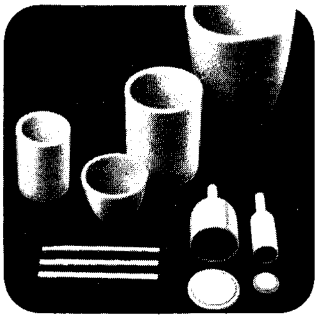

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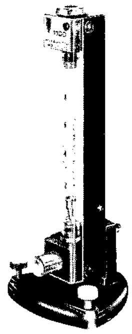

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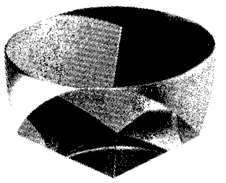

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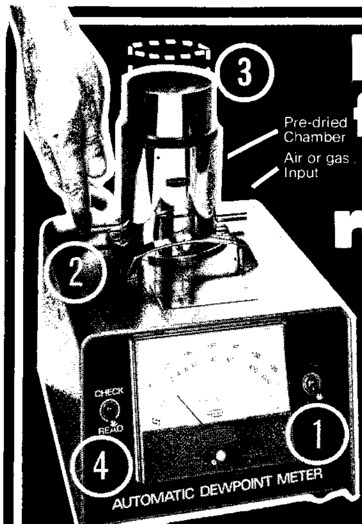

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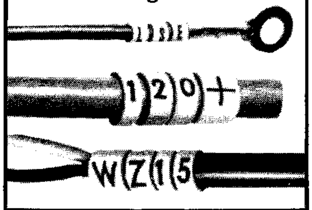

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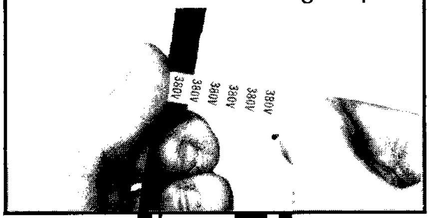

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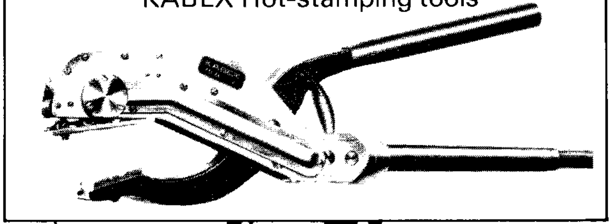

