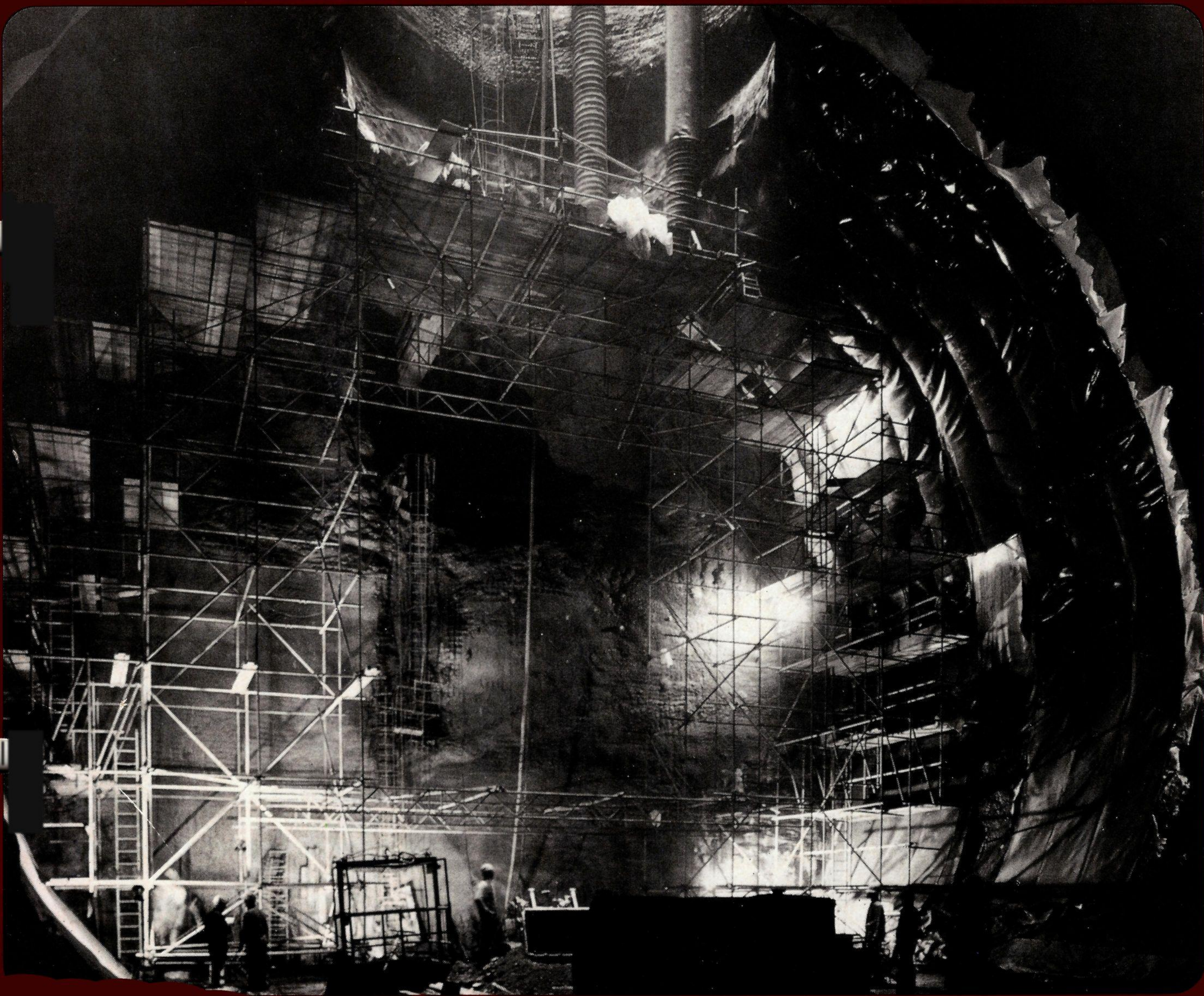
CERN COURIER



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Editors: Brian Southworth, Henri-Luc Felder, Gordon Fraser
Advertisements: Micheline Falciola

Laboratory correspondents:
Argonne National Laboratory, USA
R. Arnold
Brookhaven National Laboratory, USA
P. Wanderer
Cornell University, USA
N. Mistry
Daresbury Laboratory, UK
V. Suller
DESY Laboratory, Fed. Rep. of Germany
P. Waloschek
Fermi National Accelerator Laboratory, USA
R.A. Carrigan
KfK Karlsruhe, Fed. Rep. of Germany
M. Kuntze
GSI Darmstadt, Fed. Rep. of Germany
H. Prange
INFN, Italy
M. Gigliarelli Fiumi
Institute of High Energy Physics, Peking, China
Tu Tung-sheng
JINR Dubna, USSR
V. Sandukovsky
KEK National Laboratory, Japan
K. Kikuchi
Lawrence Berkeley Laboratory, USA
W. Carithers
Los Alamos Scientific Laboratory, USA
O.B. van Dyck
Novosibirsk Institute, USSR
V. Balakin
Orsay Laboratory, France
J.E. Augustin
Rutherford Laboratory, UK
J. Litt
Saclay Laboratory, France
A. Zylberstejn
SIN Villigen, Switzerland
G.H. Eaton
Stanford Linear Accelerator Center, USA
L. Keller
TRIUMF Laboratory, Canada
M.K. Craddock

Copies are available on request from:
Federal Republic of Germany
Frau G.V. Schlenther
DESY, Notkestr. 85, 2000 Hamburg 52
Italy —
INFN, Casella Postale 56,
00044 Frascati,
Roma
United Kingdom —
Elizabeth Marsh
Rutherford Laboratory, Chilton, Didcot
Oxfordshire OX11 0QX
USA/Canada —
Margaret Pearson
Fermilab, PO Box 500, Batavia
Illinois 60510
General distribution —
Monika Wilson
CERN 1211 Geneva 23, Switzerland

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CERN, 1211 Geneva 23, Switzerland
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(CERN COURIER only Tel. (022) 83 41 03)
USA: Fermi National Accelerator Laboratory
P.O. Box 500, Batavia, Illinois 60510
Tel. (312) 840 3000, Telex 910 230 3233

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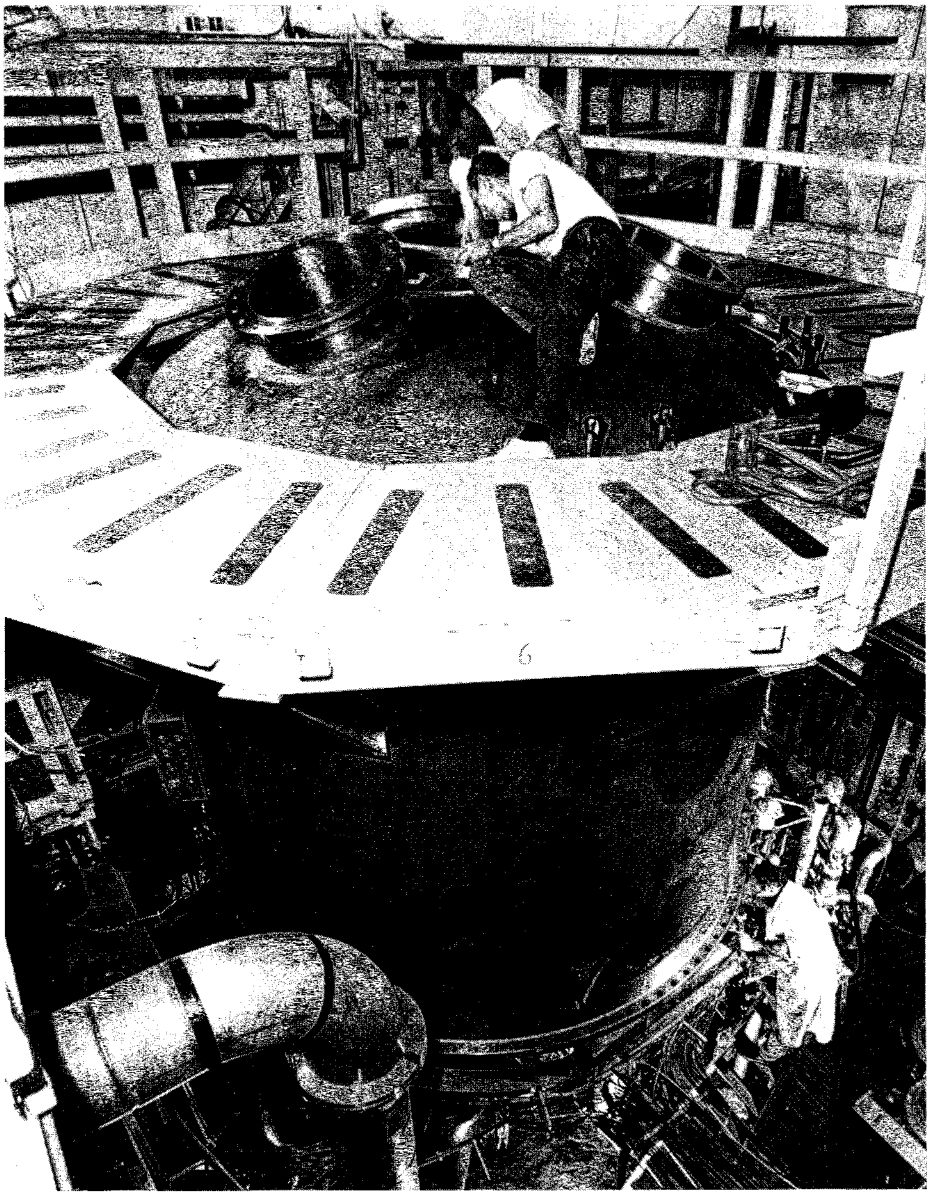
Cover photograph: Work in progress at one of the underground areas of the CERN SPS 400 GeV proton synchrotron to house experiments at the proton-antiproton collider. Later this year the SPS will be shut down to enable the necessary conversion work to be carried out for the antiproton project (Photo CERN 262.2.80).

Around the Laboratories



The 7 foot bubble chamber at Brookhaven under construction in 1969. The chamber's life has now come to an end.

(Photo Brookhaven)

BROOKHAVEN
End of bubble chamber era

The 7 foot bubble chamber on the Alternating Gradient Synchrotron at Brookhaven has come to a sudden end. On 18 January a vacuum leak stopped a neutrino experiment with the chamber filled with deuterium for a Brookhaven/Tohoku collaboration. The chamber was warmed to room temperature and the leak was found to be due to a crack through the chamber wall where a large flange was welded to the chamber body.

The flange secured the cover to an instrumentation port at the top of the chamber. The crack was about 40 cm long and penetrated completely through the 1.6 cm thick stainless steel wall. Since the weld had been poorly done by a commercial supplier, it was felt that the only acceptable repair was to machine the flange completely out and weld in one of proper design. Unfortunately this was a larger job than could be completed before the scheduled end of the experiment, and, with the ISABELLE project pressing its need for most of the people on the crew, the chamber was shut down for good.

The chamber was located in the neutrino beam. The first tracks were seen in May 1973 and the first physics pictures were taken in November of that year with a filling of hydrogen. In typical bubble chamber fashion, those earliest pictures, taken more in the spirit of chamber testing than physics production, contained the first observation of 'naked charm' (see April 1975 issue, page 108). The second clear example found in this chamber appeared only a half million pictures later (see March 1979 issue, page 111).

The chamber took a total of 3.9 million pictures during its seven-year life and it was expanded 6.7 million times. A little over half the pictures were in deuterium, a third in neon-hydrogen mixtures and about ten per cent in hydrogen. Thirty-one separate cooldowns were made to achieve this, with nine of them aimed at engineering data only, and twenty-two for physics. Although the average number of pictures per cooldown was about 175 thousand, the range stretched from zero to 1.2 million. Therein lies the story of the bubble chamber addict — the highs are so high and the lows so low.

This brings the bubble chamber era at Brookhaven to a close. From the 6 inch in 1957 through the 20, 30, 31 and 80 inch chambers to the 7 foot, Ralph Shutt was the driving force. He and many of those who worked with him through those years have already thrown themselves into the ISABELLE fray, where a good deal of what was learned in bubble chambers is immediately applicable.

ARGONNE Accelerator for neutron research

The shutdown of the Zero Gradient Synchrotron was not as sad an event for scientists involved with the Intense Pulsed Neutron Source as it was for those involved in polarized proton physics. The neutron enthusiasts are now able to get full use of the linear accelerator, which had been time-shared between the ZGS and their neutron source.

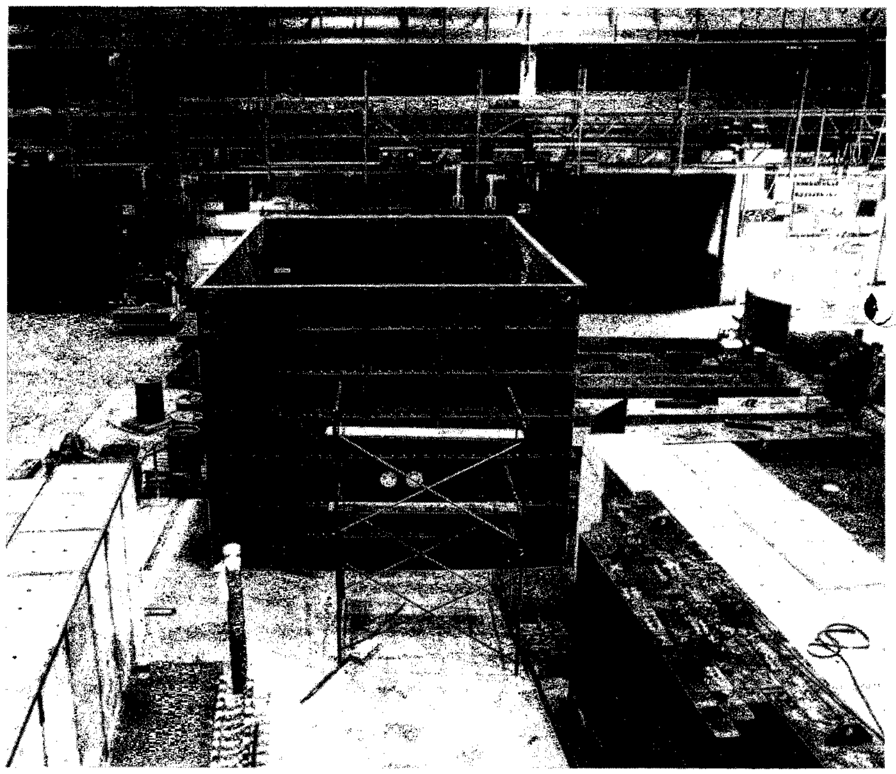
The Rapid Cycling Synchrotron, RCS, formerly known as Booster-II, since it was initially intended to increase ZGS intensities, is currently directing its proton beams at a uranium target being used as a spallation neutron source by the proton facility, known as ZING-P', for neutron beam research. Shutdown of the ZGS meant an immediate 50 per cent increase in the available proton beam intensity from the previous 1.5 μA intensity for ZING-P' neutron production. An increase of 300 per cent is expected soon when temperature constraints on target operation are removed, making it possible to increase the operating frequency of the RCS from 10 to 30 Hz. ZING-P' will have five or six more months of operating time before being shut down in preparation for switching to a new target and experimental area being built in one of the former ZGS experimental areas.

