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Cover photograph: Hera is the central figure in this reproduction of the judgement by Paris of the quarrel between Hera, Athene and Aphrodite. HERA (Hadron Electron Ring Anlage) is again up for judgement as a proposed project at the DESY Laboratory which would be a very important element of Europe's future research facilities. By making high energy electron-proton collisions possible it would open up another range of physics complementary to that which will be studied at LEP. (Photo British Museum, courtesy of D.M. Wilson)

HERA

Proton-electron colliding beam project at DESY

On 28 March there was an Open Presentation at CERN, organized by the European Committee for Future Accelerators (ECFA), of the electron-proton colliding beam project, HERA, which is being proposed at the DESY Laboratory. The Report of the Electron Proton Working Group of ECFA (the 'Green Book', ECFA 80–42, DESY HERA 80/01) was also available at the meeting.

While not a formal proposal, the Report has a detailed exposition of the physics case for constructing HERA and a design of the machine. It is also distinguished by an opening chapter which conveys the essence of the project in non-specialized terms so that people in other disciplines can rapidly understand the justification for HERA and appreciate the major features of the machine and of the experiments which can be performed with it.

The history of e-p proposals

Thinking about electron-proton colliding beams dates back to DESY reports in 1972–73. In the mid-70s several projects had e-p possibilities listed as a potential bonus — EPIC at Rutherford, PEP at Stanford, TRISTAN in Japan and ISABELLE in Brookhaven. In 1977 Chris Llewellyn-Smith and Bjorn Wiik spelled out the unique physics abilities of such facilities and reopened the discussion. CERN examined the addition of an electron ring at the SPS (the CHEEP project), Fermilab had a similar study and DESY considered adding a proton ring at PETRA (the PROPER project — which was first presented at an ECFA Study Week organized by Rutherford in October 1977). A year later ECFA concentrated on a study of PROPER culminating in a meeting at DESY in April 1979. The Proceedings of this meeting (the 'Red Book') presented a strong case for the machine.

Its major conclusions were: Electron-proton physics is ideal for the study of strong interactions; it provides unique windows into some areas of physics not accessible in any other way. The proton ring could benefit in top energy from the use of superconducting magnets since it was felt that these could now be built with confidence to achieve fields between 4.5 and 5 T. The electron ring should be able to store polarized beams in order to open up some of the potential physics. Appropriate detection systems can be built and experiments can extract the necessary information. The physics is complementary to what can be achieved on LEP and other accelerators and storage rings.

Most important for the subsequent emergence of the HERA project was the realization that the physics would be much more interesting if the peak energies could be pushed higher than could be achieved with PROPER, given the limitations imposed by the PETRA storage ring which was then under construction.

ECFA decided to continue to study the possibilities under the Chairmanship of Ugo Amaldi and four sub-groups were set up, with extensive DESY involvement but with physicists from many other centres in Europe. The sub-Groups were Theory (with G. Altarelli, J. Ellis, G. Kramer and C. Llewellyn-Smith as convenors), Machine (with B. Wiik and E. Wilson), Experiments (with P. Dalpiaz, W. Hoogland, H.E. Montgomery, D. Perkins, P. Söding, K. Tittel and R. Turlay) and Superconducting Magnet (with G. Horlitz). The number of physicists involved was about a hundred. DESY started to consider both PROPER and the largest possible ring that could be built at and around the DESY Laboratory. From that study emerged a ring circumference of 6.5 km which has set the peak parameters of the HERA project.

In October 1979 the DESY Scientific Policy Committee decided to concentrate on HERA having a peak proton energy of 820 GeV and a peak electron energy of 30 GeV.

The physics confronting HERA

The present candidates for Nature's most elementary particles are the quark constituents of hadrons and the weakly-interacting leptons. All evidence so far points to quarks and leptons being pointlike with no internal structure, and the recent successes of the unified gauge theory of weak and electromagnetic interactions provide compelling evidence to group these basic particles into simple multiplets (see for example July/August 1978 issue, page 246).

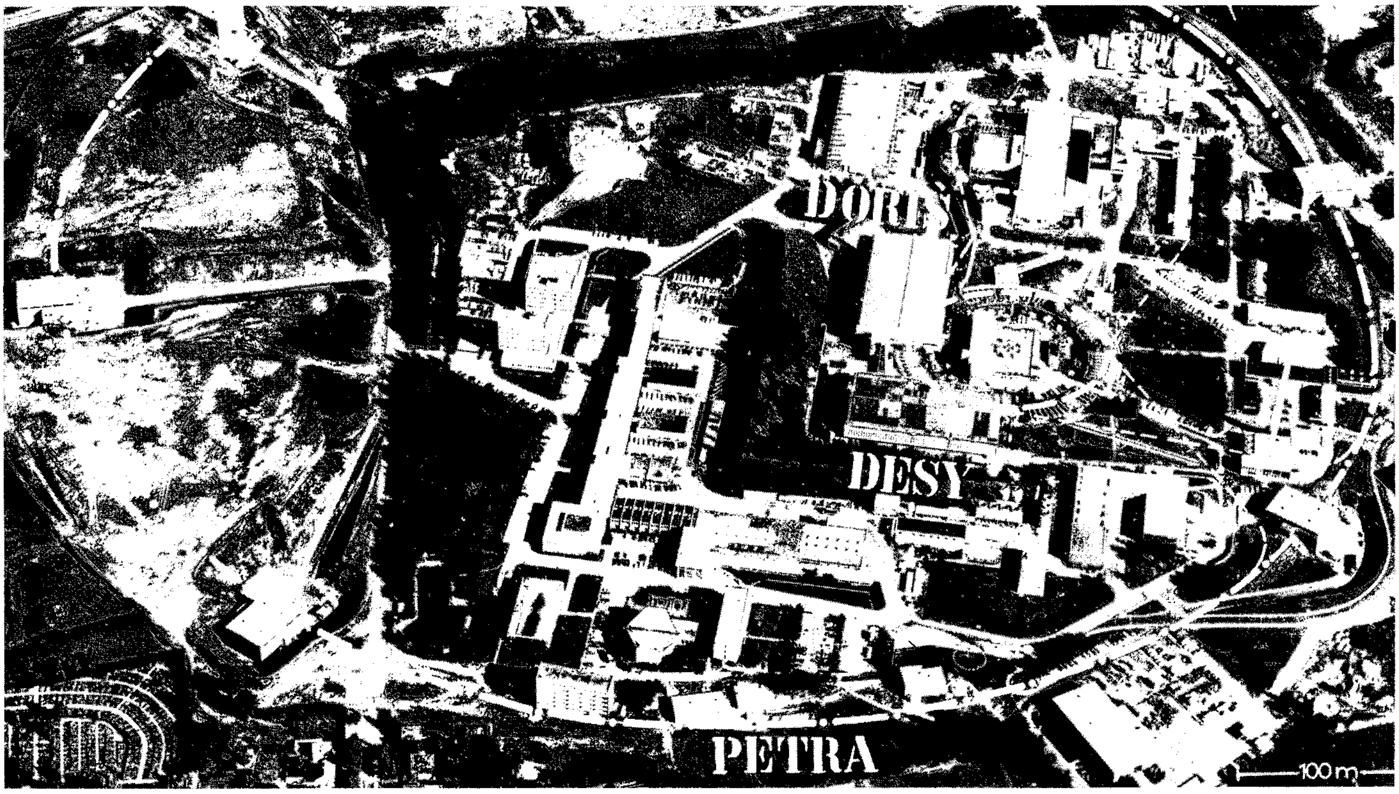
While so far there is much confidence in our present ideas on unified electroweak interactions, experiments to test them have really only scratched the surface of the energy domain where their implications should become important.