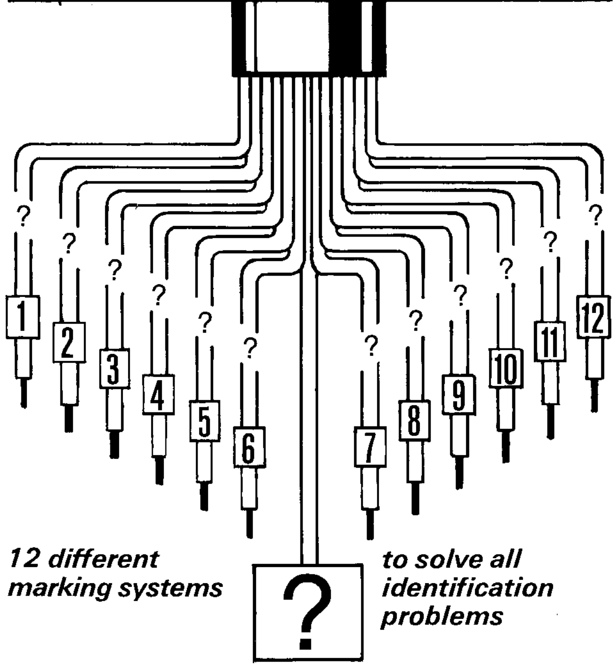

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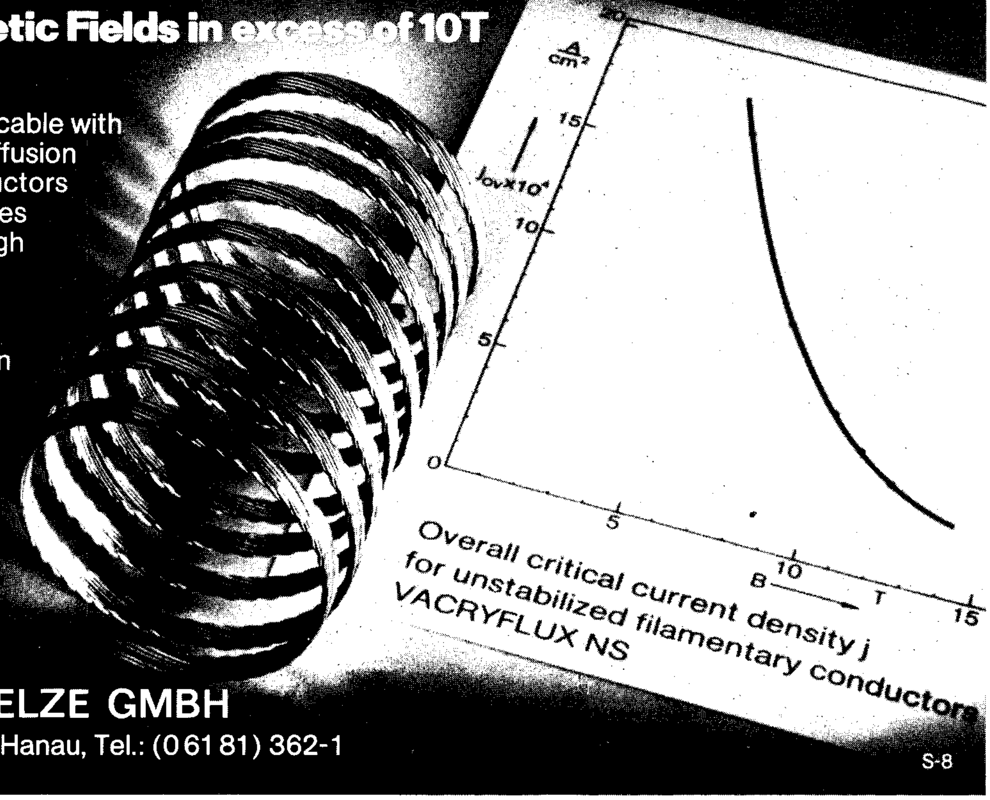
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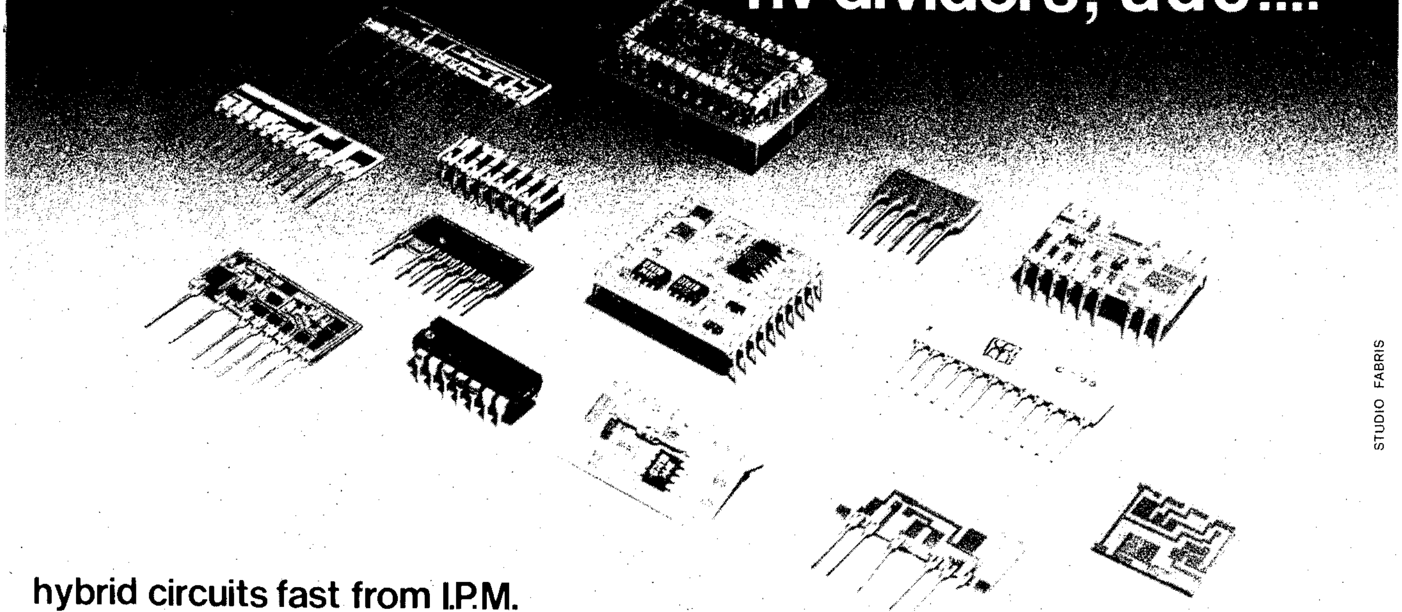