The new facility, known as IPNS-I, is scheduled to begin operation in April 1981 and it will be a national facility for the study of condensed matter. Initial construction is being carried out under a $ 6.4 million contract from the Department of Energy; Congress has just approved another $ 2.4 million for an IPNS Upgrade Project. Initial operation is expected to provide 2×10^{12} protons per pulse at an energy of 500 MeV with a 30 Hz repetition rate. This will produce a usable thermal neutron flux equivalent to that from a medium flux reactor, but will produce a usable epithermal neutron flux greater than that available at any reactor in the world. This is expected to open up areas of research hitherto not feasible with reactor neutron sources.

Efforts are already being made to exceed these performance levels by increasing the beam energy and repetition rate. It is expected that the RCS may eventually be able to produce higher energy protons, maybe up to 600 MeV, at 45 Hz with an intensity greater than 2×10^{12} protons per pulse. Many former ZGS staff have come from Divisions involved with the CP-5 reactor which shut down a few days before the ZGS.

Construction for IPNS-I began in the summer of 1979 with the pouring of the massive reinforced concrete slab to support the shielding of the proton transport system.

Zircaloy-clad uranium discs will be used as the neutron-generating target for IPNS-I, giving about fifteen neutrons per incident 500 MeV proton. The neutrons will be moderated by hydrogen-bearing materials which are surrounded by beryllium reflectors to reduce neutron leakage. The reflectors will be decoupled from the moderators by thermal neutron absorbers such as boron or cadmium to preserve the time-resolution of the pulse. Twelve neutron beam tubes have been provided for neutron-scattering instruments.

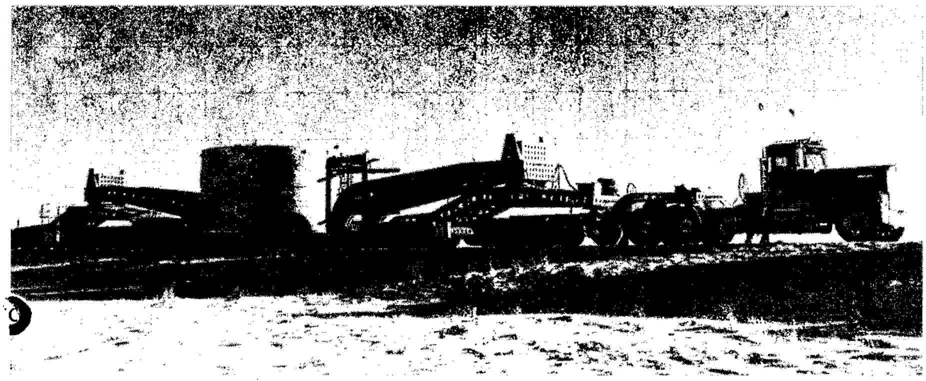


Construction of the IPNS-I beamline and target shield is progressing rapidly at Argonne to provide unique facilities for research with neutron beams. Shown here is the steel tank which will enclose the target, plus some of the proton beamline shielding. The final steering magnet will direct the beam either at a neutron scattering target or a radiation damage target through one of the two holes in the front of the tank.

(Photo Argonne)

The huge rebuilt superconducting magnet of the Argonne 12 foot bubble chamber being trucked across Wyoming en route for its new experimental duty in a spectrometer on the PEP storage ring at SLAC. It was a spectacular exercise in organization and in transport techniques.

(Photo Argonne)



A separate, but identical uranium target will be provided for fast neutron radiation damage experiments. There will be no moderators near this target and only heavy elements will be used for reflectors to inhibit neutron moderation. A switching magnet will be used to direct the proton beam to the desired target. It is expected that initially about a quarter of the time will be devoted to radiation damage measurements and the rest to neutron scattering.

Both targets will be water-cooled, and some of the moderators will be cooled to cryogenic temperatures to provide slower neutrons and narrower pulses.

Provision has also been made for a high energy proton test beam which can be used to test detectors planned for use at Fermilab or elsewhere. Thermal neutron irradiation facilities are also planned since such facilities are no longer available elsewhere at Argonne following the shutdown of the CP-5 reactor.

Moving magnet

The famous 12 foot bubble chamber completed its programme of physics at the ZGS in February 1978, shortly after approval of a proposal to build a High Resolution Spectrometer for use on the PEP electron-positron storage ring at SLAC. This proposal was made by a team from Argonne, Indiana, LBL, Michigan, Purdue, and SLAC, and involved using the huge superconducting magnet from the bubble chamber as the basis for a general purpose solenoidal spectrometer that would give high momentum resolution on charged tracks.

The magnet has an iron yoke weighing 1600 tons and extensive modifications to the iron were done during 1978 to change the system from the vertical field configuration used with the bubble chamber to the horizontal field configuration required for PEP.

Rework of the cryostat started in September 1978 and required the removal of a 1-inch thick aluminium vacuum can, 60 layers of superinsulation and the aluminium radiation shield. Panels were then cut out of the thick stainless steel cryostat and new saddles were installed to support the superconducting coil when turned 90° into its new orientation. Instrumentation wires, current leads, fill and return lines, and emergency vent stacks all had to be put into new locations. Finally, everything was welded back together, the radiation shield reinstalled, new superinsulation wrapped around the entire can and the vacuum shell rewelded.

The coil was turned in May 1979 and supported in a temporary frame. The modified helium refrigerator was connected and a cryogenic test of the magnet and refrigerator was done during July and August. By the end of September, the magnet was blessed as ready for shipment to SLAC.

Several modes of transportation between Chicago and San Francisco had been under consideration. The complete coil and vacuum container was slightly too big for the C5 A cargo plane and was also either too wide or too high (depending on the orientation) to clear the rail tunnels and bridges. Barge travel was ruled out because of worries about moves from shallow-draft to ocean-going barges and because of the high cost. It was finally decided to ship by truck. Individual road permits were obtained from seven States (Illinois, Iowa, Nebraska, Wyoming, Utah, Nevada, and California) since the load was both over wide (18.5 feet), requiring two lanes, and over weight (107 tons). This whole autorization took about a year and was an education in the operation of a Federal system of government.

A special trailer was constructed by Siebert Trailers of Stockton, California to the design of Stan Jones, who owns the successful bidding company. The tractor-trailer had 18 axles and a total of 110 tyres. With the magnet loaded, the total weight was 323 000 lbs. The 140 foot-long truck travelled mostly on Interstate 80 from Chicago to San Francisco. It started its journey from Argonne on 5 November and reached SLAC on 22 November, Thanksgiving Day. The criteria set by the individual States required the vehicle to cross most bridges at a speed of a few miles per hour and the maximum speed was 50 mph on the Salt Flats in Utah.

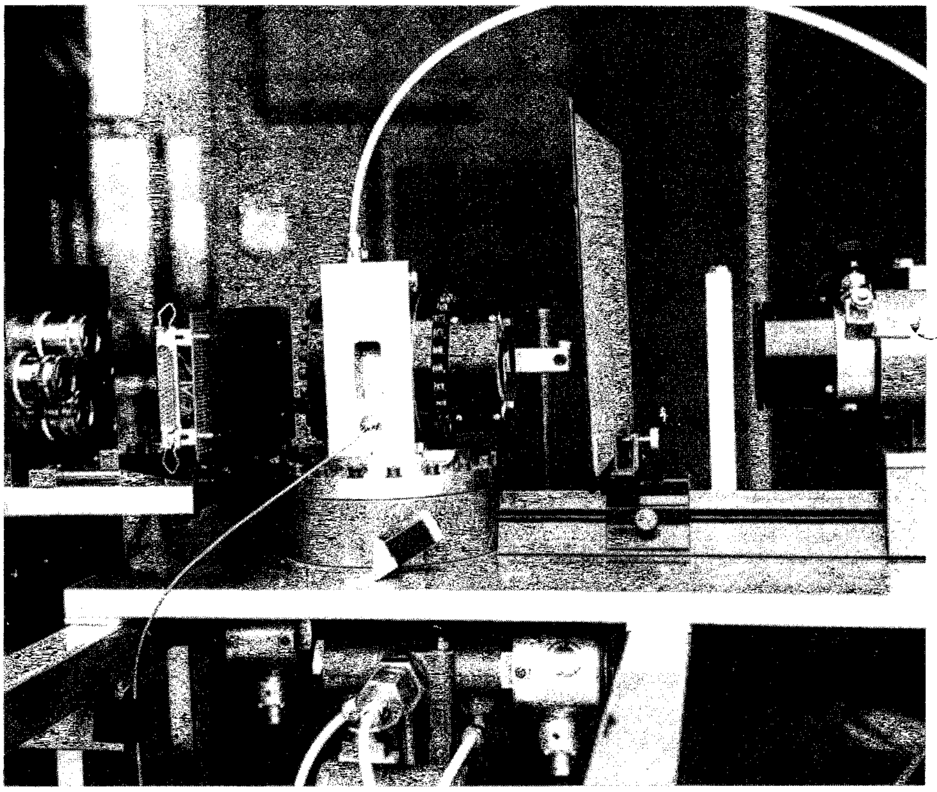
Delays came from things like a switchover from night to daytime

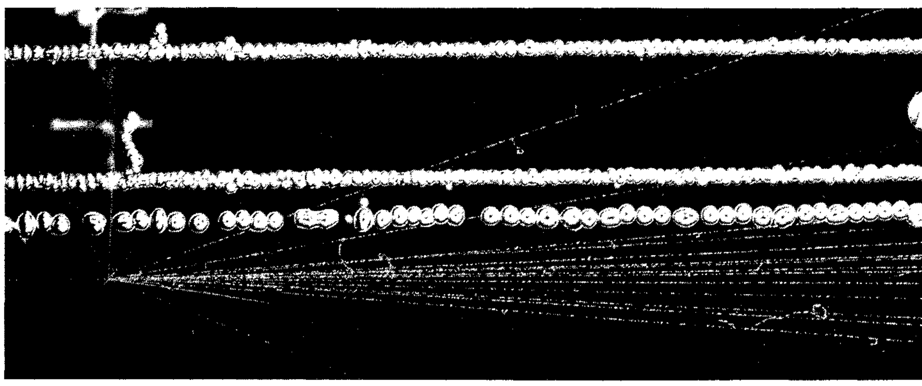
(Iowa to Nebraska), a change in the axle configuration (Nebraska to Wyoming), a football game crowd, and a snowstorm in Wyoming. The Sierra mountains were crossed via the Kit Carson Pass with the help of an additional pusher drive unit and an additional puller in front equipped with snow chains. The load attracted considerable attention from trucking enthusiasts in all States!

The magnet arrived at SLAC in excellent condition and reassembly with the iron has started at PEP. It is hoped that the experiment will be in operation before the end of the year.

CERN
Bubble chambers get smaller

The Berne Infinitesimal Bubble Chamber — BIBC — specially designed to look for charm decays. Only 6.5 cm in diameter and 3.5 cm deep, it must be one of the smallest bubble chambers used for physics.





A typical interaction in BIBC. The 'old' tracks from previous particles have bubble diameters of several millimetres.

Over the years, bubble chambers have been built bigger and bigger as physicists have searched for rarer types of interaction. However the last year has seen a sudden reversal of this trend with the introduction of some very small chambers specially designed to look for the production and decay of charmed particles.

The lifetime of charmed particles has been a controversial subject ever since the discovery of the charm quantum number. At first experimental results were in considerable disarray, but last year saw experiments homing in on a theoretically desirable value of 5×10^{-13} s.

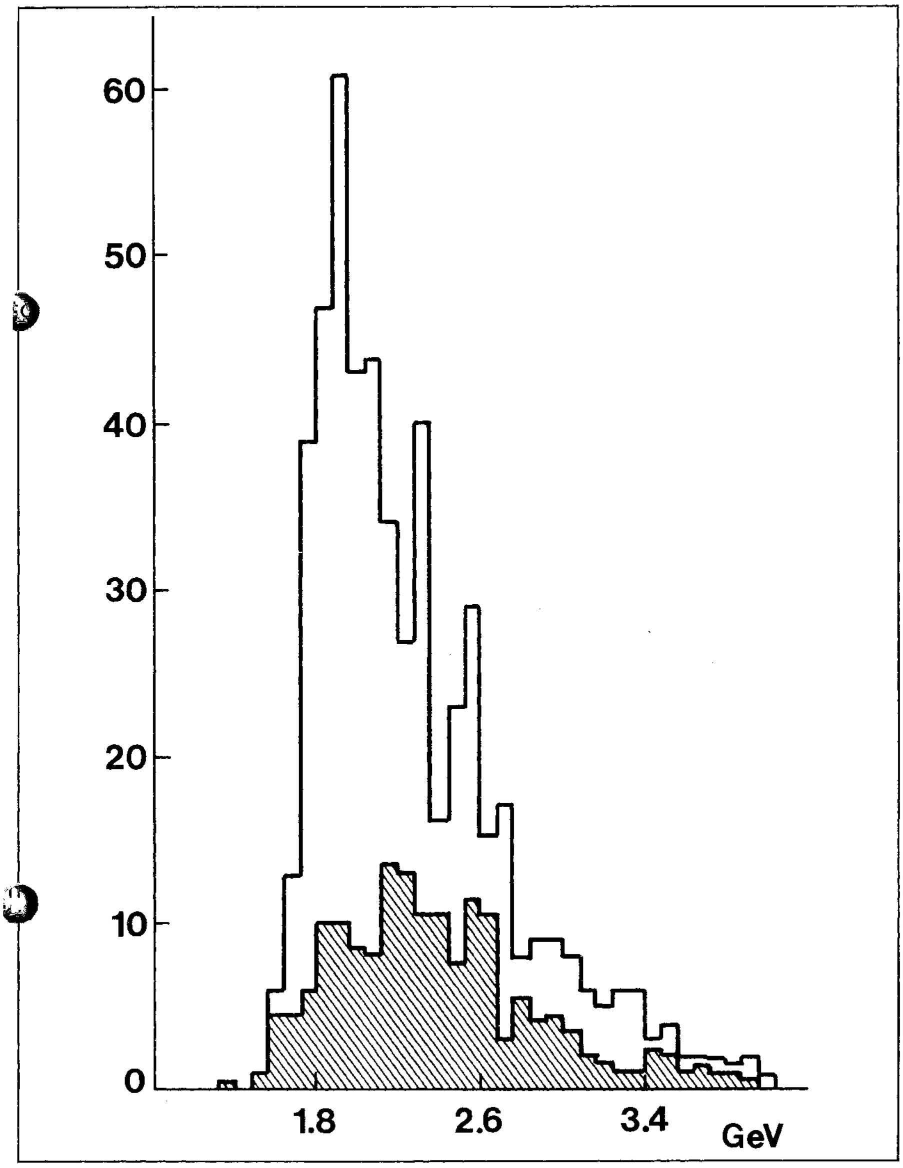
Now new results (see March issue, page 16) indicate that the lifetimes of charged and neutral charmed mesons could be different. Experiments to measure the charm lifetime continue to make news.