For example, the momentum transfers achieved in the highest energy experiments carried out so far reach only a small fraction of the predicted masses of the W and Z bosons which are assumed to carry the charged and neutral currents respectively of the weak interactions.

With the W and Z bosons yet to be found, the proposed mechanisms of weak interactions have still to be put to the test. Under appropriate conditions evidence could turn up for all sorts of unexpected new behaviour, such as additional bosons and new

Aerial view of the DESY Laboratory with the present machines indicated. HERA would extend beyond the present site boundaries but, by tunnelling some 15 m down, its construction will have negligible impact on the surroundings.

(Photo DESY)



types of weak interaction, which would demand a radical overhaul of the underlying theory.

To provide a further lever on the structure of the electroweak interactions, emphasis is placed on HERA's capabilities for handling polarized beams. This will make possible stringent tests on the exact form of the 'handedness' which seems to play such an important role in weak interactions at lower energies.

HERA will be able to explore electroweak interactions under conditions where the weak and electromagnetic parts become comparable in magnitude. Under these conditions, parity violation and other phenomena will occur on a much larger scale and be easier to compare with theory than the delicate effects due to electroweak interference seen at today's energies (see July/August 1978 issue, page 245).

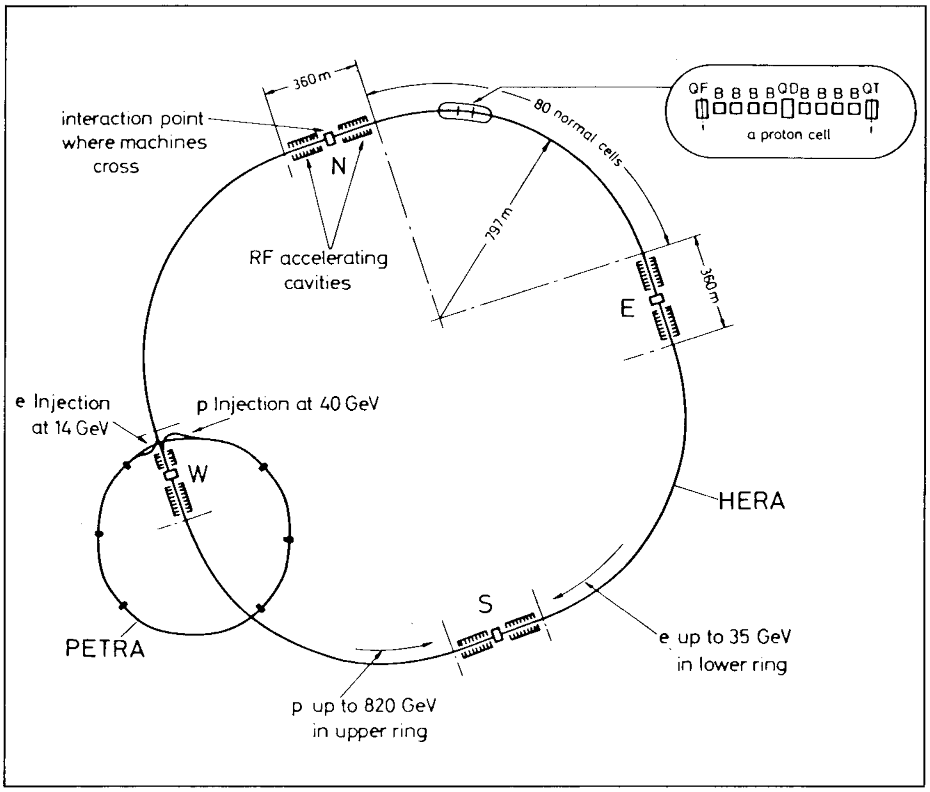
The LEP machine at CERN will also provide a vast new territory to explore these interactions. Rather than duplicating physics results, HERA and LEP should complement each other, with HERA as a high energy scattering tool, while LEP will exploit the different mechanisms of particle-antiparticle annihilation. In particular, HERA will be a particularly effective probe of the charged current interactions.

As well as exploring the electroweak forces, HERA will also open a unique new window on strong interactions. The high energies at HERA will violently shake hadron 'bags' and provide a new insight on the confinement mechanism which at present-day energies appears to lock quarks permanently inside hadrons.

It will open up a new energy domain for the study of quarks and the gluon carriers of the inter-quark force. Probably most intriguing of all, there is the possibility that HERA could reveal a substructure inside the quarks themselves, an idea n new to theoreticians who find embarrassing to have so many leptons and quarks around.

Historically, scattering experiments using lepton beams have played a prominent role in the discoveries of the successive layers in the underlying structure of matter. Much earlier this century, electron beams (the classic Franck and Hertz experiments) revealed details of atomic structure. Forty years later, electron scattering studies at SLAC, using energies millions of times greater, probed the nucleus and saw its internal structure. Finally, experiments at SLAC, CERN and Fermilab using lepton beams have in recent years probed inside the nucleon itself to reveal its constituent quarks. Perhaps the energies available with

Diagram of HERA showing its relation to the existing PETRA ring which will be used in both electron and proton injection schemes. HERA has four long straight sections which could be used for colliding beam experiments.



HERA, which will enable the structure of matter to be probed down to distances of 10^{-16} cm, will take this ory a step further and find evidence for a substructure of quarks.

While our present picture of particle interactions is appealing, the different interactions of physics still appear with their own characteristic strengths which cannot easily be related to each other, and the observed masses of particles have to be explained.

Questions spring easily to mind. Are there more quark/lepton multiplets than the ones we already know? Do free quarks exist? Are quarks and leptons really pointlike or have they some inner structure? What interactions do the intermediate bosons of weak interactions have? How do gluons behave? And so on.

HERA is by far the most detailed machine design to emerge for colliding beams of leptons and hadrons. In principle it should be able to detect new particles of mass up to 150 GeV. Physics is far from being a closed book, and HERA could certainly help add fresh pages.

The machine design

A study of the possibilities in the DESY Laboratory region for the construction of HERA resulted in a proposal of a ring 6.5 km in circumference. The ring would be tunnelled some 10 to 20 m below ground (with a 7 per cent tilt of the plane of the machine to take account of the fall of the land from north to south) and construction would cause negligible disturbance to the urban surroundings. Some 80 per cent of the land involved is outside the present DESY site boundaries. Within the site HERA would pass adjacent to the existing PETRA storage ring which could then be used in both electron and proton injection systems.