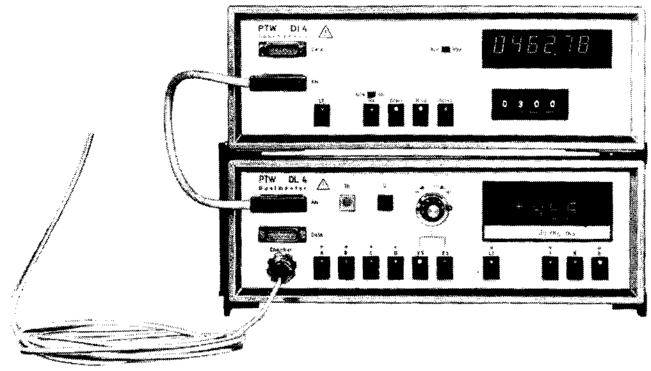

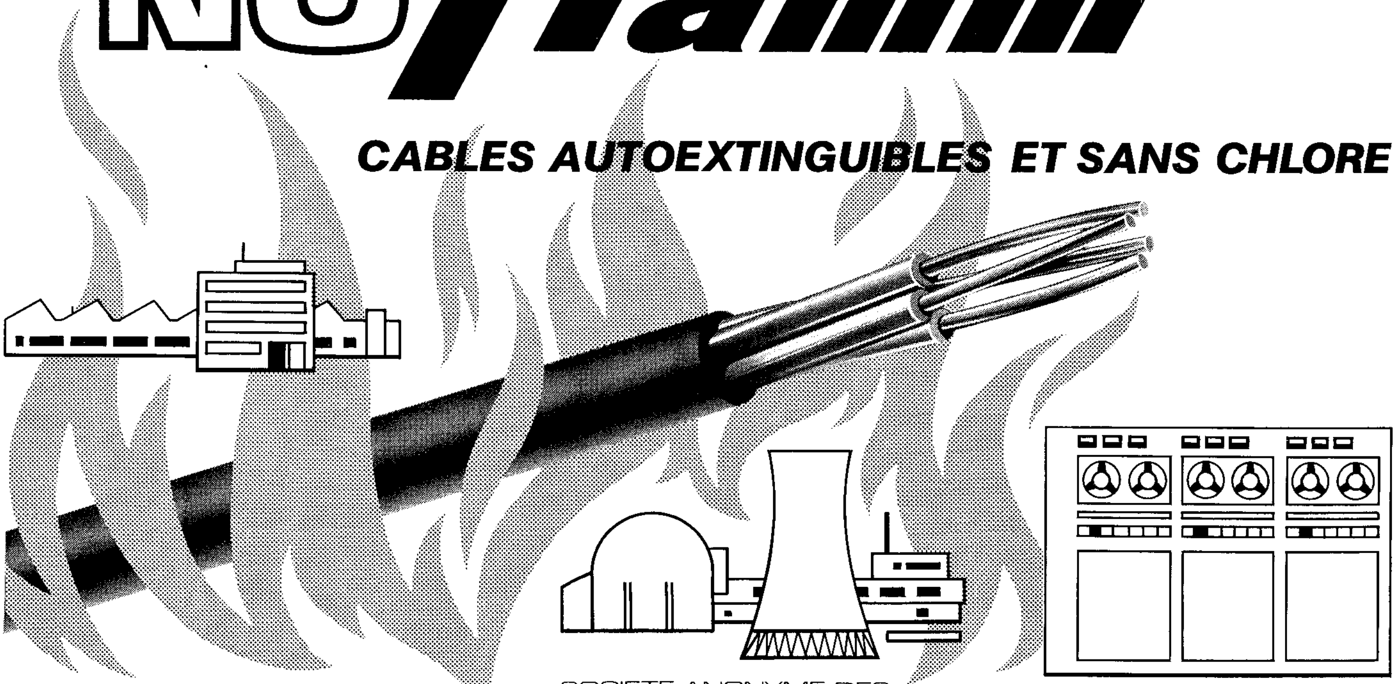

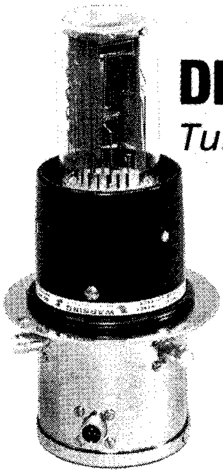

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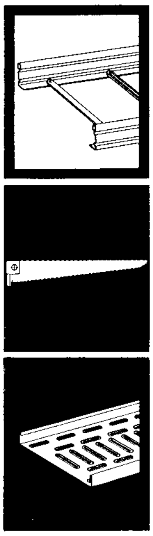

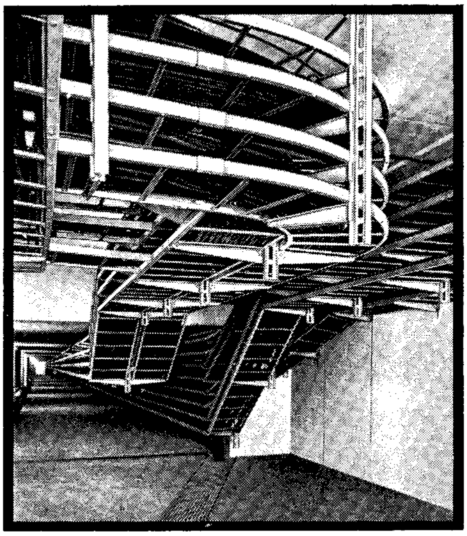

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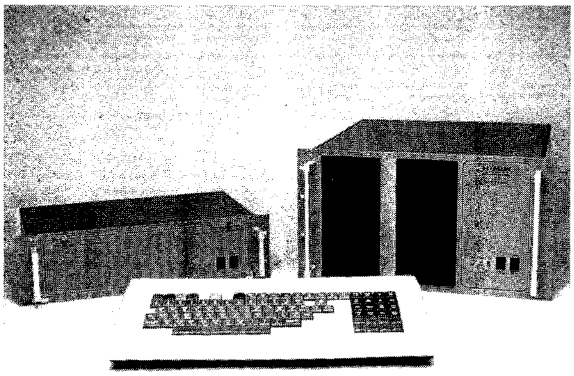

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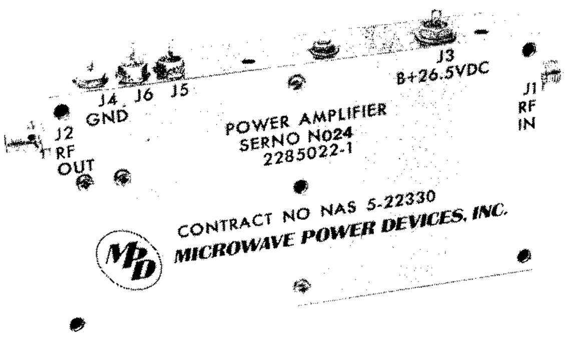