To extend the data available, two small bubble chambers have been built for use at CERN. One has a diameter of 20 cm, operates at some 50 cycles per second and is filled with liquid hydrogen (see September 1979 isue, page 258).

A second, built by a team from the University of Berne led by Beat Hahn and Edwin Hugentobler, is now in operation. This cylindrical detector is only 6.5 cm in diameter and 3.5 cm deep and must be one of the smallest bubble chambers ever used for physics. Because it uses heavy liquid, it could give an indication of how the charm reactions vary with different nuclei, so complementing the data obtained from hydrogen targets.

The rapid cycling chamber is known as LEBC (Little European Bubble Chamber) and the heavy liquid detector is called BIBC (Berne Infinitesimal Bubble Chamber), to

An enhancement near 1.9 GeV in the histogram showing $K^*K\pi$ selected from photoproduced $K^+K^-\pi^+\pi^-$ observed in the Omega spectrometer at CERN. The shaded histogram gives the expected background and the y-axis indicates events per 80 MeV bin. Such meson excitations are rarely seen.



distinguish them from the other bubble chamber operating at CERN – the mighty 3.7 m diameter Big European Bubble Chamber BEBC.

Because of the relatively short lifetime of charmed particles, their decays can take place within a track length of some 500 microns. This is comparable with the size of the bubbles in large chambers like BEBC, and makes the decays difficult to spot in these detectors.

In BIBC, the bubbles grow to 30 microns diameter within about 15 microseconds, compared with the BEBC flash delay of some 10 milliseconds. In order to obtain the desired bubble size with good contrast, the flash lasts only for 1 microsecond. Bubbles are photographed by three cameras. The expansion system works with compressed air and reaches a maximum rate of five cycles per second.

Some 200 bubbles per cm are obtained, representing an increase in bubble density of about an order of magnitude over large chambers like BEBC. With slow extracted beams from the SPS, a simple electronic trigger synchronizes the flash.

After tests in a 140 GeV beam to determine resolution and background characteristics, BIBC is being used in conjunction with a streamer chamber (built by the Max Planck Institute, Munich) which gives the momentum of the produced particles.

Looking for new mesons

Mesons are understood to be composed of quarks and antiquarks bound together in pairs. As in other quantum mechanical systems, like the hydrogen atom, these bound states are expected to have different 'radial excitations' or energy levels.

Such behaviour is seen with the heavy psions, which are composed of a charmed quark and a charmed antiquark. Since the discovery in 1974 of the lightest such state, the J/psi, many more psions have been seen, and are interpreted as excited states of the same quark-antiquark system.

While many such excitations are found for these mesons containing charmed quarks, they seem to be much rarer for the lighter spin one mesons made up from less exotic quarks. Up till recently, the only one known was the rho prime of mass 1600 MeV, a radial excitation of the ordinary rho meson.

Now an experiment using a photon beam with the Omega spectrometer in the West Area of the SPS has seen possible evidence for a radial excitation of the phi meson, a companion of the rho in the octet of light spin one mesons.

As the rho prime decays into an ordinary rho and two pions, a phi prime, if it exists, would be expected to decay into $K^*K\pi$. This K^* would then decay itself into $K\pi$. The Omega photoproduction experiment therefore searched for signals of possible new particles in the final state containing positive and negative kaon and pion pairs.

The SPS photon beam is the bremsstrahlung produced by electrons (derived from the primary protons) as they pass through a thin tungsten radiator, and the energy loss of the electrons gives the energy of the produced photons. This 'tagged' beam reaches 2×10^5 photons per burst over the energy range 20-70 GeV.

The experiment used a liquid hydrogen target and particle identification was carried out using a threshold gas Cherenkov counter. From a total of over five million triggers producing between four and nine charged particles in the final state, a sample was selected from suitable four or five particle events containing two kaons of opposite charge.

After allowing for missing particles and other reactions which could simulate $KK\pi\pi$ behaviour, a four particle mass distribution was obtained with a peak at 1.9 GeV. When events were selected which correspond to K^* production, the peak (width 400 MeV) became more distinct, while no such signal was seen in the subset of events corresponding to production of a phi plus two pions, as expected from quark selection rules. Angular distribution analysis indicates that the new enhancement probably has spin one and negative parity.

Despite this new finding, observations of radial excitations in lighter mesons are still rare, and the search continues.

DESY
Coupling constant for strong interactions

Important information on strong interactions has come from analysis of the exact structure of the hadron events observed recently at the PETRA electron-positron storage ring in which the secondary particles are confined in narrow 'jets'. The data collected now allows the calculation of the energy-dependent 'running coupling constant' for strong interactions at high energies.

Five years ago, electron-positron annihilation experiments at SPEAR and DORIS showed that as the centre of mass energy increases above 5 GeV, the produced hadrons tend to emerge as two jets. The most likely interpretation of this phenomenon is the annihilation of the electron and the positron, producing a quark and an antiquark, with the quarks subsequently fragmenting into hadrons. These have limited tranverse momentum due to the forces which confine quarks inside hadrons.

In quantum chromodynamics (QCD), the currently favoured theory of quarks and gluons, a continuous exchange of gluons between quarks accounts for the strong interactions. In this theory, as the space-time volume of the interaction decreases (i.e. momentum transfer increases), the 'running coupling constant' which describes the effective strength of the quark-gluon force decreases. This enables individual processes to be calculated and combined together in a well-defined way (perturbation theory).

In electron-positron interactions, in addition to the annihilation of an electron and a positron to produce a quark and an antiquark, gluon bremsstrahlung processes should be possible where the electron and the positron produce one or two gluons along with the quark and antiquark.

Moreover it was expected that at higher energies the gluons would come off with enough energy to manifest themselves as distinct jets of hadrons, very much like the jets coming from the quarks. The three QCD processes where the electron and positron produce a quark and an antiquark, or a quark and an antiquark together with one or two gluons, would then show up as two-, three-, and four-jet events respectively, with increasing numbers of jets having decreasing probability.

Recent high energy experiments at PETRA (see November 1979 issue, page 358) have clearly demonstrated that the interpretation of many of the observed events in terms of two jets is no longer possible. Jet broadening, increase of transverse momentum with energy and the emergence of a distinct three-jet structure can all be clearly seen without using any particular theory or model.

These observations are explained by the production of gluons along with quarks and antiquarks, and QCD calculations are in good quantitative agreement with the observed jet structure.

In this QCD framework, one of the most important tasks is to determine the effective strength of the quark-gluon force — the coupling constant. In a recent calculation by theorists from DESY and the University of Hamburg, various transverse momentum broadening effects, like the production and decay of charm and bottom quarks and the momentum transfer dependence of the fragmentation of quarks into hadrons, were taken into account. The effects of other QCD processes producing four final particles were also included.

In the energy interval 27.4–31.6 GeV, data from 1200 hadronic events registered by the Mark-J detector were compared with this calculation and gave the running coupling constant as 0.23 ± 0.02, while 900 events from the TASSO detector gave a value of 0.22 ± 0.03.

Using an earlier QCD calculation for the production of a quark-antiquark pair and a gluon, the collaboration working with the JADE detector, using a smaller sample of events, got a value of 0.17 ± 0.04. The squared momentum transfer of the events averages about 900 GeV^2. This is the highest recorded so far and means that the space-time volumes involved are small enough to make the use of perturbation methods in calculations legitimate.

RUTHERFORD
UK magnet wins American award

The Rutherford Laboratory, jointly with Oxford Instrument Co Ltd, has won a major award for technical innovation. Each year the American magazine Industrial Research/Development makes a hundred such awards for significant technical products. Most of them go to organizations inside the USA. This year, for example, only nine were made to bodies outside America.

The award has been made for the development of the first persistent superconducting magnet suitable for nuclear magnetic resonance (NMR), using niobium-tin as the superconductor. With this new magnet, NMR can be performed at 11 T.

An indirect method for producing niobium-tin superconductors was developed in collaboration with Imperial Metal Industries, the Atomic Energy Research Establishment at Harwell, and Rutherford. It uses a malleable wire consisting of thousands of fine niobium wires set in a bronze matrix to wind the solenoid.

The magnet consists of two concentric solenoids: an outer made from niobium-titanium which produces a field of 8 T, and an insert of niobium-tin which increases the field in the central region to 11 T (equivalent to a proton frequency of 470 MHz).

To achieve the stability required for high resolution NMR work these two coils have to be connected in series and operated in the persistent mode with the current circulating in an endless loop. This requires joints between the two sorts of superconductor and a very low resistance in each joint. In practice, joint resistances of less than 10^{-10} ohms are required to reduce the field decay rate to a few parts in 10^8 per hour. The development of suitable joints was the main task in the project and needed considerable effort by a team from Oxford Instruments and Rutherford.

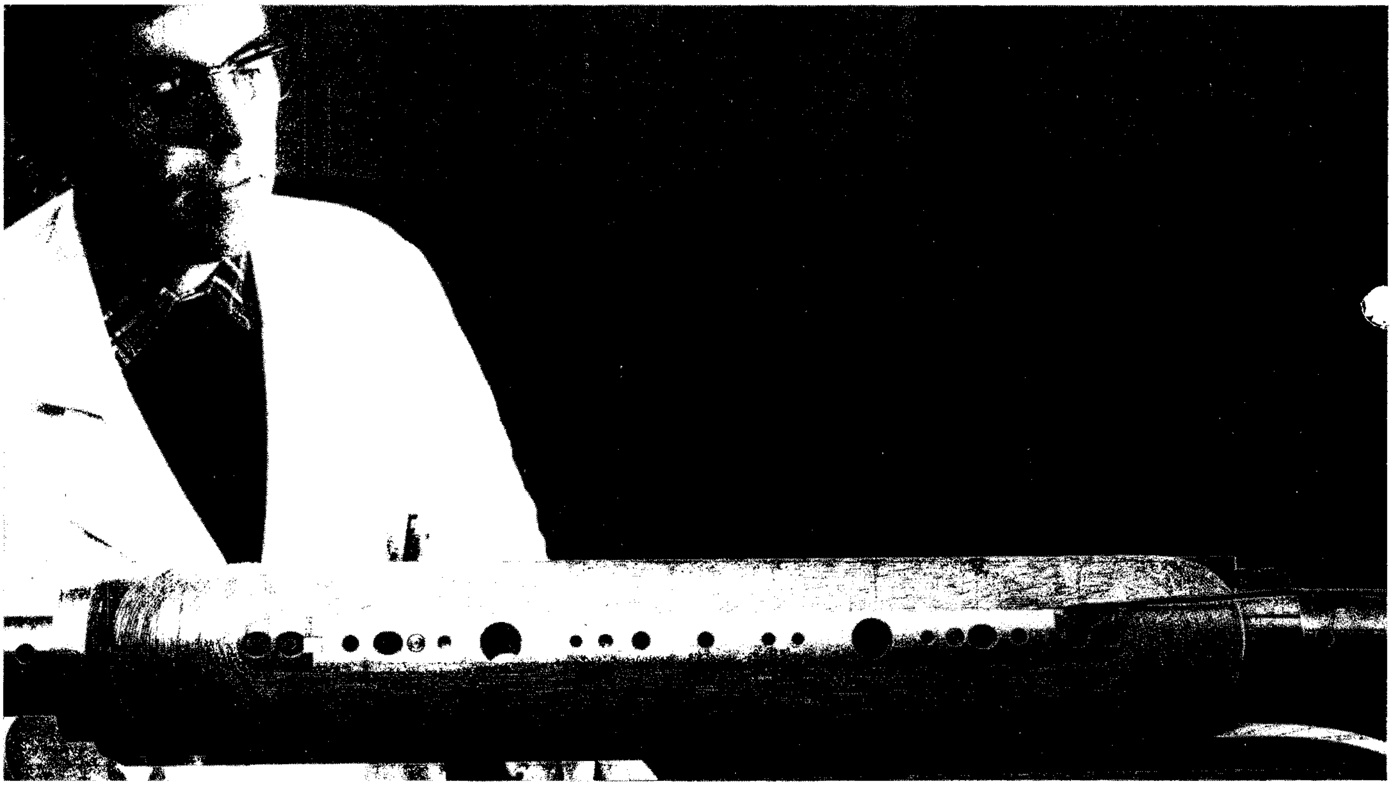
The magnet, made for the Enzyme Group at Oxford University, achieved its working field of 11 T with little trouble and has a measured decay rate of 2 parts in 10^8 per hour. Today, Oxford Instruments are producing magnets of this type for delivery all over the world. Further research has already led to the development of magnets with stable fields in excess of 11.8 T (500 MHz).

John Magraw (left) and Christopher Scott of Rutherford with the award given by the US magazine Industrial Research/ Development for a high field superconducting magnet for nuclear magnetic resonance studies.

(Photo Rutherford)

A superconducting dipole under construction at Saclay as part of the development programme for the UNK proton synchrotron in the USSR. The dipole, using niobium-titanium superconductor, was recently operated in a cryogenic system providing 1.8 K and reached peak fields in excess of 6 T.

(Photo Saclay)



SACLAY Superconducting dipole tops 6 T

The Département de Physique des Particules Elémentaires at Saclay has been working for two years in collaboration with the Institute of High Energy Physics at Serpukhov to develop superconducting magnets for use in the 3000 GeV proton synchrotron, UNK, which is proposed as the next high energy physics machine in the Soviet Union.

Several short magnets, using niobium-titanium superconductor operated at 4.2 K, were built at Saclay during 1979 with satisfactory results. One of these model magnets has now been tried in another cryogenic system which provides temperatures of 1.8 K at atmospheric pressure. This system was specially developed for investigations on controlled thermonuclear fusion with the aim of building a superconducting Tokamak reactor.