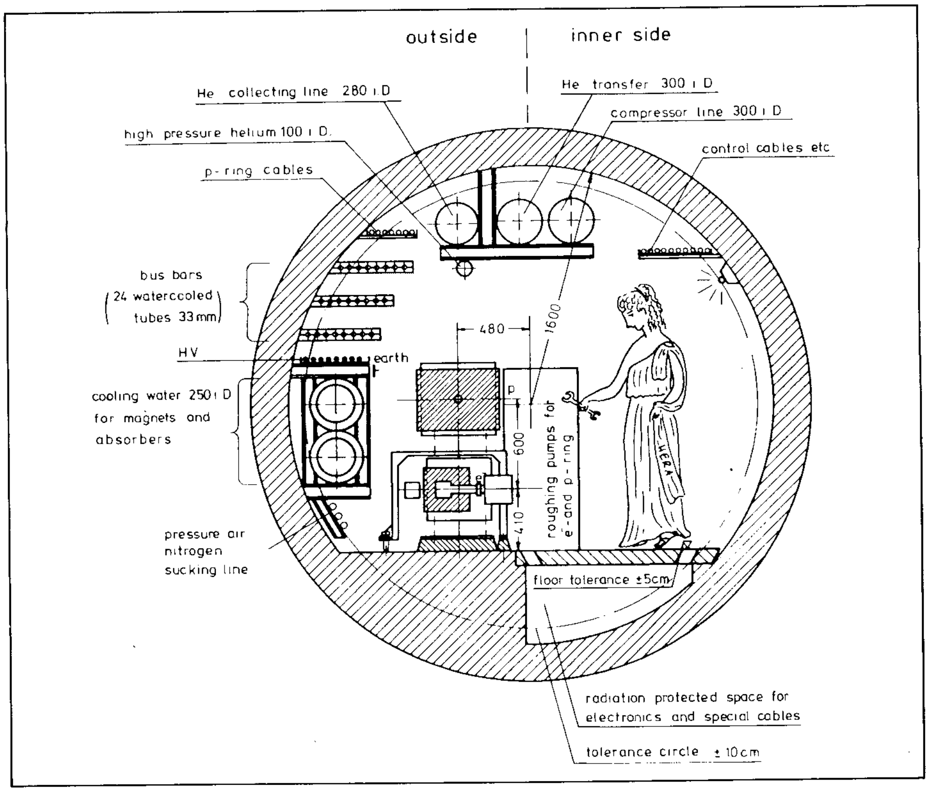
With a ring of 6.5 km circumference a peak proton energy of 820 GeV could be reached, provided that superconducting magnets to achieve 4.75 T can be built. Also with a ring of this circumference, reasonable power costs to compensate for synchrotron radiation losses sets the peak electron energy at about 30 GeV.

The ring would have four-fold symmetry with four straight sections 360 m long where r.f. cavities would be installed and where, of course, the experimental halls would be located. The halls will be 30 m along the beam direction and 50 m wide (allowing for magnet cooling installations, experimental control rooms and the possibility of having two detection systems which could be moved alternately into the ring).

The range of electron energies would be from 10 to 30 GeV. The range of proton energies would be from 100 to 820 GeV (the lower energy being set by the lowest field in the superconducting magnets where it is expected that acceptable field quality can be retained).

The luminosity at the peak energies would be 0.35×10^{32}. This is with 224 bunches in each ring and 3×10^{11} electrons, per bunch and 0.35×10^{11} protons per bunch and using conservative values for the parameters that are believed to limit the luminosity — the so-called beam-beam tune shift. The beams would collide at a small crossing angle which has some advantages (such as helping to keep synchrotron radiation out of the superconducting coils) but which limits the acceptable beam tune shift. At the crossing region the magnet configuration is so arranged that the transverse electron polarization is transformed into

The crowded HERA tunnel with the mythical figure herself lending a mechanical hand in view of the manpower shortage. The proton ring sits above the electron ring and its installation would follow that of the electron ring.



longitudinal electron polarization, as is required to make use of the polarization in the experiments.

The electron ring is almost three times the size of the existing PETRA ring but rather than being a direct copy of the PETRA design, HERA has profited from PETRA experience to incorporate some improvements. It is intended that the magnet and vacuum chamber would be built as one unit with separate ion pumps. The magnets would form part of the synchrotron radiation shield rather than having yoke and coil towards the inside of the ring. Organic components would be avoided and the exciting coil would be a single bar of conductor running through all the magnets in series. About 640 bending magnets, each 5 m long, would be distributed around the HERA circumference.

The proton ring would have superconducting magnets using niobium-titanium conductor, in wire of the Rutherford type, to reach peak fields of 4.75 T. The design has been evolved in collaboration particularly with physicists at Saclay. There would be 640 dipoles, 164 quadrupoles and 80 special magnets for the interaction regions.

The dipoles are designed to have warm bore (like the ISABELLE magnets) because of anticipated beam-induced heat of over 1 W per metre. It will also have warm iron (like the Fermilab magnets) in particular to keep cool-down times reasonably short. A special suspension system for retaining coil position (compensating for misalignments and thermal movements) has been developed incorporating spring washers which allow external adjustment without warming up the magnets. Refrigeration systems will be installed at the four long straight sections to pump supercritical helium at 3.8 K through the dipoles.

The radiofrequency systems for the two rings would operate at 500 MHz for the electron ring and 200 MHz for the proton ring. The electron r.f. units have been chosen to operate at the same frequency as those of PETRA where expertise exists at DESY; this will also allow klystrons and wave guides to be transferred from PETRA which will not need to reach its peak energies when HERA is in operation. The peak r.f. power required, to feed a maximum of 192 cavities installed in the four long sections, would be 13.2 MW.

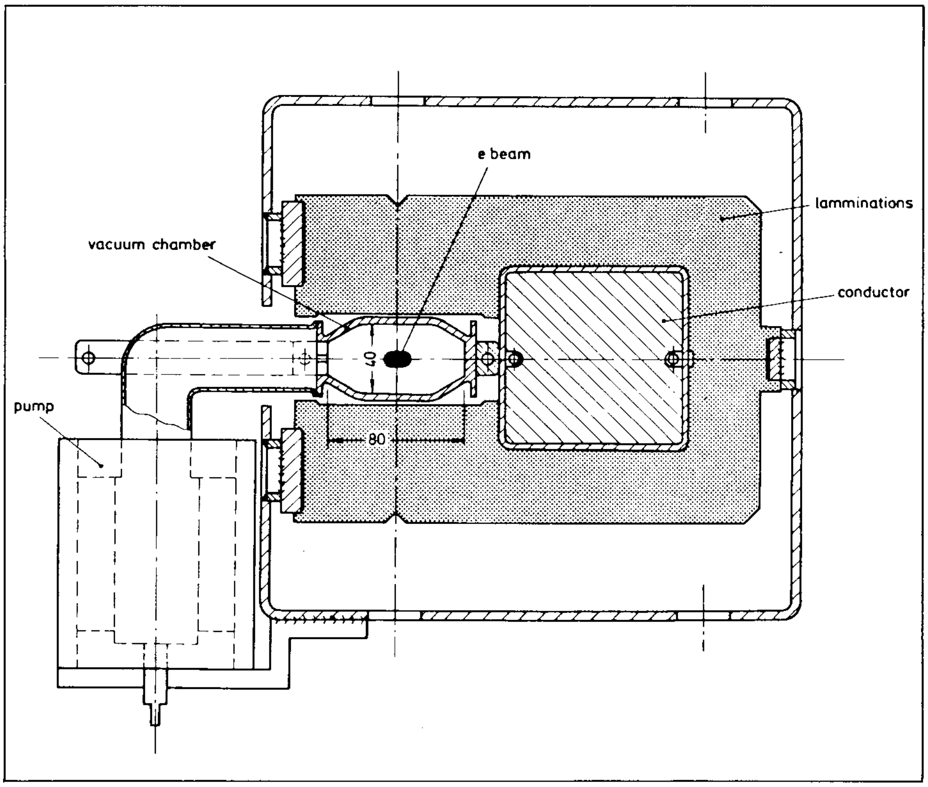
The proposed injection system for electrons (and positrons) is obviously based on the existing machines at the Laboratory. The particles would follow the route of linac, DESY synchrotron and PETRA storage ring before being injected into HERA at 14 GeV. The total filling time to build up the design intensity is expected to be about 10 minutes.