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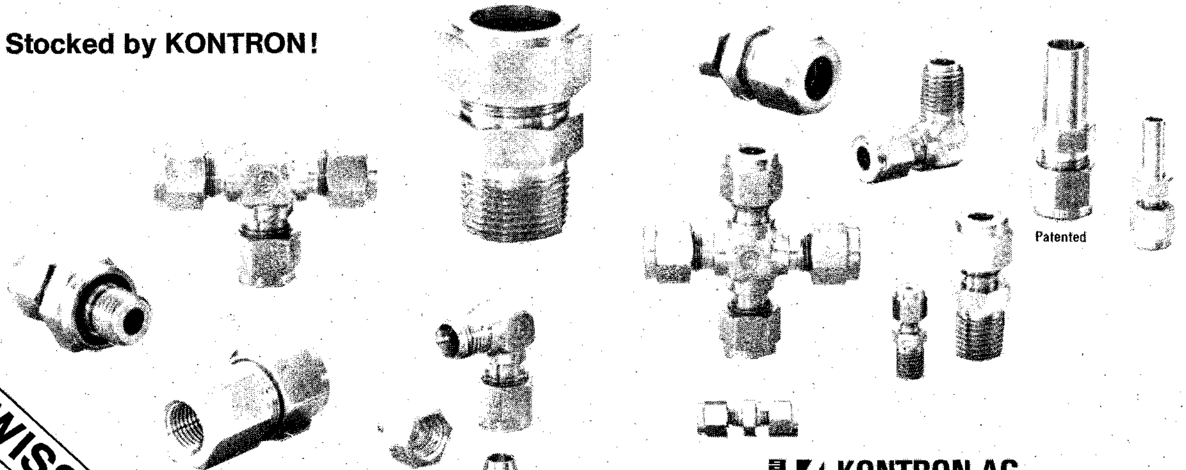

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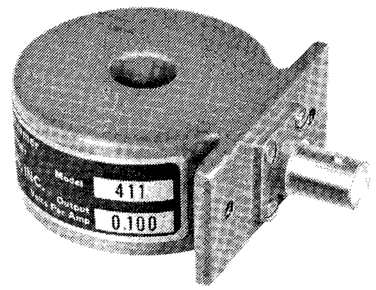

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Model No.	(Accuracy +1%, −0%) Output* (Volts/Amp)	Hole Diameter (in.)	Peak	RMS	Useful Rise Time (Nanosecond)	Droop (%/µsec)	IT Maximum (Amp Sec.)	Approximate Low Frequency 3 dB Point (Hz)	I/F Maximum (Amps Peak Per Hz)
4100	1.0	0.5	500	5	10	0.07	0.0020‡	140	0.0062
2100	1.0	2	500	5	20	0.06	0.0053‡	115	0.017
3100†	1.0	3.5	500	5	50	0.02	0.030‡	40	0.096
150	0.5	2	1,000	10	20	0.04	0.021‡	30	0.067
325	0.25	3.5	2,000	15	30	0.1	0.093	200	0.58
410	0.1	0.5	5,000	50	10	0.12	0.27	240	1.7
411	0.1	0.5	5,000	50	10	0.0005	0.19‡	1	0.59
110	0.1	2	5,000	50	20	0.0005	0.49‡	1	1.5
110A	0.1	2	10,000	50	20	0.0005	0.49‡	1	1.5
310†	0.1	3.5	5,000	40	40	0.02	0.58	40	3.6
1010†	0.1	10.75	5,000	120	50	0.15	0.7	300	4.4
1025	0.025	2	20,000	150	100	0.14	0.60	270	3.7
3025†	0.025	3.5	20,000	150	100	0.004	3.2	7	20.
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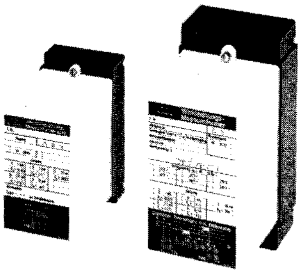

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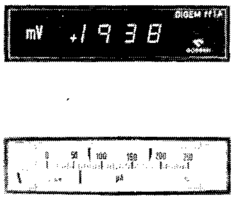

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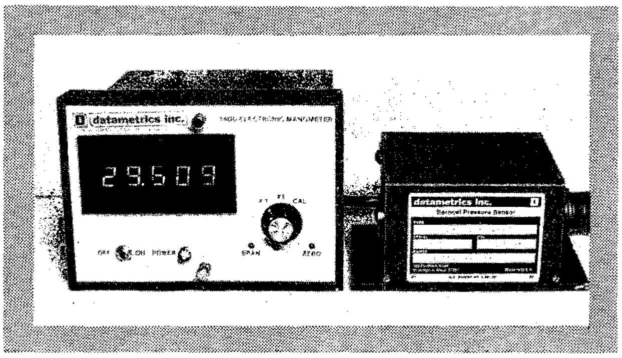

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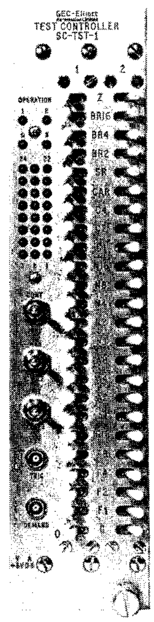

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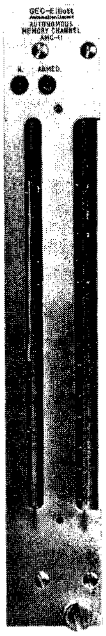

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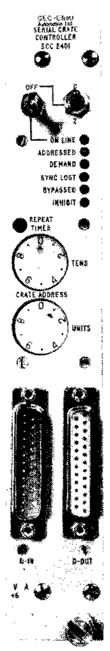