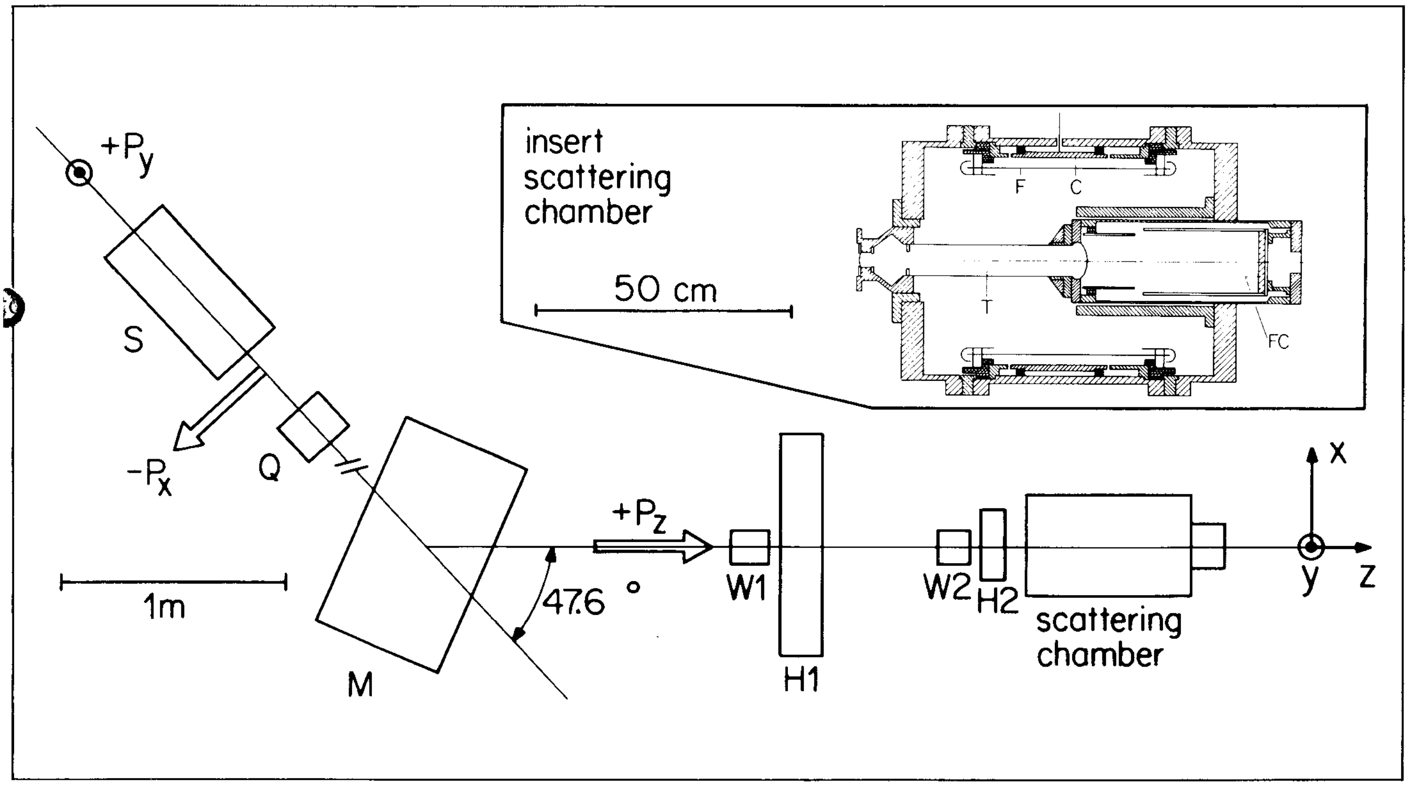
The central field of the dipole reached a peak of just over 6 T which was an increase of about 20 per cent over its earlier performance of 4.2 K. Also this peak field was achieved after only four quenches showing that the 'training' characteristics of the magnet are good.

The mechanical structure of the magnet proved reliable so that the much higher currents in the superconductor could be used. It is particularly encouraging that the high peak field has been achieved using cryogenic techniques which are simple and well proven. This makes it possible to envisage the use of magnets with niobium-titanium superconductor to provide higher fields, and thus higher proton synchrotron energy for a given radius, than has been considered up t^ now.

SIN Parity violation in proton-proton interactions

It is known that the assumption of parity conservation in strong interactions is justified to a high degree of accuracy but a small parity violating component is expected to arise from the hadronic weak interaction. This can be measured by comparing proton-proton total cross-sections using beams of longitudinally polarized protons of positive and negative helicity incident on an unpolarized hydrogen target. Results from SIN show the violation in accordance

Layout of the experiment and apparatus used to measure parity violation in proton-proton interactions at SIN. The spin handling elements (solenoid S, deflection magnet M), the beam scanners H1 and H2, the beam modulation elements Q, W1, W2 and the scattering chamber are drawn. The insert shows the scattering chamber in more detail: the target vessel (T), the Faraday Cup (FC) and the ionization chamber which consists of an aluminium foil (F) at 10 kV and the ion collector (C). The measurements are in agreement with the level expected by theory.



with theory and add weight to those obtained at Los Alamos using a similar method.

The main problem is that the expected asymmetry arising from the parity violation is extremely small, at the level of 10^{-7}, so that the experiment must have even smaller statistical and systematic errors. An ETHZ, SIN, Madison, Zurich and Karlsruhe group has been carrying out such an experiment using 45 MeV protons where the expected effect is a few times 10^{-7}, while a group at Los Alamos has used 15 MeV protons, where the expected effect is about half as large.

The experiment at SIN made use of the 50 MeV polarized proton beam from the injector cyclotron. Polarized protons are produced in an atomic-beam type polarized ion source and the beam current on the target was about 1.2 μA. Radiofrequency transitions, which act on the neutral atomic beam in the source, were used to switch the proton polarization between ± 0.83 every 30 ms.

A solenoid precessed the vertical polarization of the cyclotron beam into the horizontal plane and a deflection magnet produced a longitudinally polarized beam. Protons scattered in a high pressure hydrogen target by between 25 and 55 degrees entered a cylindrical ionization chamber (diameter 40 cm). To obtain the numbers of scattered and incident protons, the currents from the ionization chamber and the Faraday cup were integrated during 20 ms.

Individual 20 ms measurements were separated by 10 ms dead time, during which the polarization was reversed, the digitized integrated charges were stored in a computer and beam scanners moved through the beam. To suppress periodic extraneous noise, the phase of the polarization-switching signal was reversed after eight such 30 ms cycles and after sixteen cycles the initial sign of polarization for the following sixteen measurements was set by a pseudo random-number generator.

Systematic errors, which are associated with the reversal of polarization, but are unrelated to parity violation, can arise from modulations of intensity, position, diameter and small residual transverse polarization components of the beam. Therefore a continuous on-line record of the beam intensity and beam polarization profiles were obtained from digital beam monitors. In order to obtain information about the position as well as the angle of the incident beam, two complete x-y scanners are provided, one of them 100 cm and the other 15 cm from the target.

In addition, to obtain corrections (or at least upper limits) for these spurious effects, the sensitivity of the apparatus to unwanted effects was measured by introducing artificial modulations of the beam, combined with deliberate beam misalignments.

The group also considered systematic effects arising from the parity violating beta-decay of nuclei produced by the polarized protons inside the scattering chamber. This effect was reduced by introducing a weak transverse magnetic field (± 1 mT) over the target and the beamstop and reversing the field every minute. The total uncertainty in the measured asymmetry due to all systematic errors was $\pm 0.5 \times 10^{-7}$. The final result for 45 MeV protons is $(-3.2 \pm 1.1) \times 10^{-7}$ where the uncertainty (one standard deviation) includes all systematic and statistical errors. The latest Los Alamos result for 15 MeV protons is $(-1.7 \pm 0.8) \times 10^{-7}$.

These results appear to confirm parity violating effects in the hadronic interaction at the level predicted by theory and, within errors, give the expected ratio between the effects at the two different proton energies.

TRIUMF
Recent achievements and installations

Following one of the most productive quarters in its history, the TRIUMF cyclotron has just completed a six week shutdown for improvements and new installations.

The biomedical group reached a milestone in December with completion of the first series of human patient experiments, following earlier tests on cells, mice and pigs. Four elderly cancer patients received pion treatment for skin nodules, each being given ten daily fractions of about 300 rad in the stopping region. Other skin nodules on these patients were treated with X-rays as a control. The tumour response and the skin reaction nearby are being studied over several months to assess the radiation effects. Further patients will be treated in March.

Proton beams of 100 μA were used for these runs — the maximum currently available for regular running. However, efforts are under way to raise the beam intensity to an eventual 400 μA. On 10 December a beam of 150 μA was run successfully for several minutes, the limitation being some temperature levels around the pion-production target. A beam of 140 μA could be maintained for more than 30 minutes. These currents were obtained in the normal 100 per cent duty factor mode: in a pulsed mode with 66 per cent duty factor peak intensities of 170 μA were achieved.

During 1980 it is hoped to demonstrate 200 μA operation. One of the factors which has made high intensities easier to obtain has been improved capture of the beam from the ion source. Recent installation of a second harmonic buncher in the injection line has raised the fraction of the beam from the ion source transmitted to 500 MeV from about 35 to 55 per cent.

Medium energy resolution operation, MERO, is to be contrasted with the normal (NERO, 2-3 $\times 10^{-3}$) and proposed high (HERO, 2 $\times 10^{-4}$) resolution modes. The achievement of MERO at 200 MeV was reported in the July 1979 issue, page 196. With the aid of slits centred on low energy orbits in the cyclotron, single turns were extracted with a measured energy spread of 166 ± 20 keV, rather than the regular 500 to 600 keV. The cyclotron stability is at present insufficient to maintain separate turns above 250 MeV. Nevertheless the energy-radius correlation has been good enough to permit beams of 0.1 per cent energy resolution to be extracted at 200, 250, 275, 350 and 500 MeV for periods of half an hour or more. Beam intensities of 4 μA have been obtained and 10 μA should be possible. Work is now under way towards HERO. The stability will be improved to keep the turns separate to 500 MeV and third harmonic r.f. flat-topping will be added to achieve microampere intensities.

Using MERO beams the medium energy resolution spectrometer was shown to be capable of the specified 10^{-3} energy resolution. At 200 MeV, with the front end counters and all vacuum windows removed, the overall resolution (including contributions from the beam) was 230 keV. At 500 MeV a resolution of 615 keV was seen with the usual front end scatterers in place.

Three new sections of beamline were commissioned in the autumn. The extension to the slow pion/muon channel, incorporating a crossed-field separator on loan from Berkeley, was commissioned with both 77 MeV and surface muons. The surface positive muon flux was 6.5×10^{5} per s per 100 μA in a 4 cm diameter spot. Spin precession in the separator magnetic field makes transversely polarized positive muons available for muon spin rotation studies. The 77 MeV negative muon flux was 5×10^{5} per s per 100 μA in a 2×3 cm spot. The beam is being used to feed the time projection chamber in the muon to electron conversion search experiment (see March issue, page 21).

A beamline has been designed to provide very low intensity (10^{5}

protons per s) to a helium-3 cooled frozen butanol polarized target while 10^{14} protons per s beams are being run for pion production. Commissioning of the first half of the line confirmed that these low intensities can be achieved through partial stripping and the use of a 1 mm diameter collimator.

The first section of a beamline to provide 65 to 100 MeV protons for isotope production was installed and 72 and 90 MeV beams delivered on target at the microampere level. Initial tests on iodine-123 production confirm that the 72 MeV (p, 5n) reaction on a sodium iodide target results in an isotopically and radiochemically purer product than the 500 MeV spallation reaction on caesium used up to now (see November 1979 issue, page 357).

Over the past five years the BASQUE collaboration has made a comprehensive study of the nucleon-nucleon interaction between 200 and 520 MeV using both unpolarized and polarized neutron and proton beams (see April 1977 issue, page 108). The total and differential cross-sections, analysing power and many of the Wolfenstein parameters have been measured with an accuracy that has led to a generally more precise and unambiguous knowledge of the phase shifts over this whole energy region. This phase of the programme was completed in December (with suitable celebration). However, the ghost of BASQUE has not yet been laid — a new phase will soon begin using a polarized target.

The chief shutdown activity in the cyclotron was the strengthening of the dee structure. Each of the two dees is built from quarter wavelength cavities with 3 m long unsupported high voltage 'hot arms'. Heating and creep in the surfaces has led to sagging of these arms with consequent voltage asymmetries and r.f. leakage into the beam gap and vacuum tank. A straightening and strengthening programme in January has resulted in the highest-ever Q-values.

In the experimental areas the major activity was the installation of an isotope production facility immediately in front of the high intensity 500 MeV beam stop (see June 1978 issue, page 212). Six targets can be irradiated simultaneously, completely immersed in cooling water and capable of dissipating 4 kW each. When cooked they can be removed to a hot cell on the beam stop shielding, 10 m above. Also in the meson hall, a start was made on the construction of a fast pion/muon channel with the pouring of concrete for the magnet bases. A number of magnets are ready and the line is scheduled for completion later in the year. Finally, in the proton area, the final section of the very low intensity line was installed.

Speeches on science

We step a little outside our standard content in CERN COURIER to relay major parts of two recent speeches. They were both given from very distinct standpoints and they both contain important statements on the role of science.

The first is the address given at the Vatican on 10 November 1979 by His Holiness the Pope on the occasion of the celebration by the Pontifical Academy of Science of the centenary of the birth of Albert Einstein. Other speeches at the ceremony were given by Carlos Chagas on Einstein as a man and by Paul Dirac and Victor Weisskopf on the significance of Einstein's scientific work.

The second is the address by Abdus Salam to the Executive Board of UNESCO on 17 October 1979 having been awarded the Einstein Medal by UNESCO and the Nobel Prize for Physics.

Address by his Holiness Pope John Paul II

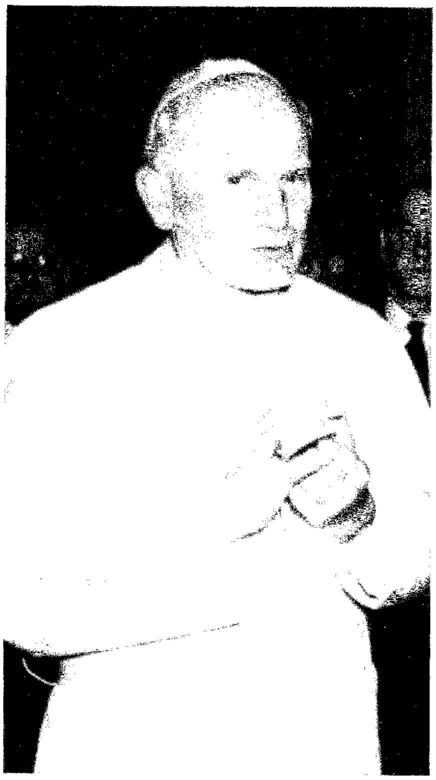
'The Holy See wishes to add its voice to the homage due to Albert Einstein for his eminent contribution to the progress of science, that is to say, to the truth immanent in the mystery of the universe.

I feel myself fully at one with my predecessor, Pius XI, and with those who succeeded him in the Chair of St Peter, in calling on the members of the Papal Academy of Sciences, and with them all men of science, to 'devote themselves, in ever nobler and more intense endeavour, to the progress of science, and to ask nothing more of them than that; for in this splendid aim and exalted task lies the mission of serving truth, with which we charge them...'