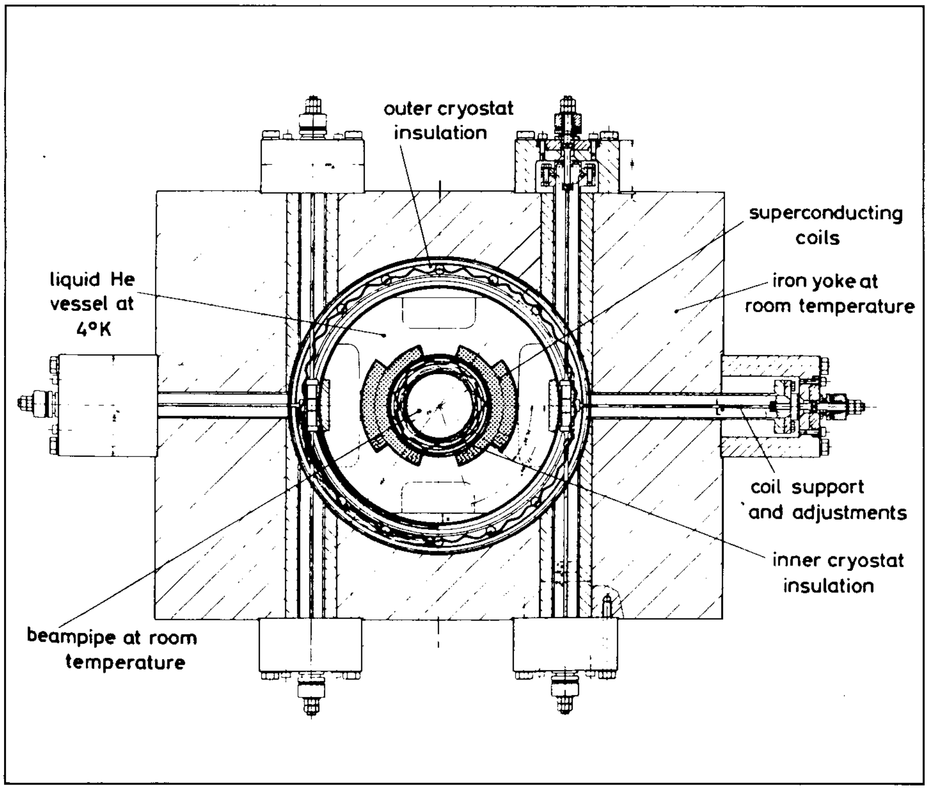
For protons a 50 MeV linac will have to be built but it will be possible to use the DESY synchrotron and PETRA after installing additional r.f. systems and by-passes to avoid the electron r.f. cavities in the synchrotron. The magnets can be taken high enough in PETRA to allow proton acceleration to 40 GeV before injection into HERA. The filling time will be about 8.5 minutes.

Experimentation at HERA

A look at the experimental conditions which would prevail at HERA have given confidence that the interesting physics could be extracted. The possible sources of background, which could confuse the detectors, are troublesome but can be eliminated or reduced to a sufficient extent.

Cross-sections of the electron ring magnet (above) and the proton ring superconducting magnet (below). Both designs have novel features, described in the text.





Synchrotron radiation is a problem and is accentuated by the introduction of sharper beam bends at the interaction regions to achieve the required beam polarization conditions. Nevertheless the use of collimators and special detector design can control the problem. Collisions of protons and electrons with residual gas molecules in the interaction regions can also be reduced or distinguished from true collision events to a sufficient extent by using veto counters and appropriate kinematical cuts.

Two particular detectors were designed in outline as being appropriate for HERA. One was a 'neutral current detector' based on detectors installed in a large superconducting solenoid. This detector would aim to measure the parameters of an emerging lepton with great precision while worrying less about the corresponding jet of hadrons. Alternatively a 'charged current detector' based on a 4 π fine-grained calorimeter would give very good precision on the emerging hadrons and pay less attention to the leptons.

Costs and timescales

Since the HERA project has not reached the stage of formal proposal, the anticipated costs and timescales have not yet been spelled out in great detail. Nevertheless some information was given at the 28 March meeting and in the 'green book' report, which is likely to be very close to the final figures.

The cost of the project is estimated at about 600 million Deutschmarks of which some 160 MDM is required for the civil engineering work and some 170 MDM for the superconducting magnets. The 'new money' which the DESY Laboratory is likely to be asking for, spread over some seven years of construction, is between 500 and 550 MDM.

There is a preliminary estimate that about 400 people will be involved in the project. DESY would like to recruit some 70 additional staff, since this is the number which would be needed to operate the additional facilities long-term, and could move almost 250 people of the existing staff onto HERA if it is authorized.

The remaining effort of about 100 people it is hoped can be found amongst potential users of the machine from outside the Laboratory, half within the Federal Republic of Germany and half elsewhere in Europe. Specific components, such as the linac, ion pump system, etc... could be farmed out to other Laboratories, so that there is no need for people to move in large numbers to DESY.

It is hoped that approval of the project will be forthcoming by mid-1981, following further discussions both inside and outside Germany, more prototype work and the preparation of a formal proposal. If this authorization date were met it would be possible to bring the electron ring into action in 1986 and the proton ring (installed above the electron ring) two years later.

It is obvious that some electron-positron physics in the electron ring could be possible during the two years prior to completion of the proton ring. However, there would be a great deal of machine physics to be done with the electrons (perfecting feedback systems, mastering the polarization techniques). Also there may not be much to be gained from electron-positron physics at energies up to 30 to 35 GeV when, for this, LEP will be able to exceed the HERA parameters. The exceptions may be the finding of the top quark and a study of the electromagnetic-weak interference region. Nevertheless, the HERA emphasis is definitely on electron-proton physics.

An ECFA meeting following the exposition of the HERA project on 28 March took a preliminary look at the project and expressed its great interest in the physics and the machine design. ECFA has always stated that two significant project are desirable in Europe to sustain the high energy physics community with front-line research facilities. The ECFA Working Group Report (described in the March issue, page 11) showed that fruitful programmes could be mounted on both LEP and HERA with the present levels of finance and manpower. HERA is now being discussed in the European high energy physics community prior to formulating an ECFA recommendation at its meeting scheduled for 9 May.