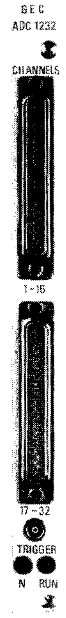

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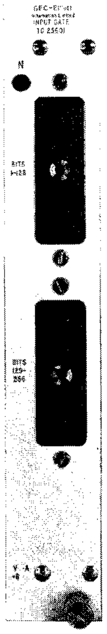

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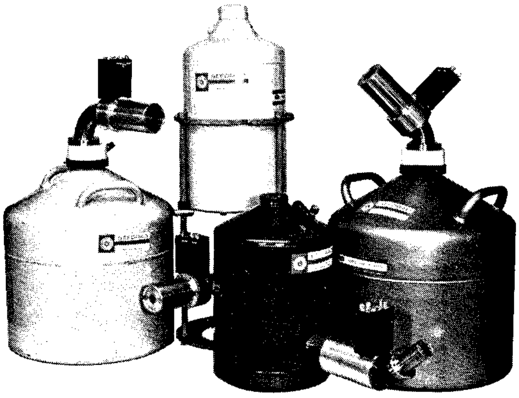

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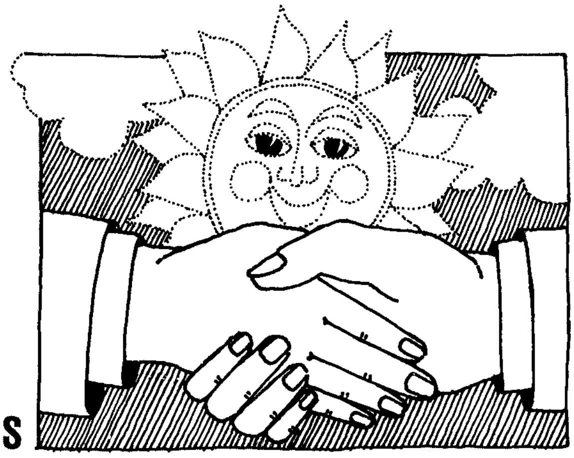

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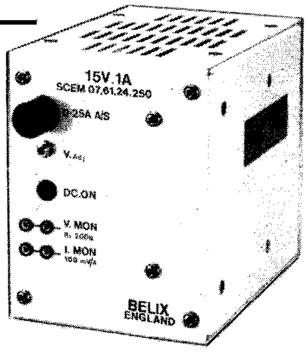

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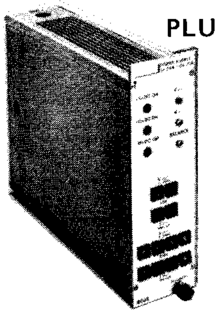

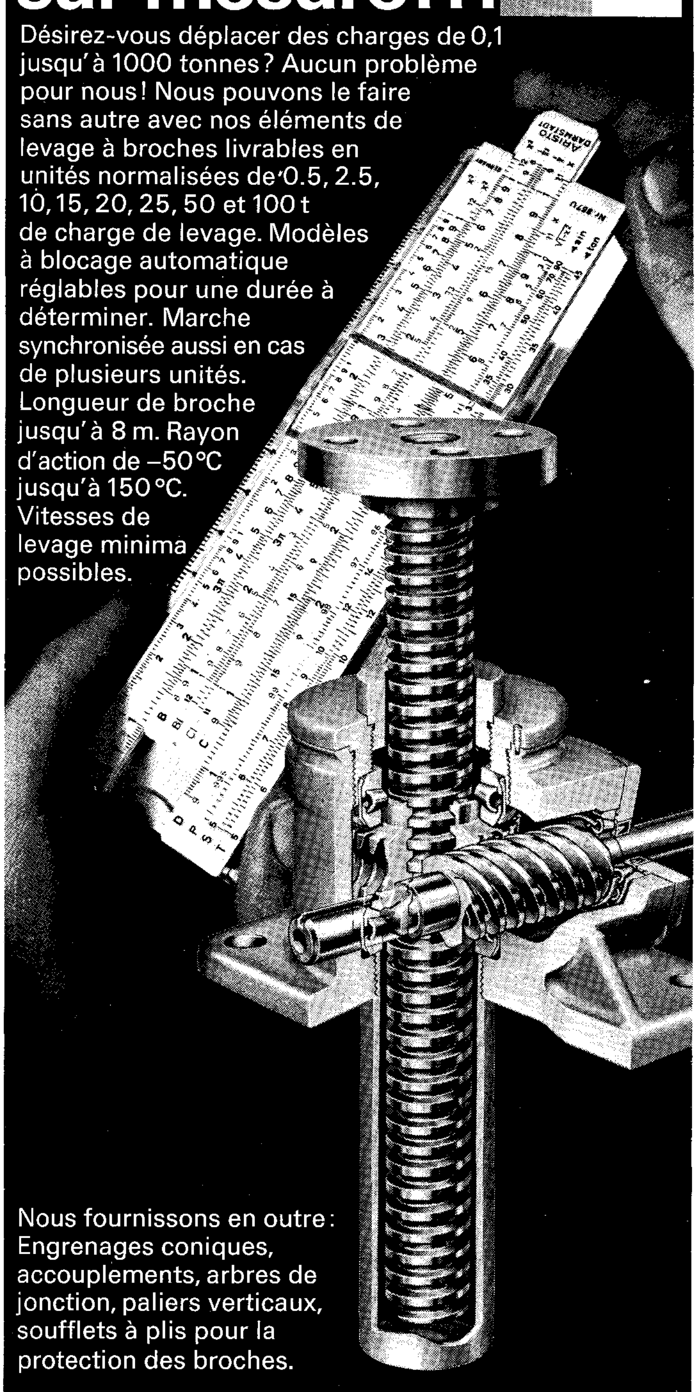

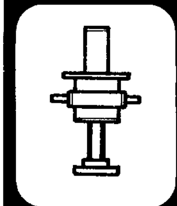
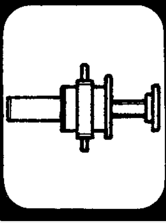
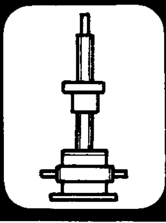
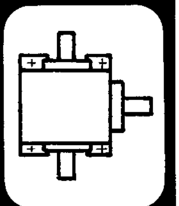