The search for truth is the task of basic science. The scientist exploring this first slope of his domain may well feel the fascination of the words of Saint Augustine 'love well the intellect', and with it its function, which is to discern the truth. Pure science is a blessing worthy to be well loved, for it is knowledge and therefore the perfection of man in his

The Pope — from Galileo to Einstein.

(Photo Felici)



intelligence. Over and above its technical applications, it should be honoured for itself, as an integral part of culture. Basic science is a universal asset, which all people should be entirely free to develop without being subjected to any form of international constraint or intellectual colonialism.

Basic research should be untrammelled by the powers in the political and economic spheres, who should co-operate in its development without hampering its creativity or harnessing it to their own ends. Like every other truth, scientific truth is accountable in the last resort only to itself and to the supreme Truth which is God, creator of man and of all things.

The second function of science is the search for practical applications, which are fully developed in the various branches of technology. In thus translating its theories into concrete terms, science is a necessity for humanity, in order to meet the legitimate needs of its existence and to overcome the various ills which beset it. There can be no doubt that applied science has been and will be of immense service to mankind, if only it is inspired by love, governed by wisdom and sustained by the courage to resist the undue interference of any powers of tyranny. Applied science must be allied with conscience, so that the trinomial science - technology - conscience serves the true welfare of mankind.

Regrettably, however, as I had occasion to remark in my encyclical Redemptor hominis, 'the man of today seems always threatened by his own creations... This appears to be the main theme of the drama of human existence today'. From this drama, which threatens to turn into tragedy, man must emerge victorious: he must reassert his dominion over the world and his full control over what he produces. Today, as I wrote in the same encyclical, 'the fundamental meaning of man's dominion and control over the visible world, a task assigned to him by the Creator himself, lies in the priority of ethics over technology, the pre-eminence of the person over the thing, and the superiority of mind over matter'.

This threefold superiority is assured once one accepts and maintains the notion of the transcendence of man over the world and of God over man. As the guardian and advocate of this order in transcendence, the Church feels it can help science to preserve its ideal purity in the domain of basic research and be of service to mankind in the field of its practical applications.

The Church gladly acknowledges, furthermore, the benefits it has itself received from science. Science was among the aspects of modern culture envisaged in the statement of the Vatican Council: 'As regards religion there is a completely new atmosphere... people are taking a hard look at all magical world-views and prevailing superstitions, and demanding a more personal and active commitment of faith, so that not a few have achieved a lively sense of the divine.'

Collaboration between religion and modern science is to the advantage of both, without in any way limiting their respective autonomy. Just as religion demands religious freedom, so science makes a legitimate claim for liberty in research. The Vatican II Oecumenical Council, after following the Vatican I Council in reaffirming the just freedom of human arts and sciences to use their own principles and methods in their respective fields, paid formal recognition to 'the legitimate autonomy of culture and especially of the sciences'. On the occasion of this solemn tribute to the memory of Einstein, I wish to confirm once again the Council's declarations on the autonomy of science in its function of research into the truth written in creation by the finger of God. In its admiration for the genius of this great intellect, which shows the mark of the Spirit of creation, the Church would not wish in any way to usurp the responsibility of passing judgement on the doctrine concerning the great systems of the universe: it is a doctrine, nevertheless, which the Church would recommend to the consideration of theologians in the search for harmony between scientific truth and the truth of revelation.

Galileo and Einstein each characterized an epoch. Galileo's greatness is recognized by all, as is that of Einstein; however, unlike the man we are honouring, Galileo had much to suffer at the hands of the men and the bodies of the Church. The Vatican Council admitted and deplored certain inadmissible actions: 'We cannot but deplore certain attitudes (not unknown among Christians) deriving from a shortsighted view of the rightful autonomy of science; they have occasioned conflict and controversy and have misled many to opposing faith and science.'

To go further in the direction indicated by the Council, I would urge theologians, men of science and historians, in a spirit of sincere collaboration, to make a deeper study of the case of Galileo and, by the impartial acknowledgement of wrongs done, no matter by whom, to disperse the mistrust which this affair still arouses in many minds and which militates against the fruitful concord of science and faith, the harmony between the Church and the world. Such a task will have my full support, for it can respect the truth of faith and of science and open the door to future collaboration.

I should like to submit for your consideration and reflection some points which seem to me important in the attempt to view the Galileo affair in its true light, where the congruences between religion and science are more numerous and notably more significant than the misunderstandings which gave rise to the bitter and painful controversy extending over the centuries which followed.

Galileo, who is justly called the founder of modern physics, declared explicitly that the two truths — that of faith and that of science — can never be in contradiction.

The Vatican II Council expresses a similar view, indeed uses almost the same words when it teaches as follows: 'Methodical research in all branches of knowledge, provided it is carried out in a truly scientific manner and does not override moral laws, can never conflict with the faith, because the things of the world and the things of faith derive from the same God.'

Galileo in his scientific research felt the presence of the Creator, spurring him on, anticipating and encouraging his intuitions, stirring the depths of his mind. Writing of the invention of the telescope and recalling some of his astronomical discoveries, he says: 'All this was discovered and observed in these last days with the 'telescope' I invented after illumination by divine grace'.

Galileo's acknowledgement of divine illumination in the mind of the scientist finds an echo in the text already quoted of the Council's declaration on the Church in the present-day world: 'The humble and persevering investigator of the secrets of nature is being led, as it were, by the hand of God in spite of himself.'

The humility prescribed by the Council's text is a virtue of the mind as necessary for scientific research as for adherence to the faith. Humility creates a climate favourable to the dialogue between the believer and the scientist: it invites God's illumination, which — whether recognized or not yet recognized — is beloved in both cases by the humble seeker after truth.

Galileo formulated certain epistemological standards which are essential to achieving agreement between the holy Scripture and science. In his letter to the Dowager Grand Duchess of Tuscany, he reaffirms the truth of the Scriptures: 'The holy Scripture can never lie, provided its true meaning is discerned and this, to my mind undeniably, is often hidden and very different from the message conveyed by the apparent meaning of the words themselves'. Galileo introduces the principle of an interpretation of the sacred books which goes beyond their literal meaning but conforms to their intention and to the type of exegesis proper to each. It is necessary, as he says, for 'the wise men expounding the Scriptures to reveal their true meaning.'

That there may be more than one rule of interpretation of the holy Scriptures is admitted by the Church's authority. In the encyclical Divino afflante Spiritu of Pius XII it is explicitly acknowledged that different forms of literature are present in the holy books, and that interpretation must therefore conform to the character of each.

The various points of agreement do not suffice alone to resolve all the problems of the Galileo affair, but they help to create a point of departure from which an honourable solution may be reached, a state of mind conducive to the fair and honest settlement of ancient enmities.

The existence of the Papal Academy of Sciences, with which Galileo was in a way associated through the ancient institution preceding that of today which has many eminent scientists among its members, is a visible demonstration, without any form of racial or religious discrimination, of the profound harmony which can exist between the truths of science and the truths of faith.'

Address by Professor Abdus Salam

'The Holy Quran enjoins us to reflect on the verities of Allah's created laws of nature; however, that our generation has been privileged to glimpse a part of His design is a bounty and a grace for which I render thanks with a humble heart.

My first thought on this occasion is with the great European experimental laboratory at Geneva — CERN — in the founding of which UNESCO (through Professor Pierre Auger) played a major role. This Laboratory in 1973 provided the first experimental evidence of neutral currents which are an essential part of the prediction of the theory. My thoughts go equally to the Stanford Linear Accelerator Center in the United States which last year in an epic experiment provided confirmation of the second aspect of the theory — its very heart — the unification of electromagnetic forces with the weak nuclear forces to one part in 4000. An experiment at Novosibirsk by a group led by Professor Barkov further confirmed the findings of SLAC.

The history of science, like the history of all civilization, has gone through cycles and I can perhaps illustrate this with an actual example.

Seven hundred and fifty years ago, an improverished Scotsman left his native glens to travel South to Toledo in Spain. His name was Michael, his quest to live and work at the Arab Universities of Toledo and Cordova, where the greatest of Jewish scholars, Moses Bin Maimoun, had taught a generation before.

Michael reached Toledo in 1217 AD. Once in Toledo, he formed the ambitious project of introducing Aristotle to Latin Europe, translating, not from the original Greek, which he knew not, but from the Arabic translation then taught in Spain.

Toledo's school, representing as it did, the finest synthesis of Arabic, Greek, Latin and Hebrew scholarship, was one of the most memorable of international assays in scientific collaboration. To Toledo and Cordova came scholars not only from the rich countries of the East, like Syria, Egypt, Iran and Afghanistan — but also from developing lands of the West like Scotland.

Then as now, there were obstacles to this international scientific concourse, with an economic and intellectual disparity between different parts of the world. Men like Michael the Scot, and his contemporary Alfred the Englishman, were singularities. They did not represent any flourishing schools of research in their own countries. With the best will in the world, their teachers at Toledo doubted the wisdom and value of training them for advanced scientific research. At least one of his masters counselled young Michael to go back to clipping sheep and to the weaving of woollen cloths.

In respect of this cycle of scientific disparity, I can be more quantitative. George Sarton, in his monumental five-volume History of Science chose to divide his story of achievement in sciences into ages, each age lasting half a century. With each half century he associated one central figure: thus 450 BC to 400 BC he calls the Age of Plato. This is followed by half centuries of Aristotle, of Euclid, of Archimedes and so on. From 600 AD to 650 AD is the Chinese half centuries of Hsüan Tsang, from 650 AD to 700 AD that of I-Ching, and then from 750 AD to 1100 AD it is the unbroken succession of the Ages of Jabir, Khwarizmi, Razi, Masudi, Wafa, Biruni and Omar Khayam — Arabs, Turks, Afghans and Persians — men belonging to the culture of Islam.

After 1100 appear the first Western names — Gerard of Cremona, Jacob Anatoli, Roger Bacon — but the honours are still shared with the names of Ibn-Rushd (Averroes), Moses Bin Maimoun, Tusi and Ifn-Nafis — the man who anticipated Harvey's theory of circulation of blood. After 1350, however, the developing world loses out except for the occasional flash of scientific work, like that of Ulugh Beg — the grandson of Tamurlane — in Samarkand in 1400 AD, or of Maharaja Jai Singh of Jaipur in 1720 who corrected the serious errors of the then Western tables of eclipses of the sun and the moon by as much as six minutes of arc. As it was, Jai Singh's techniques were surpassed soon after with the development of the telescope in Europe. As a contemporary chronicler wrote 'With him on the funeral pyre, expired also all Science in the East.'

Abdus Salam — the developing countries through the ages.

And this brings us to this century when the cycle begun by Michael the Scot turns full circle, and it is we in the developing world who turn to the West for Science. As Alkindi wrote 1100 years ago: 'It is fitting then for us not to be ashamed to acknowledge truth and to assimilate it from whatever source it comes to us, even if it is brought to us by foreign peoples. For him who scales the truth there is nothing of higher value than truth itself; it never cheapens nor abases him.'

During this period, starting with this century, in the world of physics the first name is that of C.V. Raman — the Nobel Laureate of 1930, then of Yukawa, Tomonaga and Esaki, in between Lee, Yang and Ting. The question we must ponder is this: are we today firmly on the road to a renaissance in Sciences — as the West was in the 12th Century at the time of Michael the Scot? Unfortunately the answer is No.

There are two prerequisites to this renaissance: one, availability of places like Toledo for international concourse, where one can light a candle from a candle. Second, the interest in developing societies to give the topmost priority to the acquisition of knowledge, as for example was given in Japan after the Meiji Revolution.

Regarding the first point, regretfully the opportunities for international scientific concourse are fast shrinking, with greater and greater restrictions in the traditional countries like the UK and USA on acceptance of overseas scholars, including those from developing countries. It is becoming increasingly clear that the developing world will need internationally run (UN and UNESCO run) Institutions, Universities of Science, not just for research, but for the high level teaching of traditional Technology and Sciences, both Pure and Applied.

The second prerequisite for development of Science and Technology is a passionate, consuming desire on the part of the developing countries and the removal of all internal barriers in its acquiring. Unfortunately the prognosis in this respect is not very bright.

The fact that I became and remained a research physicist is due to three accidents. The first was the 2nd World War; as soon as I showed some competence in Sciences, my well-wishers, my parents, all those around me, destined me for a career in the then prestigious Indian Civil Service. As it happened, with the War the Civil Service Examination was suspended for the duration. But for this I would be a Civil Service functionary today,

The second accident was again connected with the War. The then Prime Minister of my home State — the Panjab — collected some funds for the War Effort. The war ended; the funds were left unutilized. He decided to institute 'Small Farmers Son's Scholarships' for study abroad. A number were offered; I was one of those fortunate to be selected and sail the same year — 1946 — to Cambridge. Several other scholarships were awarded; unhappily the other scholars were promised admission for subsequent years. In between, the subcontinent was partitioned and with it the scholarships disappeared. The entire exercise of the then Prime Minister succeeded in one thing only — in sending me for research at St John's College, Cambridge, where Professor Dirac lived and worked. You can understand why I started this lecture with humble praise to Allah for his Grace and Beneficience.

The third accident happened after I returned to Pakistan from Cambridge to teach and to try to found a school of research. In no uncertain terms, it was made plain for me that this was impossible. I must either leave physics research or my country. With anguish in my heart, I made myself an exile — and it was this anguish which led me to propose the creation of an International Centre for Theoretical Physics, with the most active sponsorship of the Government of Pakistan and other developing countries. The idea was to award what we call 'Associateships' of the Centre, so that a deserving young man may spend his period of vacation in an invigorating environment in close touch with his peers in research, to charge his batteries with new ideas, while still spending nine months of his academic year in his own country, working at his University.

With UNESCO's active help, and with very generous assistance from the Government of Italy and the Town of Trieste, the Centre was created by the IAEA in Trieste in 1964. UNESCO joined as equal partners with IAEA in 1970. Over the fifteen years that the Centre has existed, it has veered from emphasis on fundamental and basic physics towards subjects on the interface of pure and applied physics — subjects like Physics of Materials, Physics of Energy, Physics of Fusion, Physics of Reactors, Physics of Solar and other unconventional sources, Geophysics, Physics of Oceans, and Deserts, Systems Analysis — this, in addition to High Energy Physics, Quantum Gravity, Cosmology, Atomic and Nuclear Physics and Mathematics.

This shift from pure to applied physics was not made because we thought that pure physics is less important for developing countries. It was simply that there was not, and still is not, any other international institute responsive to needs of technological hunger involving the discipline of physics. Every year around 1500 physicists — half from developing countries — spend of the order of six weeks or more at the Centre attending extended symposia or research workshops.

The world needs today international institutions with requisite stability, e.g. on the applied side, institutes like the Wheat and the Rice Research Institutes, and on the educational and physics side, institutes like the International Centre for Theoretical Physics. Such Institutes must become parts of the normal, continuing, stable United Nations scene; otherwise the Science and Technology gap of the North and the South will never, never be bridged.