Protons in a spin

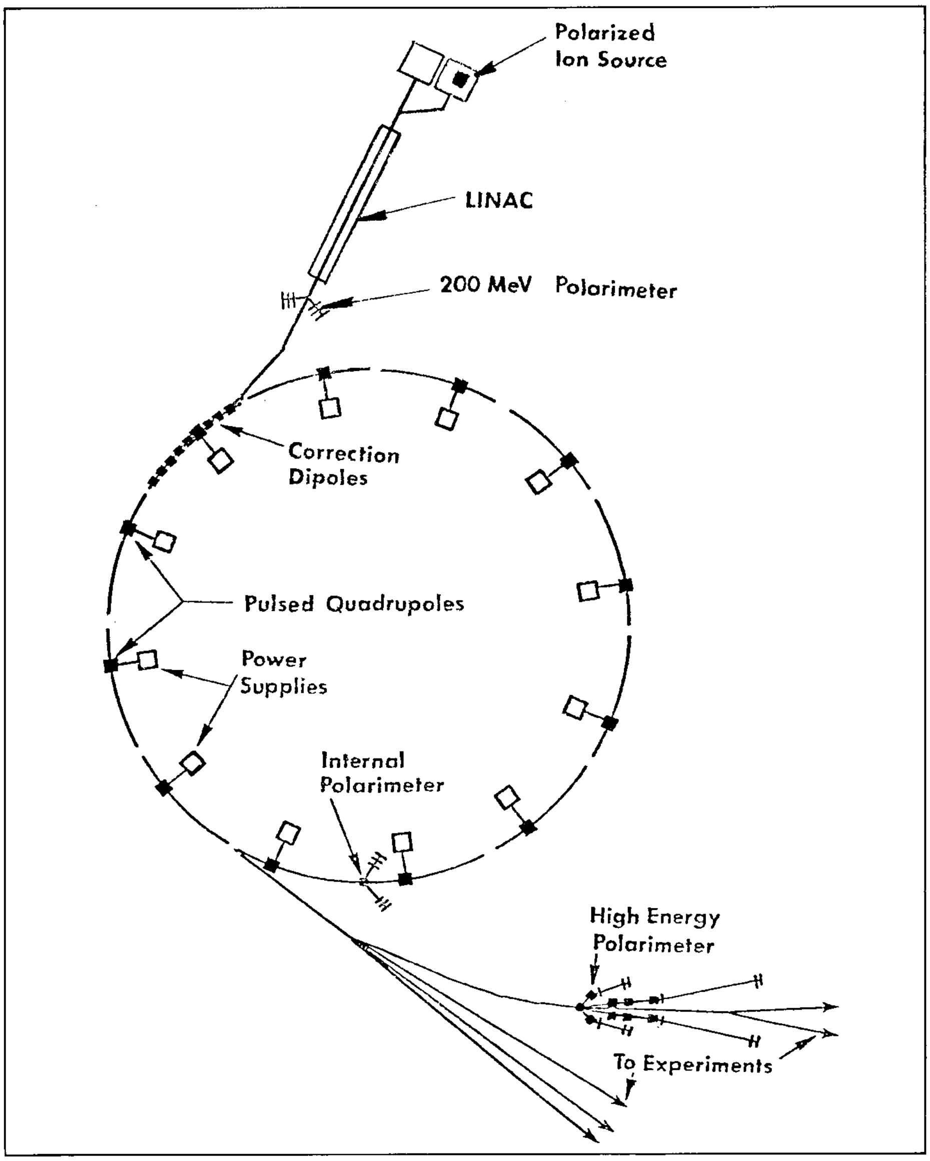
Scattering experiments using polarized beams are a potentially rich source of detailed information on particle interactions. The swan-song of the Argonne Zero Gradient Synchrotron before it shut down last year was the acceleration of polarized proton beams to GeV energies. Experiments with these beams yielded a series of unexpected results (see for example October issue 1978, page 347 and November issue 1979, page 351) and this success has prompted Brookhaven and Fermilab to launch polarized proton beam programmes for the near future.

After some three years of study, design and evaluation, Brookhaven and the USA Department of Energy have agreed on a plan to modify the 33 GeV Alternating Gradient Synchrotron to allow the acceleration of polarized protons. Because of ISABELLE's heavy manpower demands, physicists from Argonne, Brookhaven, Michigan, Rice and Yale will collaborate in order to make these modifications.

In some sense the AGS polarized beam project began at the 1977 Ann Arbor Workshop (see December 1977 issue, page 418) which concluded that it might be possible to jump depolarizing resonances at strong focusing synchrotrons. The 1978 Brookhaven Summer Study investigated in detail the possibility of polarized proton acceleration in the AGS and produced the 'Preliminary Design Study and Cost Estimate'.

For the past eighteen months the technical feasibility and overall impact of the project have been carefully evaluated by Brookhaven. Although the project has many technically challenging problems it appears that by 1983 the AGS should be able to accelerate about 10^{11} polarized protons/pulse to 26 GeV with a polarization of about 60 per cent.

Much of the physics enthusiasm for polarized protons came from the results at the Argonne ZGS. Large and unexpected spin-spin forces in high transverse momentum proton-proton elastic scattering were discovered by the Michigan / Argonne



Layout of the Alternating Gradient Synchrotron at Brookhaven showing the major modifications that must be made to allow acceleration of polarized protons. It is hoped that a programme of polarized beam experiments will be possible from 1983.

group and these forces may still be growing at the maximum transverse momentum values available at the GS–5 GeV^2. This is not understood in terms of the generally accepted version of quantum chromodynamics theory (though there are alternative ideas in line with the results, proposed by a few people such as G. Preparata and J. Soffer at CERN). Thus it seemed important to extend the study of spin effects to the AGS where values of 10 to 15 GeV^2 could be reached. Studying these spin-spin forces should help in understanding the direct quark-quark interaction.

Although no proposals are yet being considered for the polarized beam, several experimental groups are already starting to plan polarized beam programmes. In fact a proposal by a Michigan / Argonne / Brookhaven / Copenhagen / Miami collaboration to study spin effects with a conventional beam and a polarized target has been approved, while a Brookhaven / Minnesota group is proposing to measure large transverse momentum elastic scattering. The Yale and Massachusetts groups are each gearing up their polarized proton targets, and the Michigan and Rice polarized targets both seem to be moving eastward.

The biggest problem in accelerating polarized protons at the AGS will be to manoeuvre the proton beam through depolarizing resonances without losing all the polarization. Unfortunately, these resonances are about ten times worse at the strong focusing AGS than at the weak focusing ZGS. Nevertheless the same type of resonance jumping scheme will be used and should be successful, according to depolarization experts such as E.D. Courant.

One of the most challenging technical problems will be to develop the pulsed quadrupole magnets required to jump through the eight 'intrinsic' depolarization resonances. There will be twelve of these quadrupoles, each with a 1 μs rise time, compared to the two ZGS quadrupoles, with 10 μs rise times. The AGS quadrupoles will be constructed of ferrite by Michigan, while Brookhaven will construct the 25 kV, 3 kA power supplies and Argonne will aid in the system's design.

The other major problem is the polarized ion source. While the 100 μA ZGS polarized proton ion source could be used, it would give an intensity of only about 2×10^{10} polarized protons/pulse. A negative hydrogen ion polarized source is preferred since the AGS injection system will be changed to negative ions within the next year; Argonne is constructing such a source to give 10 to 100 μA with Yale aiding in its detailed design. This source should result in accelerated beam intensities of about 3×10^{10} to 3×10^{11} polarized protons/pulse. Argonne and Brookhaven will collaborate on the modification of the preaccelerator dome to house the polarized ion source.