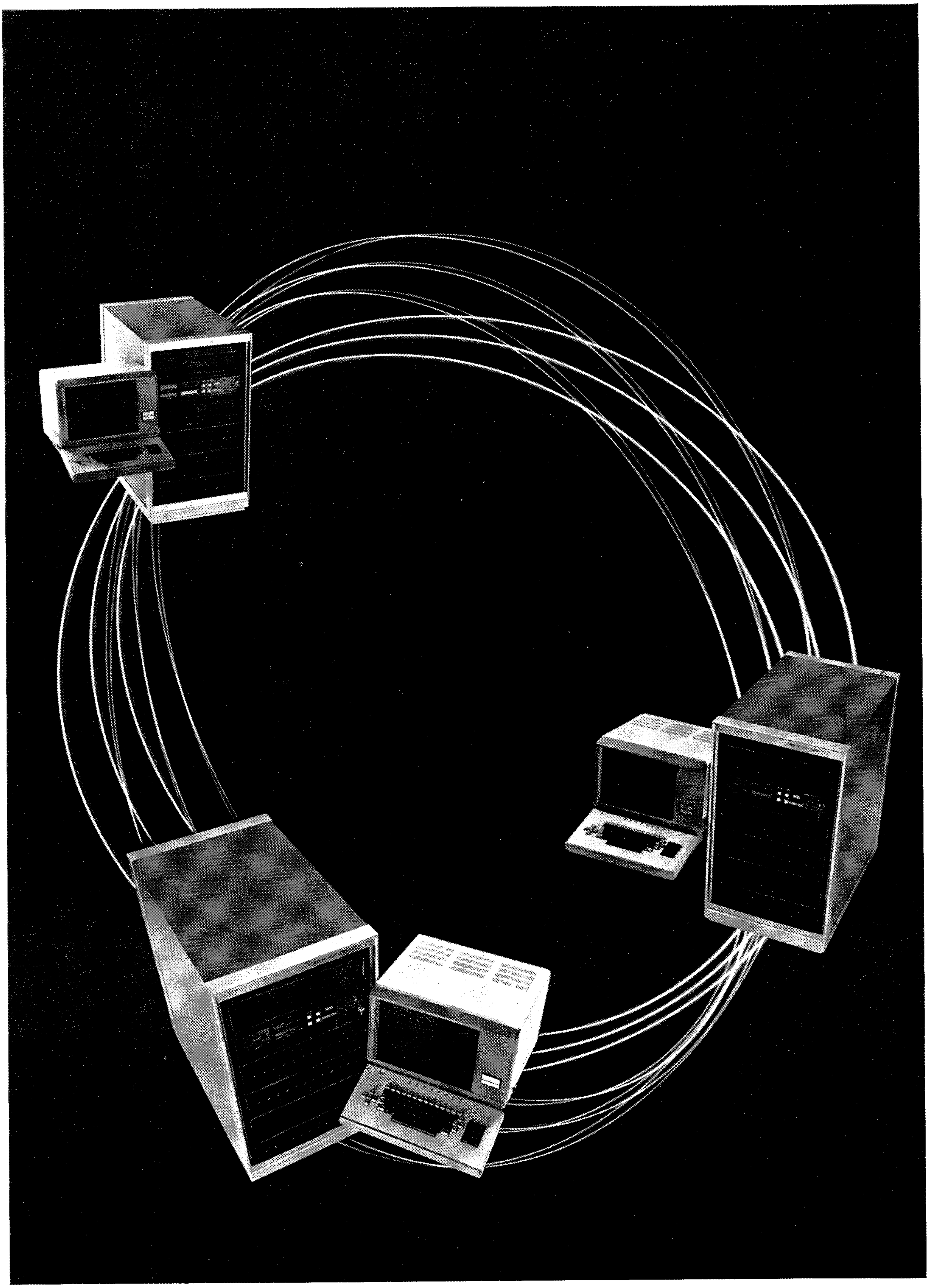

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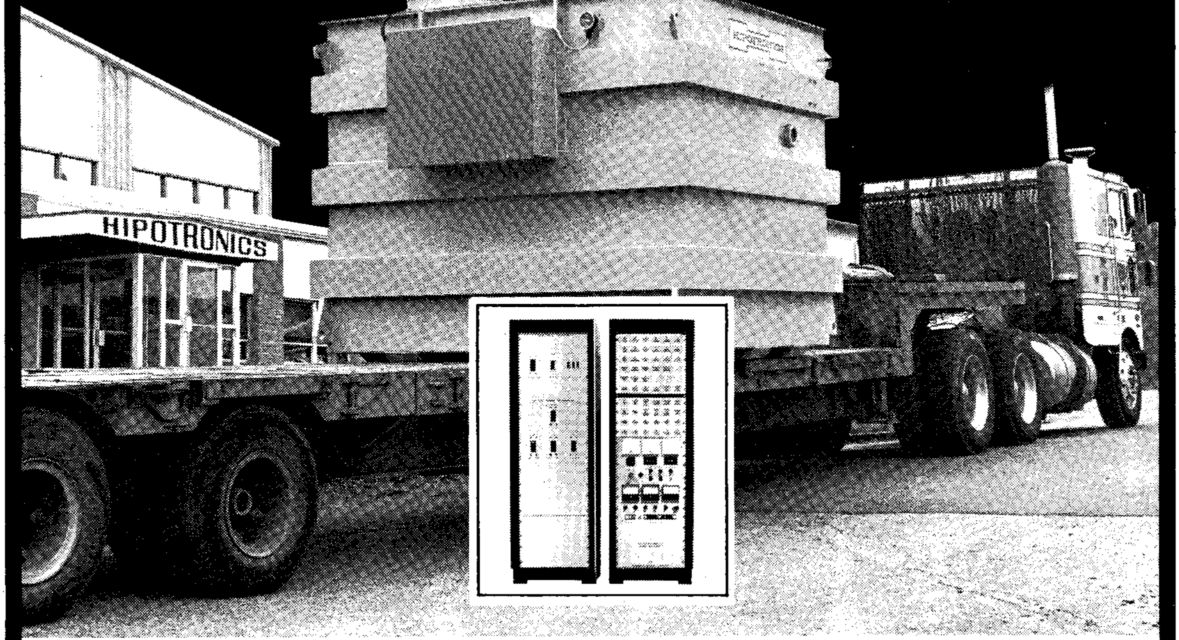
Tlx.: 201108 nd paris

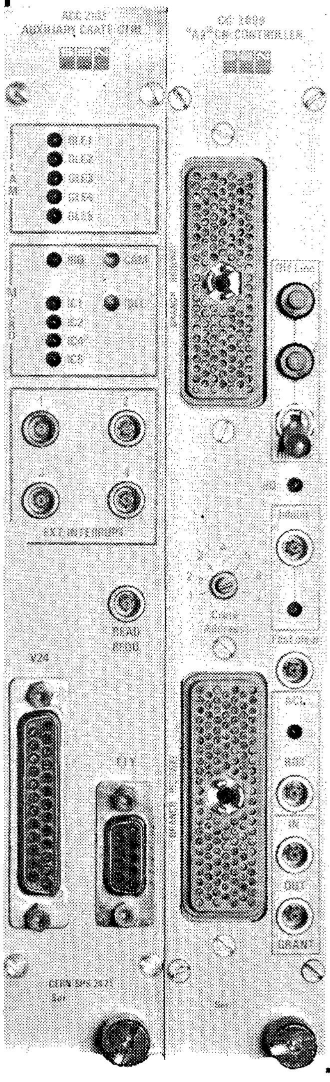

HIPOTRONICS

CAMAC

Introducing the next stage of the most powerful CAMAC Controller System ACC 2103/CCA2 2089

ACC 2103 Auxiliary Crate Controller

- 16 bit Texas TM 9900 microcomputer
- 16 K 16 bit RAM directly addressable from CAMAC at 1μs/Word
- up to 8 K EPROM for permanent programs
- TTY and RS 232 C interfaces
- built in LAM Grader
- CAMAC module addressed as memory positions for simple software
- programming in assembly language or high level language
- CAMAC Read/Write cycle less than 10 μs in autonomous mode
- also compatible with SCC-L2 and Nord 10-PIO Controllers



CCA2 2089 A2 Parallel Crate Controller

- fully conforms to the new EUR 6500 specs
- single board construction

SYSTEM OPERATION

The A2 Crate Controller is a parallel Crate Controller and includes all the same functions plus new control logic for local data handling using a microprocessor module (as ex. ACC 2103). The A2 provides access to the N and L lines via a rear panel connector for the Auxiliary Crate Controller placed in any normal station. It also handles the remote/local access request conflicts. Front-end data processing is governed by the ACC 2103 just as long as the man computer does not require access to this particular crate: However, when this occurs, the local processor is released, its status saved and the Branch Demand processed. Once the Branch Demand has been filled, control returns to the ACC 2103.

Brief configuration guide

- For systems not requiring permanently available high-level languages the ACC 2099 (single width) is normally sufficient.
- to improve input/output and intersystem communication, the SEN CI 2092 communications interface (high speed, multi-channel, buffered, micro-processor controlled) may be added.
- for fully autonomous systems, a version combining the features of the ACC 2103 and of a Crate Controller will be available shortly (Type STACC 2107 – Stand Alone CAMAC Computer).