I would like to conclude with three appeals. The first to the International Community — both of Governments and of the Scientists. A world so divided between the haves and the have nots of Science and Technology cannot endure; at present an International Centre for Theoretical Physics is all that is internationally available for physics in a hundred developing countries. Somehow, somewhere, a break must come.

My second appeal is to the developing countries. In the end, Science and Technology among them is their own responsibility. Speaking as one of them, ley me say this: your men of science are a precious asset. Prize them, give them opportunities, responsibilities for scientific and technological development of their own countries.

And finally I wish to make a particular appeal to my brothers in the Islamic countries. It is their forebears who were the torchbearers of international scientific research in the 8th, 9th, 10th and 11th Centuries. It was these forebears who funded Bait-ul-Hikmas — Advanced Institutes of Sciences — where concourses of scholars from Arabia, Iran, India, Turkey and the Byzantium congregated. Be generous once again. Create a Talent Fund — available to all Islamic, Arab and developing countries, so that no potential high level talented scientist is wasted. My humble personal contribution to this Fund will be all I possess — the $60 000 the Swedish Academy has so generously awarded me. Rabbana Taqqabal Minna.'

Physics monitor

Tidying up the baryons

During the last few years a quiet revolution has taken place in the classification of the known baryons and our understanding of their composition in terms of the quark model.

Some fifteen years ago, the SU6 model was introduced which combined the highly successful SU3 internal symmetry scheme (covering isospin and strangeness quantum numbers) with quark spin and angular momentum.

This model groups baryons into different multiplets of three quarks. The lightest and commonest baryons fit into a basic 56-fold quark/spin multiplet containing the baryon decuplet of spin 3/2 (four possible spin states) and the octet of spin 1/2 (two spin states) with no angular momentum between the quarks. When the quarks rotate around each other, higher multiplets can be obtained to accommodate heavier baryons.

For the first angular momentum excitation, the model predicted 70 quark/spin states with masses in the region 1500–1800 MeV, and as time went by and more baryons were found, these states were accounted for.

For baryons heavier than about 1800 MeV, the situation gets complicated as in this region several different SU6 multiplets overlap, and it is not easy to decide how the observed states should be assigned to the various multiplets.

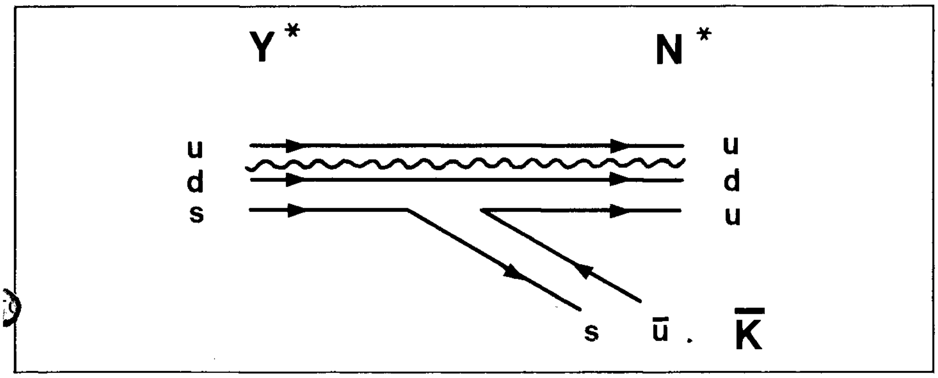
A complete theory of baryons would predict both the exact masses of all the particles and the relative rates of the different possible decay channels. However SU6 is only an approximate symmetry and cannot by itself give exact predictions for masses and decay rates. This hindered the assignment of particles to SU6 multiplets using observed mass values and decay rates.

As time went on, it became clear that there was another problem. No matter how they were assigned to SU6 multiplets, the number of heavy baryons observed above 1800 MeV fell far short of what was expected.

The idea which has emerged is to exploit the analogy between electromagnetic interactions and the 'colour' force held to be responsible for inter-quark forces. Perhaps the gluon exchange of the colour force can produce visible effects in quark spectroscopy in the same way that electromagnetism produces the hyperfine structure seen in atomic states.

The three quarks contained in each baryon can be considered as a superposition of quark pairs, each pair behaving as a simple oscillator under the influence of a colour force which is a direct analogy of the

A quark diagram of the decay of a hyperon resonance, illustrating the suppression of certain decay modes. The excitation of the u-d quark pair on the left-hand side cannot be lost and results in an excited baryon. Thus this baryon cannot be an ordinary nucleon. The same selection rule applies in the corresponding formation processes, and explains why some of the baryon resonances expected by a simple quark model are in fact not seen.



magnetic dipole interaction between electrically charged particles.

The approach taken by Nathan Isgur and Gabriel Karl uses non-relativistic approximations for single gluon exchange. This model falls far short of the full picture of relativistic quantum chromodynamics, the currently 'approved' theory of quarks and gluons, but nevertheless it seems to work.

Isgur and Karl, and others, have worked out the implications of this mechanism for the baryons, and find that many quark/spin configurations expected from SU6 alone are experimentally suppressed.

This happens because the three quarks maintain their identities, and excitations of one quark pair cannot easily be lost or transferred to other pairs.

For example the simple quark model predicts seven different heavy lambda particles with spin 3/2 and positive parity, but the new model says that only one of these can be formed from neutral kaons and nucleons. So far only one such resonance has been reported!

As well as accounting for the shortage of observed baryon states, the model also gives good values for the observed masses and relative decay rates.

Describing this model and its successes at last year's Geneva conference (see September 1979 issue, page 248), Tony Hey pointed out the 'impressive integrity' of experiments in not finding baryon states which until this latest work were thought to be 'theoretically desirable'.

In principle, the model is equally valid for mesons. With the notable exception of the psions, meson resonances are much more difficult to find than baryons, and the predictions remain untested.

Cosmic ray antiprotons

A recent cosmic ray experiment has provided the first significant evidence for antimatter in the cosmic rays entering the Earth's upper atmosphere.

Antiprotons are produced along with other hadrons when primary high energy particles (either from an accelerator or in cosmic rays) hit nuclear targets.

At CERN, recent trials of methods to control antiprotons have enabled them to be stored for the first time and have shown that they do not decay quickly (see October 1979 issue, page 312).

According to well-established theoretical ideas, antiprotons should be just as stable as protons, but the difficulties of obtaining and storing antiparticles have made this hypothesis difficult to test. However the observation of antiprotons in cosmic rays provides new evidence for their relative stability.

In the experiment, the apparatus of the New Mexico/NASA collaboration was carried by balloon to an altitude of some 35 km over Texas. The particles encountered in the upper atmosphere were analysed by a gas Cherenkov counter, a two-ton superconducting magnet, scintillators, multiwire proportional counters and shower counters. Data was transmitted to the ground station and recorded.

The idea was to look at the negatively-charged particles, using the Cherenkov to eliminate counts due to muons and pions, and the shower counters to eliminate electrons. After allowing for particles resulting from cosmic ray interactions in the upper atmosphere, the experiment produced some 28 events which could be interpreted as antiprotons coming from outer space.

This gives a ratio of cosmic ray antiprotons to protons in outer space of 5×10^{-4}. This is just what is expected from the interaction of primary cosmic rays with the thin interstellar gas, so the antiprotons are not interpreted as primordial particles left over from the 'Big Bang'.

If this is true, the antiproton lifetime should be at least comparable with the time cosmic rays remain within our galaxy, currently estimated to be of the order of 10^7 years — a big improvement on the antiproton lifetime limits obtained in Laboratory experiments, but still a long way short of the established limits on the proton lifetime (see December 1979 issue, page 415).

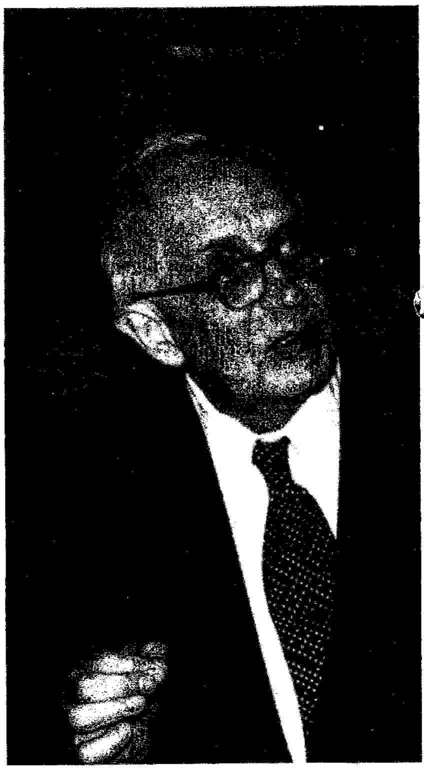
More balloon experiments are planned, and for the more distant future, the possibility of putting an experiment aboard the Space Shuttle is being investigated.

People and things

Michael Crowley-Milling of CERN, winner of this year's Glazebrook Prize from the UK Institute of Physics.

J. Pniewski

(Photo K. Kilian)



On People

Eric Burhop, well-known high energy physicist from University College London, died on 22 January. He was particularly associated with the nuclear emulsion technique both in its heyday of cosmic ray research and early accelerator experiments and in its revived role in hybrid systems for the observation of charmed particle tracks, where he played a pioneering role.

The Swedish physicist Erik Rudberg died on 2 January. He was President of the European Physical Society from 1970 to 1972 and in that office wrote for CERN COURIER (February issue 1971) a message of welcome on the decision to build the SPS.

Gale Pewitt has been named Deputy Director for Operations at the Argonne Laboratory. In the 1960s he led the design and construction of the 12 foot hydrogen bubble chamber with its pioneering use of a large superconducting magnet. He subsequently became Director of the High Energy Facilities Division.

The Polish physicist J. Pniewski received the degree of Doctor Honoris Causa at the University of Heidelberg in February for his contributions to research on hypernuclei. He participated with Marian Danysz in the discovery of hypernuclei in a nuclear emulsion experiment in 1952.

Arthur and Janice Roberts have retired from Fermilab and moved to Hawaii to work on the DUMAND underwater neutrino experiment. Besides his career in physics, Arthur Roberts has a reputation in music and recently composed a song to celebrate CERN's 25th Anniversary (see November, 1979 issue, page 369).

Among the award winners of the UK Institute of Physics for 1980 were Michael Crowley-Milling of CERN (Glazebrook Medal and Prize) for his work on the control system of the SPS, Paul Murphy of Manchester University and John Thresher of Rutherford Laboratory (Rutherford Medal and Prize) for their contributions to particle physics and Viki Weisskopf who received an Honorary Fellowship.

André Martin of the CERN Theory Division has been elected 'Correspondant de l'Académie des Sciences de l'Institut de France'.

In a recent ceremony at the White House, President Carter awarded the National Medal of Science, one of the highest US awards, to 20 eminent researchers. Among those who received the award this year were Richard Feynman and Victor Weisskopf.

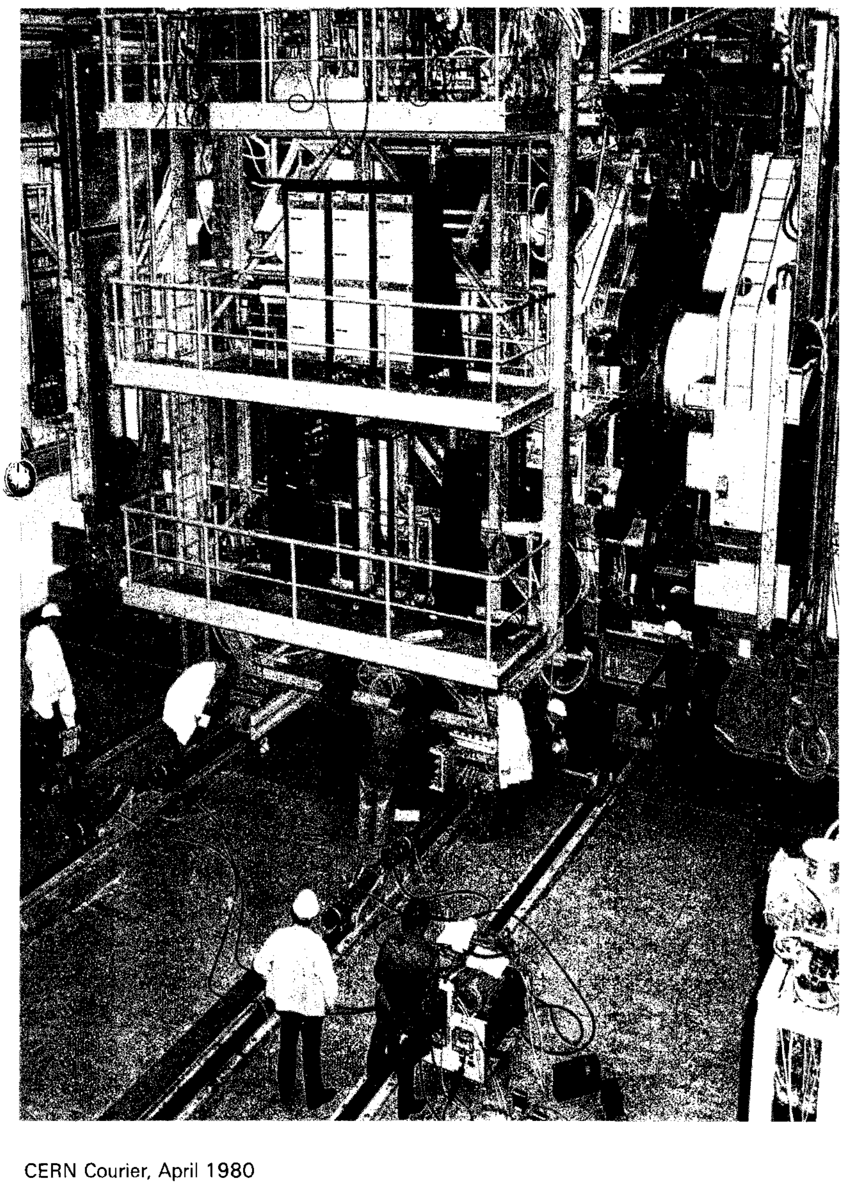
PETRA and DORIS

During the January shutdown of PETRA, additional high-frequency sections were installed, bringing the total number of cavities to 60. Power is supplied for the first time by the full complement of eight klystrons operating at 600 kW each. During the same shutdown, the French-German detector CELLO was moved into its operating position, replacing PLUTO which is now being improved for another experiment at PETRA. In the first few days of operation after the winter shutdown, PETRA reached a record total energy of 36 GeV.

In the meantime DORIS is running at the upsilon prime energy. The two groups taking data, DASP-2 and LENA, hope to collect over 1500 hadronic annihilation events in this energy region. The luminosity of DORIS has been improved and about 50 nb^{-1} per day are currently collected. In addition to high energy physics, about 20 per cent of the machine time is devoted to synchrotron radiation experiments. The performance of the storage ring DORIS has considerably improved using PIA (the positron intensity accumulator) at the injection phase. Both, positrons and electrons are currently refilled to the maximum allowed current without dumping the remaining beams — a fast and efficient procedure.