The 'imperfection' depolarizing resonances will be avoided using 96 correction dipole magnets already in the AGS. These require new power supplies with computer control to produce the necessary harmonics to miss 47 different resonances. This system will be constructed by Brookhaven with software aid from Rice and Michigan.

Various polarimeters must be constructed to study depolarization effects and to measure the final beam polarization. These measurements require very close co-operation between accelerator physicists and experimenters. A 200 MeV polarimeter, which is being built at Rice, will measure the left-right asymmetry in proton-carbon scattering at the end of the linac. Michigan is building an internal polarimeter, to monitor the polarization during acceleration, and a high energy polarimeter, which will give an absolute measurement of the polarization by studying proton-proton elastic scattering from a hydrogen target.

While all the hardware work for the next few years will concentrate on polarized protons for research at the AGS, it is hard to forget that around 1986 the AGS will become the injector for ISABELLE. Ernie Courant has been studying the acceleration of polarized protons to 400 GeV in ISABELLE using the 'Siberian Snake' scheme. This novel idea for handling depolarization becomes easier as the energy increases and, if it really works, the late 1980s might see exciting studies of spin-spin effects at collision energies of up to 400 GeV per beam.

Fermilab: Polarized proton beam

In November 1979, approval was given to develop a polarized proton beam at the Fermilab 400 GeV synchrotron. Operation is expected around 1983 opening the way to this fruitful approach to physics at hundreds of GeV. Collaborators in this effort include Argonne, Fermilab, LAPP, Kyoto, Berkeley, Rice and the Italian INFN.

The polarized beam facility will be a joint project between Argonne and the Fermilab Meson Department. Argonne will have responsibility for most of the technical components and will construct sixteen new superconducting quadrupoles for the beamline. Conventional dipoles, formerly used at the ZGS, will be shimmed and reused. Fermilab will be responsible for the conventional construction and for a new experimental area built as an extension of the Meson Area.

The parity-violating decay of lambdas or antilambdas will be used to produce the polarized protons or antiprotons. The beam will cover an energy range from about 50 to 350 GeV with either 400 or 1000 GeV primary protons. With some rearrangement it could work at 80 per cent of the highest primary momentum available from the Tevatron. The average transverse proton polarization at 250 GeV will be about 45 per cent for an intensity of over 10^7 polarized protons per spill (using 3×10^{12} primary protons at 400 GeV). The intensity per pulse will be higher when the Tevatron is in operation. The Tevatron will also make available fluxes of over 10^6 polarized antiprotons at energies up to 250 GeV.

There will be two basic modes of operation, one using the high momentum end point of the lambda production spectrum and the other using a correlation between polarization and position at a focus. The polarization can be reversed at short intervals and any direction of polarization can be obtained at the experiment by using a so-called magnetic spin precession snake.

The polarized beam facility can be used to carry out an intensive programme of experiments on spin effects in the proton-proton and proton-antiproton system, up to the limit of Fermilab energies. It will be a natural extension of the programme of high energy scattering carried on at the ZGS.

The first experiment, after the parameters of the beam have been established, may be a study of spin effects at high transverse momentum by detecting neutral pions produced using a transversely polarized beam scattering from a liquid hydrogen target.

These measurements could then be followed up using both a longitudinally polarized beam and a polarized target to look at interactions between the fundamental constituents of the proton. Later experiments might measure asymmetries in jet production at large transverse momentum. Another first-round experiment could be the study of the spin dependence of the rise of the proton-proton total cross-section at high energies. Experiments could also be done to help understand the enhanced particle production from nuclear targets. Experiments have also been discussed to study production of pions, di-muons and strange particles.

Meanwhile other experiments using polarized targets have provided important evidence for appreciable spin effects at high energy. Studies at both CERN and Fermilab show that the polarization parameter (which describes the spin effects in proton-proton scattering) changes sign twice with increasing momentum transfer, having an appreciable positive value in the region of the second maximum in the elastic differential cross-section (2 GeV^2 squared momentum transfer).

Nuclear extremes

The logo of the International Conference on Extreme States in Nuclear Systems (ESINS). It is an artist's view of the penetration of a relativistic heavy ion through nuclear matter.

An International Conference on Extreme States in Nuclear Systems (ESINS) was held in Dresden from 4–9 February, with three hundred participants from twenty countries. The Conference was organized by the Central Institute for Nuclear Research, Rossendorf, and Dresden Technical University to review present knowledge about nuclear sysems under extreme conditions.

The programme — a mixture of speculative ideas as well as established knowledge — covered the following topics: compression of nuclear matter in heavy ion collisions, creation of nuclear compounds in reactions at relativistic energies, dynamics of complex nuclear states in deep inelastic heavy ion reactions, nuclear behaviour at very high spin, present status of creating superheavy nuclei and quantum electrodynamics of strong fields, formation of pion condensate and corresponding astrophysical topics, multiquark systems and quasinuclear nucleon-antinucleon states.

Heavy ions at relativistic energies

Highlights were the recent Berkeley and Dubna experiments with relativistic heavy ions. Using the JINR 2 m propane bubble chamber, inelastic interactions of carbon nuclei up to energies of 40 GeV with tantalum and carbon nuclei have been studied. Events with sequential collisions of the projectile-like fragments in the forward direction indicate that the projectile retains its individuality during the whole process, an observation which was not expected.

The underlying dynamics of this process (for example, the role of quark substructure in nuclei) is not yet clear. Semi- inclusive and exclusive measurements, such as are planned with the 4π plastic ball detector now under construction by the Berkeley / Darmstadt / Marburg collaboration, could uncover the mechanism of these nucleus-nucleus collisions.

Shock waves

New three-dimensional fluid dynamical calculations further strengthen confidence in the concept of shock wave creation in nucleus-nucleus collisions. The peak in the angular distribution at the Mach angle for nearly central collisions of neon on uranium has been qualitatively confirmed by recent experiments of the Frankfurt group by selecting out high multiplicity events.

For intermediate impact parameters, shock wave dynamics predicts that two nuclear residues will be kicked apart in definite azimuthal directions. Experimentally, this has been seen in the Berkeley coincidence measurements. This looks like the start of the study of highly compressed nuclear matter.

Nuclear collectivity

Several contributions demonstrated that great progress has been made in the investigation of nuclear structure and dynamics, and new facets of 'nuclear collectivity' are now under study.

The idea of the pion condensate required the analysis of correlated

Discussion between S.T. Belyaev of the Kurchatov Institute Moscow (at the microphone) and R. Bock of Darmstadt (right) after a talk on heavy ion reactions leading to extreme states in nuclear systems. Seated is P. Radvanyi of Saclay.

(Photo Akademie der Wissenschaften der DDR)

particle-hole states with different pion quantum numbers. Particle-hole interaction modes become critical when momentum transfers are greater than twice the pion mass. Such excitations can be investigated in proton scattering reactions on nuclei. It is to be hoped that the energy resolution required to do these experiments well will become available in the near future. No experimental evidence of pion condensate in actual nuclei has yet been found.