France: **ORTEC Sarl**; 7, rue des Solets; Tel. (1) 6872571 - Tlx 202553F, F-94 RUNGIS – **Germany:** **SEN ELEKTRONIK GmbH**; Brandstücken 11; Tel. 041 802046 - Tlx 2163705d, D-2000 HAMBURG 53 – **DIDAS Digital System**; Radspielstrasse 8; Tel. 089 916710 - Tlx 529167d - D-8000 MÜNCHEN 81 – **Switzerland:** **SEN ELECTRONIQUE SA**; CP 39; Tel. (022) 442940 - Tlx 23359ch - CH-1211 GENÈVE 13 – **SEN ELEKTRONIK AG**; Austrasse 4; Tel. (01) 9455103; Tlx 58257ch - CH-8604 VOLKETSWIL – **United Kingdom:** **SEN ELECTRONICS LTD**; London Street; Chertsey; Tel. 9328.66744 - GB - KT168AP SURREY – **OFFICES THROUGHOUT THE WORLD.**

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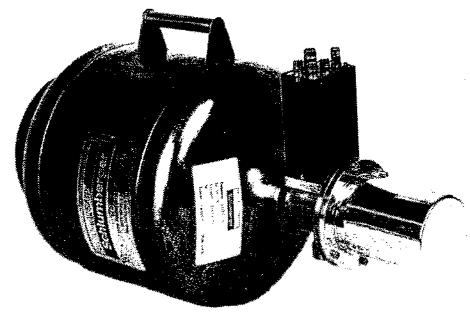
SEN
ELECTRONIQUE

Fine spectrometry outside the laboratory

• Detector with special cryostat SH005P



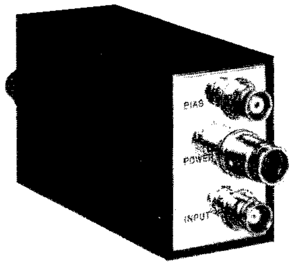
ENERTEC has developed a completely new type of cryostat which is portable and capable of orientation at any angle without risk of liquid nitrogen spillage.

The portable cryostat can be used with any of the different x and γ ray detectors made from silicon and germanium.

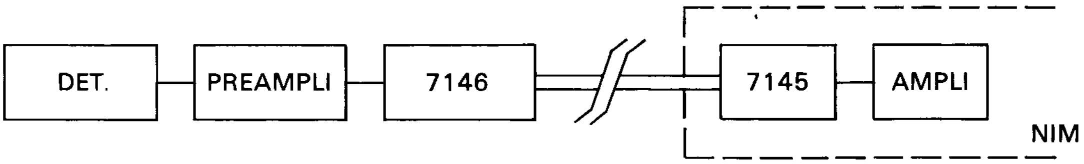
- Small size
- Light weight (12 kg)
- Holding time of 5 days
- Capable of orientation at any angle

SHOO5P cryostat may be a joker for you who have to deal with topographical constraints, near accelerators, reactors or outside the laboratory.

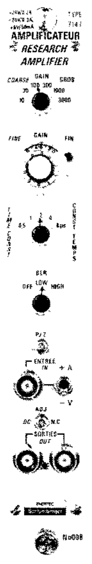
• Dedicated electronics



Remote preamplifier and amplifier adapters (7145, 7146) this set of two modules is designed for long range transmission, over several hundred meters of analog signals without degradation of resolution.



• Linear amplifier for high resolution 7147



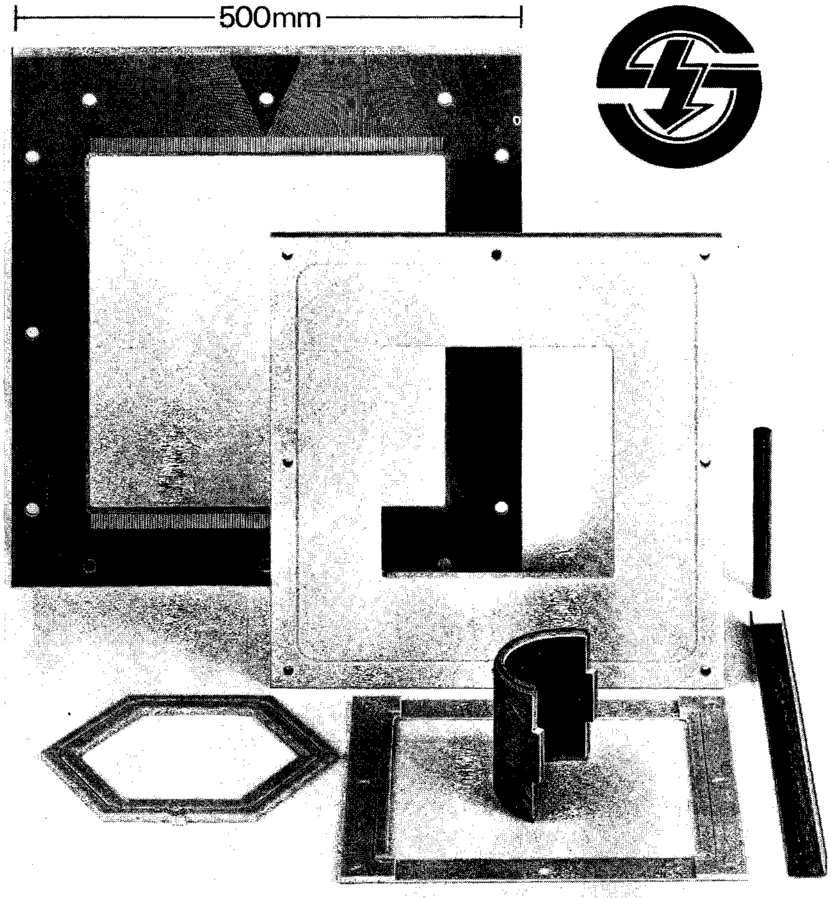
Nuclear spectrometry amplifier 7147 for high resolution.

Especially adapted to high counting rate owing to an excellent base line restoring circuitry.

Can be directly connected to pile up rejector unit 7150.

ENERTEC
Schlumberger

Branche Instrumentation Nucléaire
1, rue Nieuport – 78140 **VELIZY-VILLACOUBLAY** – **FRANCE**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