The 1400 ton CELLO detector being moved into position at the PETRA storage ring. It replaces the PLUTO detector.

(Photo DESY)



PEP ready to go

As we go to press, injection tests into the new Berkeley-Stanford electron-positron storage ring, PEP, at SLAC are scheduled for mid-March. Circulating beams are planned by the end of the month with sufficient radiofrequency power installed to take the energy to about 11 GeV. A month later all the r.f. should be in place. Four detection systems (Mark II, MAC, DELCO and the free quark search) will probably be able to start work as soon as beams are available.

Japan-USA collaboration

Japanese scientists are becoming involved in extensive collaborations at US high energy physics Laboratories (Argonne, Berkeley, Brookhaven, Fermilab and Stanford) following the signing of an Agreement in November between the US Department of Energy and the Japanese Bureau of Scientific and International Affairs. The collaboration also covers work in fusion, coal conversion, photosynthesis and geothermal energy. In high energy physics, joint experiments could involve some $ 50 million from Japan being invested into the research programmes at US Laboratories.

Fermilab project names

A variety of names have been used over the past few years as titles for the projects to extend the research facilities at Fermilab. The present nomenclature is as follows: The construction of the ring of superconducting magnets and its refrigeration system (a project which is already authorized) is called the 'Energy Saver'. The addition of a radiofrequency system, sufficient refrigeration to pulse to 1000 GeV, the equipment to achieve proton-antiproton collisions and the corresponding colliding beam experimental areas is known as 'Tevatron Phase I'. This project is included in the USA President's budget for Fiscal Year 1981 and a Design Study has recently been issued. The installation of an extraction system for 1000 GeV proton beams and all the upgrading of equipment and experimental areas to mount a 1000 GeV fixed target programme is known as 'Tevatron Phase II'. A detailed design study for Phase II has not yet been issued.

As a step towards Tevatron Phase I stochastic cooling was achieved at Fermilab for the first time on 9 February. This technique which was invented and first demonstrated at CERN is essential to achieve high intensity antiproton beams. We hope to cover proton-antiproton plans at both Laboratories in some detail in our June issue.

AGS age 20

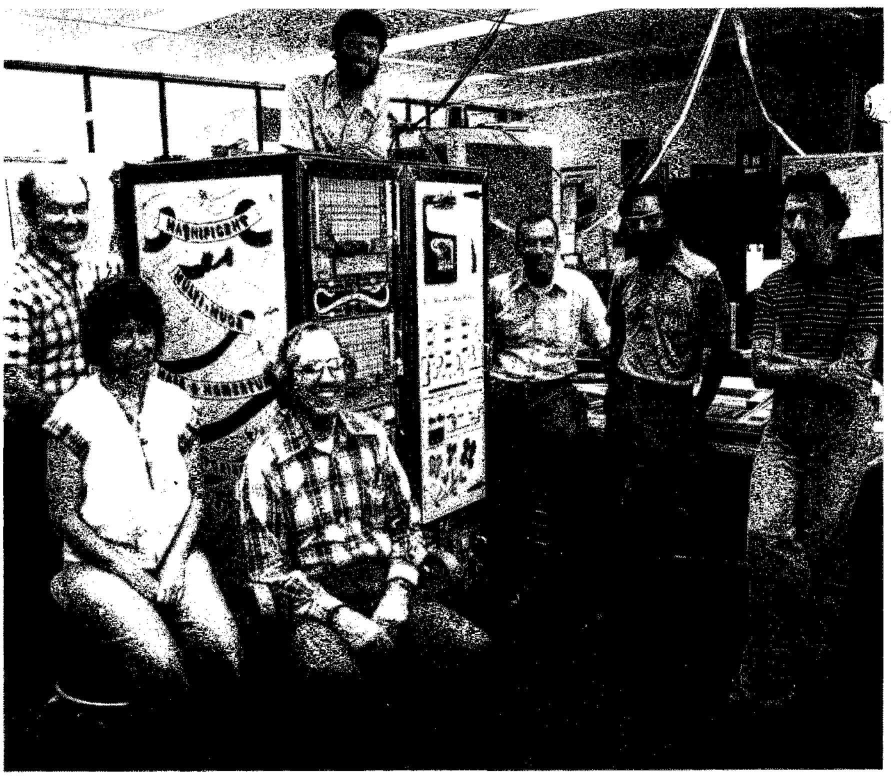
On 22 May Brookhaven National Laboratory will celebrate the twentieth year of operation of the Alternating Gradient Synchrotron. The many discoveries made during the life of this machine — CP violation, two types of neutrinos, the J/psi and other new particles and resonances — have contributed greatly to the advancement of high energy physics and there is much cause for celebration. Talks will cover the history of the AGS and a reception and dinner will follow in the evening.

The annual meeting of the High Energy Discussion Group (HEDG), the Brookhaven Users Association, will be held in conjunction with the celebration. Talks on 23 May will be devoted to a summary of the progress made in the construction of ISABELLE, and a workshop for potential ISABELLE users is scheduled for 24 May.

Brookhaven extends an invitation to the whole high energy physics community to attend the celebration. Details of the programme and dinner reservations are available from Ronald Rau's office at Brookhaven.

Heavy ion fusion systems receive support

The Department of Energy in the USA set up a review committee under the Chairmanship of John Foster to look at progress with the inertial confinement technique to achieve thermonuclear fusion in reactors. The technique involves the implosion of deuterium-tritium pellets and there are several systems under study to determine the optimum 'driver' to cause the implosion. Since 1976 the possibility of using accelerators and storage rings to produce high energy, high intensity heavy ion beams as the driver has been investigated particularly at Argonne, Berkeley and Brookhaven. The review Committee says that such systems 'have great promise as reactor candidates because of their higher efficiency, their developed repetitive pulse technology



Somewhat more garish than the sedate hardware usually found around high energy experiments is Fermilab's M-7 — Magnificent Multi-Muon Mass and Momentum Measuring Machine. With it are (left to right) Merle Watson (the artist of the group), Kathy Turner, Tom Droege, Dave Harding (behind the cabinet), Tom Wesson, Irwin Gaines and John Peoples.

(Photo Fermilab)

and their favourable theoretical predictions of target coupling.' The Committee calls for an annual expenditure of over $ 250 million to pursue the various inertial confinement fusion systems.

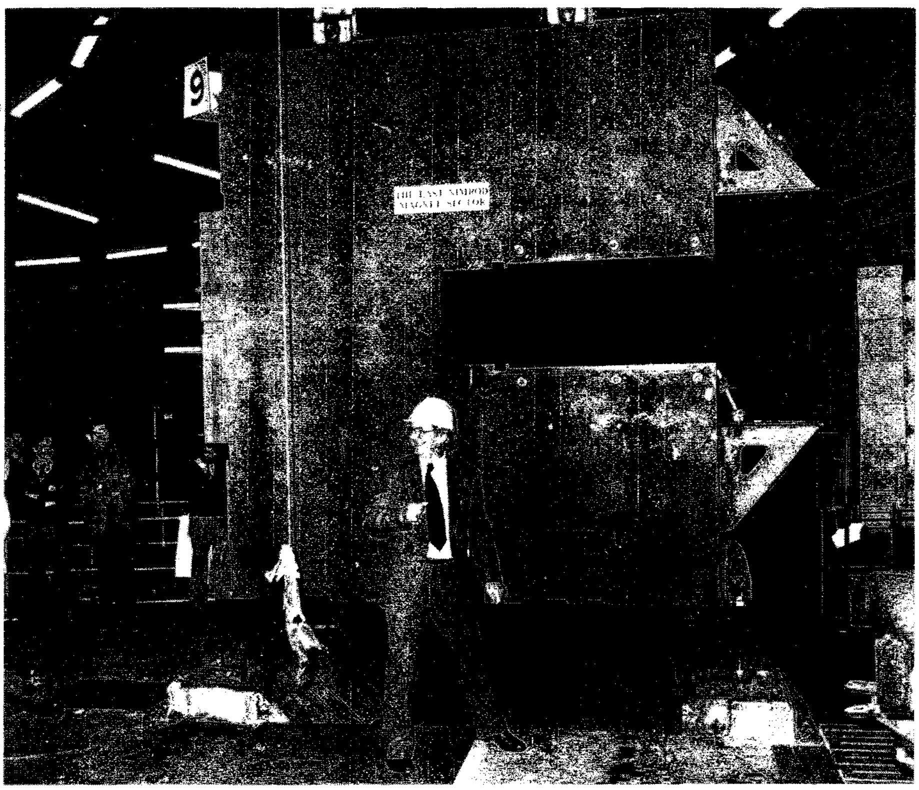
Conferences

On 25 September–1 October the 1980 International Symposium on High Energy Physics with Polarized Beams and Polarized Targets will be held at Lausanne, Switzerland. The Symposium will cover technological progress with beams and targets, polarization experiments and theoretical aspects of polarization phenomena. Further information can be obtained from C. Joseph (Université de Lausanne, Institut de Physique Nucléaire, CH 1015 Lausanne) or R. Hess (Université de Genève, Département de Physique nucléaire et corpusculaire, CH 1211 Genève 4).

Scientific Culture Congress

On 6-8 February an International Congress on 'Scientific Culture in the Contemporary World' was held in Milan. It was one of these rare occasions when leading scientists from different disciplines came together to review progress in their respective fields of research. These were sessions on Physics, Mathematics, Biology, Science Culture and Society. The developments in cosmology and high energy physics attracted a lot of attention and the Congress was attended by large numbers of interested young people. The journal 'Scientia' has published a special volume, in French and in English, in connection with the Congress with many interesting articles on the frontiers of science, and science in the contemporary world. Among others, René Thom has written about 'Mathematics and Scientific Theorizing', Ilya Prigogine on 'The Microscopic Significance of Irreversibility and the Emergence of a New Time' and Vitaly Ginzburg on 'Recent Developments in Physics and Astrophysics'. Ugo Amaldi has written about 'Particle Accelerators and Scientific Culture': this article is also available separately as a CERN Yellow Report in English (number CERN 79-06) and in French (CERN 79-07).

The Novosibirsk/SLAC Conference on Storage Ring Instrumentation, announced in our March issue as scheduled for 5–11 March, did not take place.



David Gray officiates at the farewell ceremony to mark the removal of the last sector of the 7 GeV Nimrod proton synchrotron at the Rutherford Laboratory. The machine has now been removed to make way for the Spallation Neutron Source.

(Photo Rutherford)

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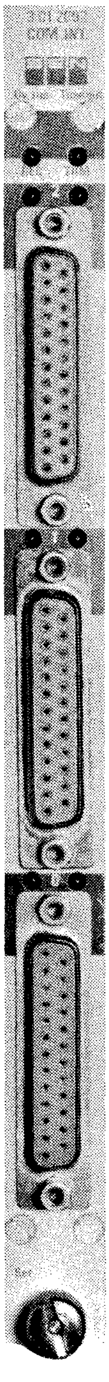

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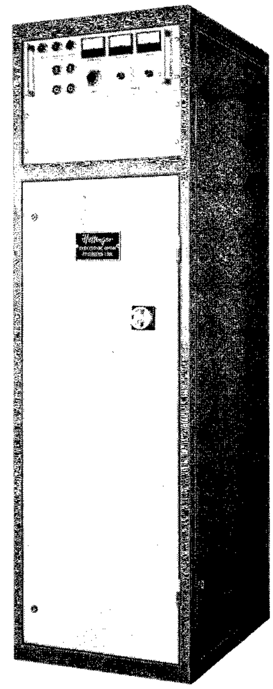

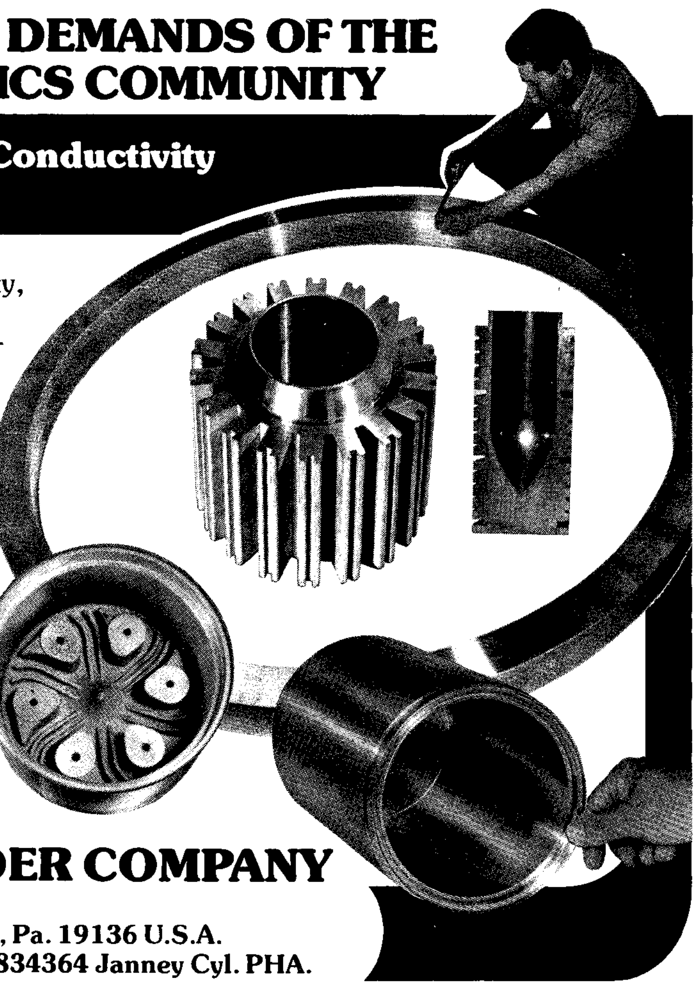

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Size	16k	32k	48k	64k	16k	32k	48k	64k	32k	16k	32k	32k	128k	64k
Word length (bits)	16	16	16	16	16	16	16	16	8	16	16	16	8	16
Access time (ns)	2000	2000	2000	2000	1000	1000	1000	1000	500	500	1000	1000	500	500
Number of pointers	4	4	4	4	1W/1R	1W/1R	1W/1R	1W/1R	1	1	1	1	1	1
DMI (Direct Memory Increment)	●	●	●	●	*	*	*	*						
DMM (Direct Memory Modify)					*	*	*	*						
Automatic pointer increment	●	●	●	●	●	●	●	●	●	●	●	●	●	●
Overflow buffer size (words)	63	63	63	63	64	64	64	64						
Data compressor					op'n	op'n	op'n	op'n						
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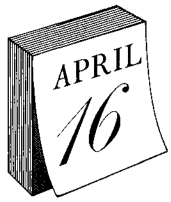