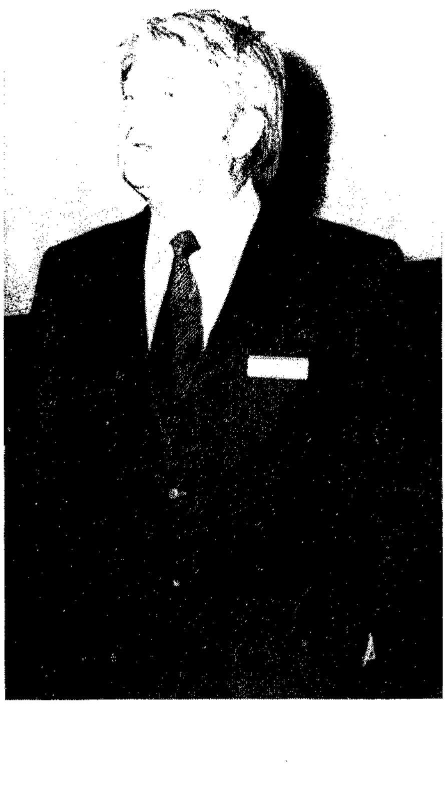
Nuclear rotations are now studied close to the spin region, where rotationally induced fission sets in. Refined gamma-gamma coincidence techniques make it possible to find band intersections away from the Yrast level by selecting transitions with nearly equal energies. Most of these intersections can be well understood from the results of the rotating quasiparticle model. Very interesting information is expected to come from these studies of the rotational fission process.

Extreme states in heavy ion collisions

Recent experiments at Darmstadt, using accelerated uranium-238 ions on a uranium-238 target, gave a lower limit for the time it takes for the two nuclei to break up (3 to 4×10^{-21} s) in a sequential decay (even for the heaviest intermediate systems with atomic numbers greater than 110). This short time, which is characteristic of deep inelastic heavy ion collisions, manifests itself in a rapid balancing of the charge between the fragments. How is the charge transported through the neck of the double nuclear system as the fission develops? One possible explanation is the excitation of the isovector giant dipole mode, representing a longitudinal vibration of the system.

Some extreme nuclear states have already lost their speculative character and entered into the realm of known phenomena. Now heavy ion physics has a lot of other new challenging problems to solve. As the field develops, close connections between high energy particle physicists and low energy nuclear physicists are very important and the ESINS Conference did a lot to strengthen these contacts.

The help of L. Münchow, one of the local organizers of the Conference, in preparing this report is much appreciated.



Arkadi Migdal (Moscow) speaking about phase transitions in neutron matter and dynamics of nuclear stars.

(Photo Akademie der Wissenschaften der DDR)

LOS ALAMOS New linac structure works

One of the projects in the Accelerator Technology Division at Los Alamos is the design of the Fusion Materials Irradiation Test Facility (FMIT) which is to be built at Hanford. The concept, which originated at Brookhaven, is to accelerate a current of 100 mA of deuterons to 35 MeV and strip them to yield a high flux of 14 MeV neutrons. Such a flux will be encountered in fusion reactors and can thus be used to investigate material properties for the reactors.

An idea that Los Alamos decided to try for FMIT emerged from thinking about a similar project in the USSR (from I.M. Kapchinski of ITEP and I. Teplekov of Serpukhov). It tries to respond, in one structure at the input end of the linac, to the needs of the preliminary acceleration, beam focusing and beam bunching. Conventional structures require separate systems for all three functions.The idea is particularly attractive for the first stage of a linac where bunching needs to be achieved to give the beam the right form to pass through a subsequent conventional structure and where magnetic fields have to be relatively high to achieve beam focusing (which is velocity dependent).

The new structure goes under the name of radiofrequency quadrupole, RFQ. It has four poles running the length of a vacuum tube which is fed with r.f. power. The poles are scalloped so that the tips near the beam are spaced further and further apart as the beam moves along the tube. The scalloping achieves electric fields which produce acceleration and bunching. Alternate pole tips are negative and positive to produce beam focusing. Feeding in a d.c. beam results in an accelerated, focused and bunched beam emerging.

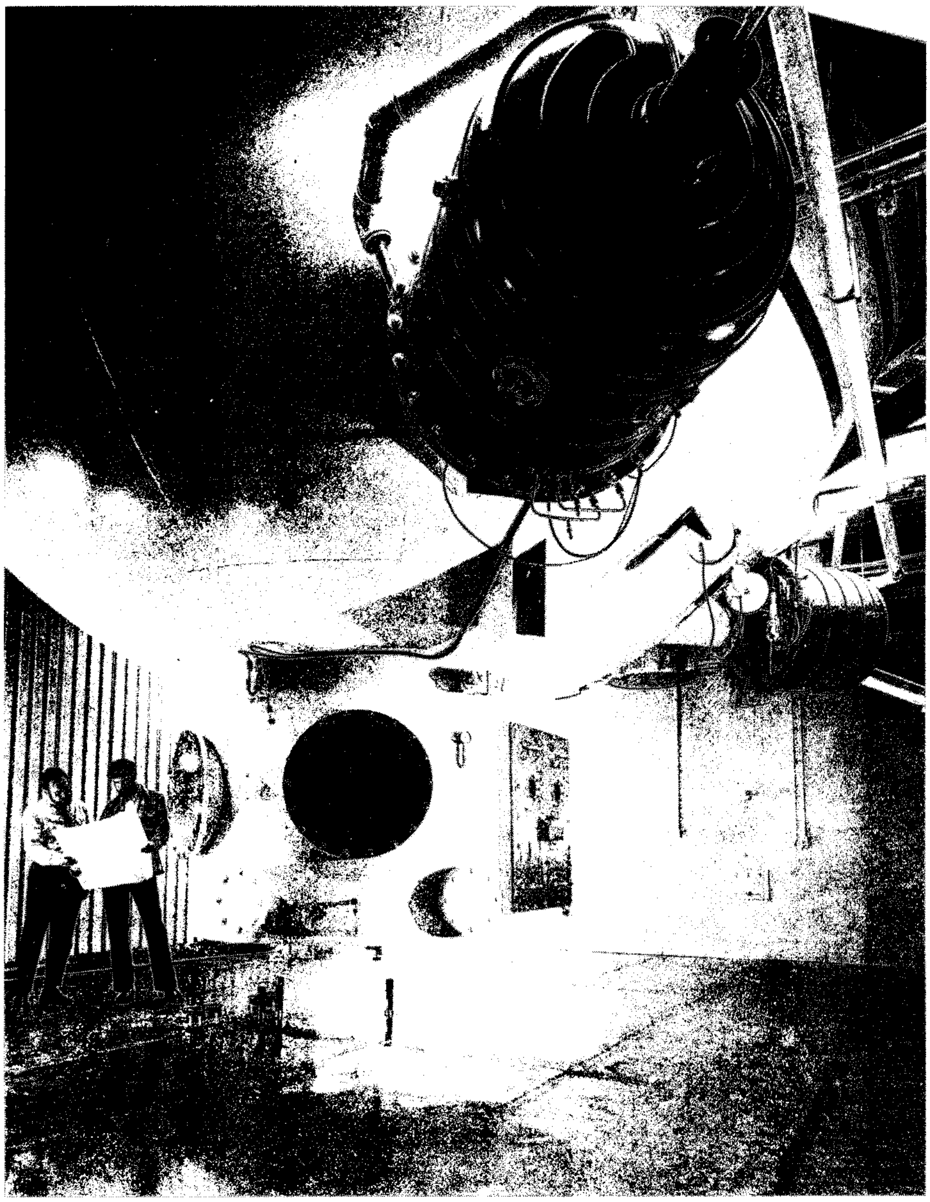
An RFQ has been built and worked well immediately when switched on. It is now intended to incorporate such a structure in the FMIT and there are other applications, such as accelerators in medical environments, where the simplicity and economy of the RFQ looks very attractive.