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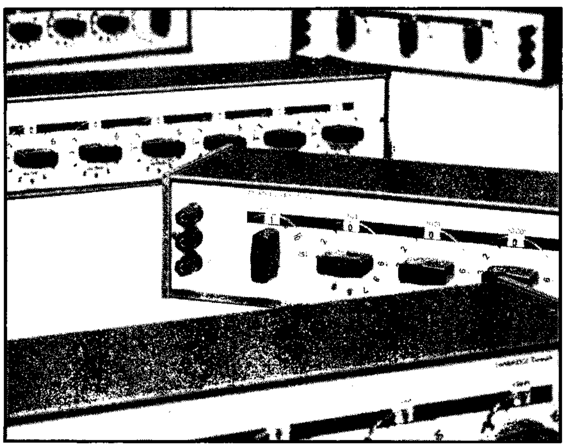

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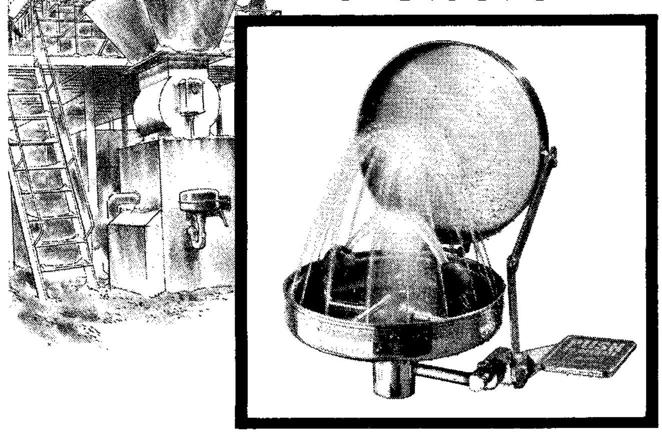

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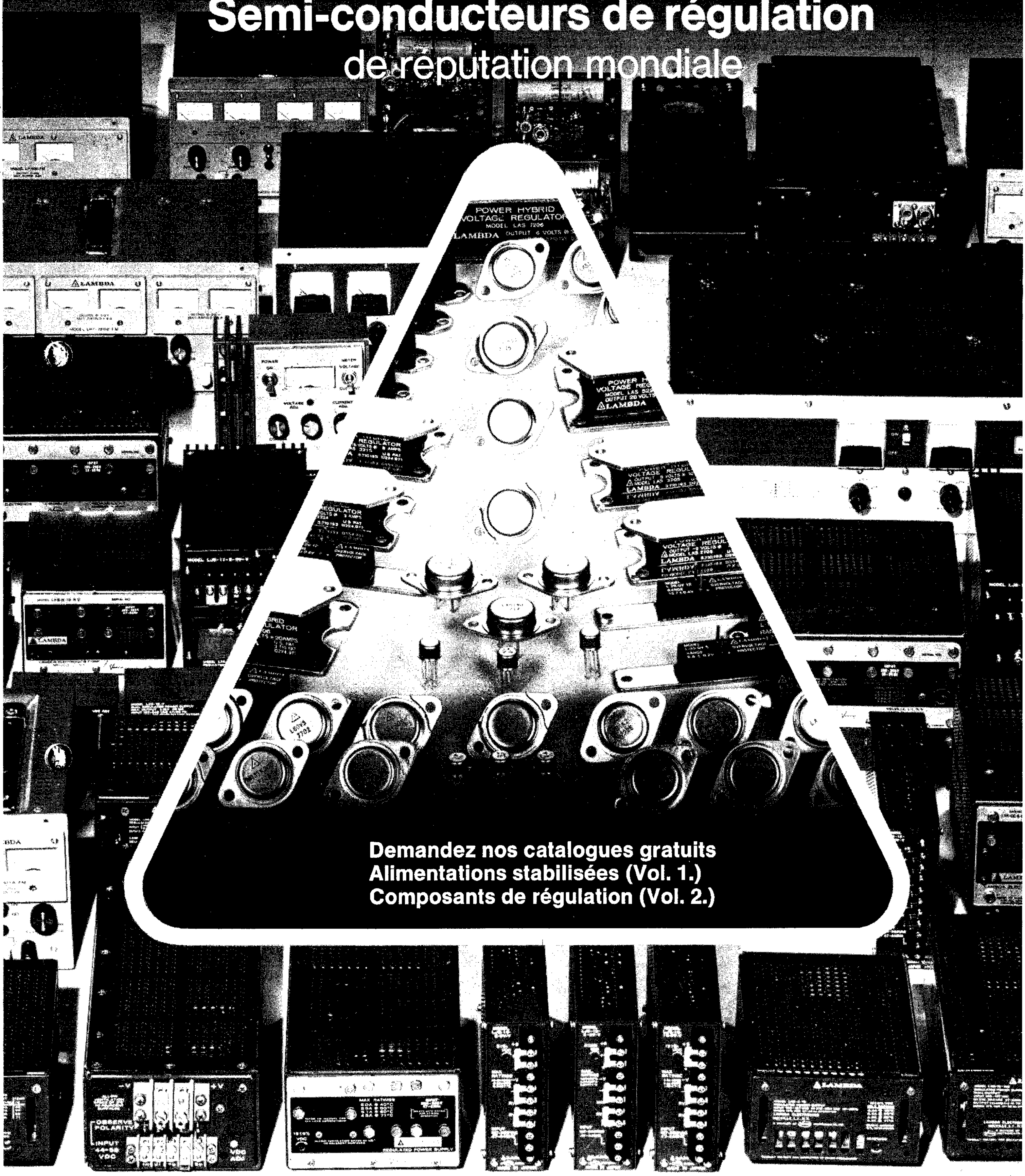

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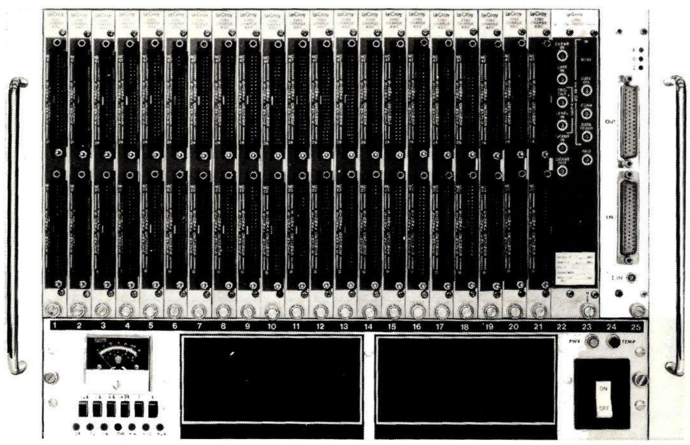

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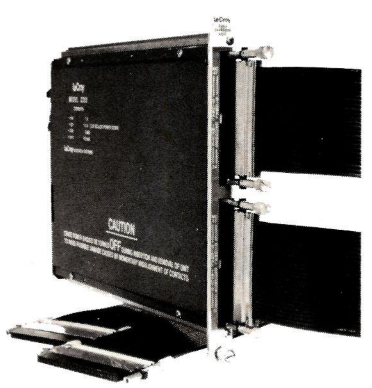

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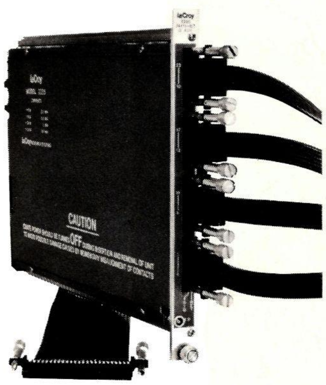

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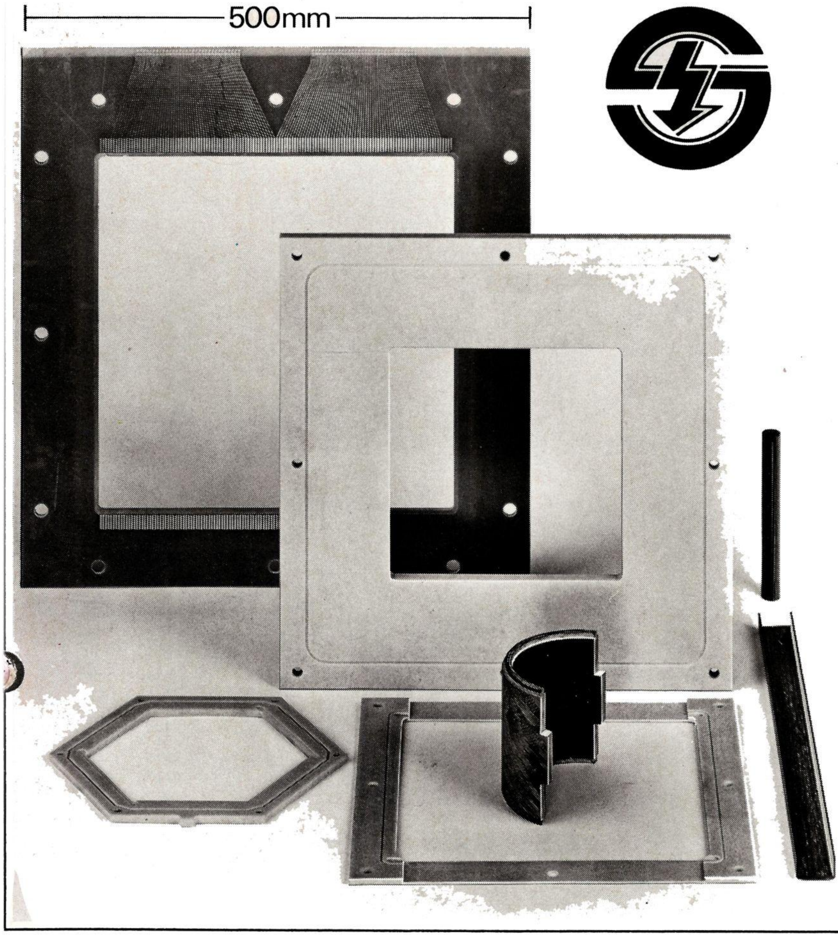

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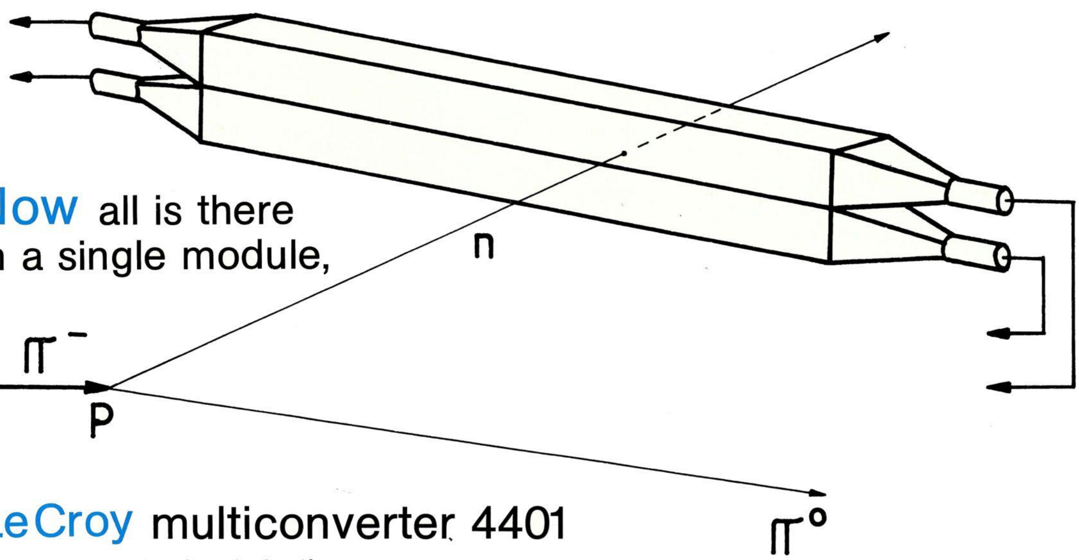

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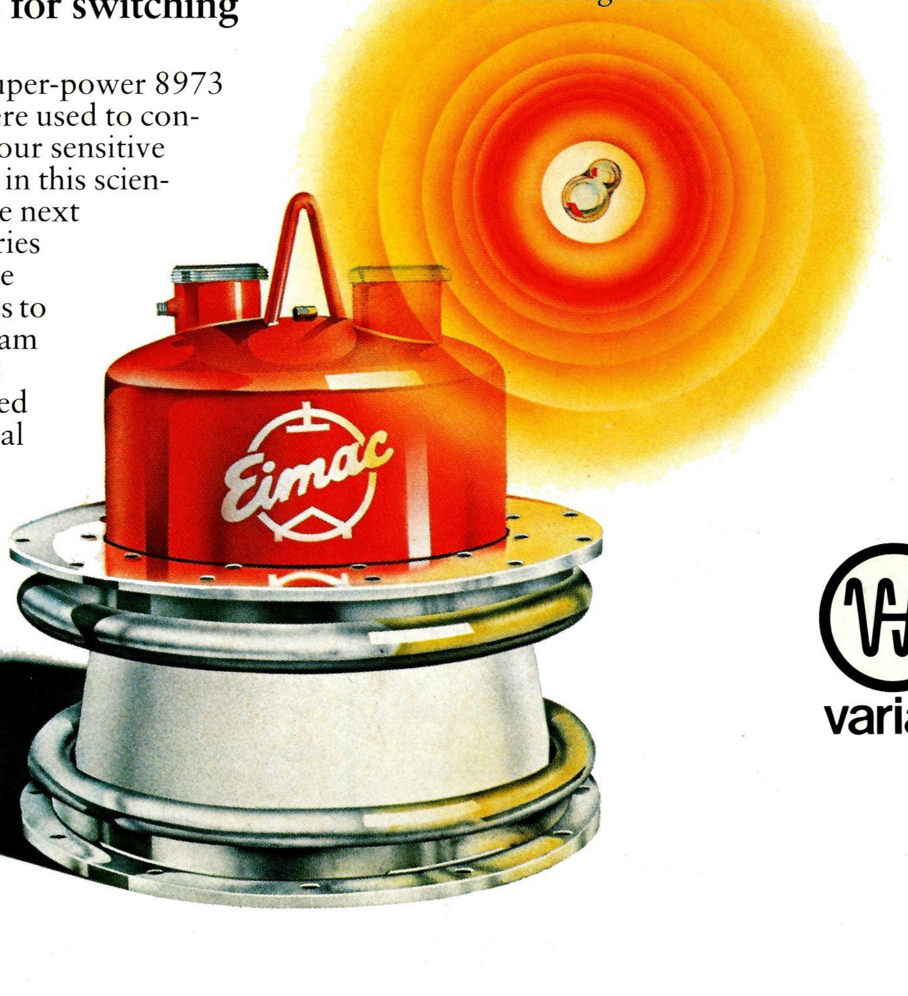

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