BERKELEY
Neutral beams

A promising technique to provide additional heating of magnetically-confined plasmas in Tokamak fusion reactors is the injection of high energy neutral atoms. The neutral atoms should be able to penetrate into the plasma without being disturbed by the prevailing fields. Once in the plasma, they will ionize and transmit further energy to the ions in the plasma to increase the temperature to the level necessary or fusion reactions to take place.

The Tokamak Fusion Test Reactor project, TFTR, at Princeton (led by Paul Reardon, formerly of Fermilab) plans for four neutral beam injection systems. The development of such injectors has been assigned to the Lawrence Berkeley Laboratory, in collaboration with the Lawrence Livermore Laboratory, under the direction of Walter Hartsough, and with Kenow Lou as project manager. The first successful operation of a high energy, high intensity prototype has recently been achieved at Berkeley.

Deuterium beams were accelerated to 120 keV in pulses of 0.5 s duration producing 7 MW of power. The development programmes will continue using sources of positive deuterium ions (the 'conventional' route to neutral beams via transmission through a neutralizing volume of deuterium gas) and using negative deuterium ions. Higher voltages, higher currents, longer pulse durations and system reliability are all development goals.



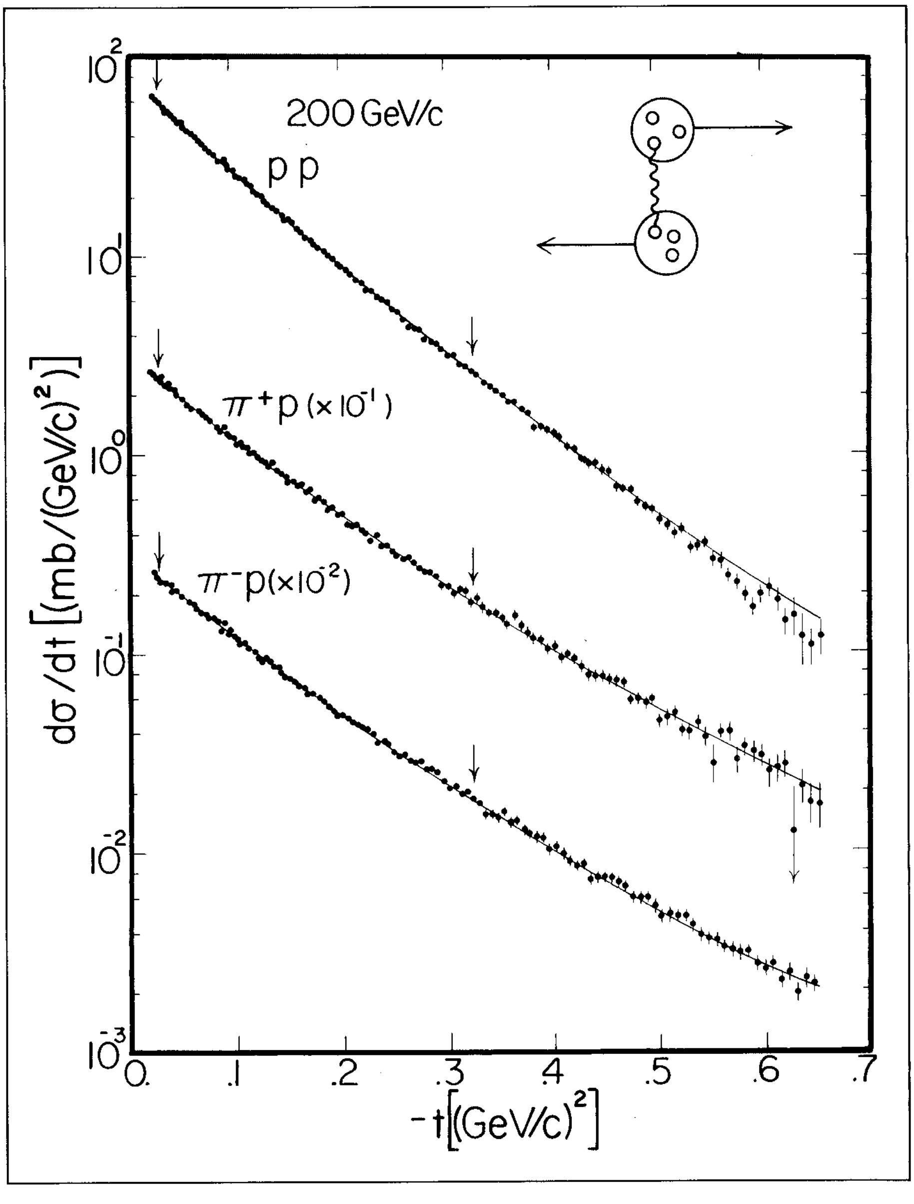
The neutral beam test facility at Berkeley. High energy, high intensity beams appropriate for Tokamak plasma heating have been achieved.

(Photo Berkeley)

FERMILAB
More on quark structure of hadrons

The additive quark model has once again shown itself capable of explaining a complex phenomena in an intuitively elegant manner. A Fermilab/Yale group engaged in an extensive programme of hadron (pion, kaon and proton particles and

Elastic scattering cross-sections from a set of high statistics (about 10^6 events in the proton curve) for 200 GeV pions and protons at Fermilab, with the fitted curves for the quark model parameterization. Also shown is the single quark scattering diagram that is assumed to dominate.



antiparticles) on proton elastic scattering at the Meson Laboratory at Fermilab has reported a substantially steeper and more complex momentum transfer dependence of differential cross-sections than expected.

The parameter t represents the squared four-momentum transfer between the incident and forward scattered particle and the angle of scattering is proportional to the square root of t. In the small angle region (when t is less than about 0.5 GeV) the distribution of scattered particles at high energies is roughly exponential in t.

Deviations from this simple behaviour have been known for some time, but not their exact form and underlying nature. The Fermilab/Yale group measured the deviations from an exponential behaviour in a series of very precise experiments and find that a natural explanation follows from the additive quark model. In the context of this model they are able to extract the radius of the 'clothed quark' in the proton and pion and find it is between 0.35 and 0.45 fm.

The primary goal of the experiment has been to measure the interference of the nuclear and Coulomb forces by looking at elastic scattering of the long-lived hadrons in the very small t region (about 0.002 GeV) where they are comparable.

The size of the interference is predicted by dispersion relations and its measurement tests many of the underlying assumptions of strong interaction theory as well as the high energy behaviour of total cross-sections. Having a larger acceptance than previous similar experiments allowed the group to determine the nuclear part with high precision over a much larger t range.

The conventional parameterization of the nuclear part proved inadequate; the data showed the t distribution becoming very steep at smal t. This presented a serious problem for the extraction of the magnitude of the Coloumb-nuclear interference effect since it depended on the knowledge of the form of the nuclear part. It also raised the fundamental question 'What determines the small t behaviour of nuclear scattering?'.

As early as 1965, theorists conjectured that hadron scattering from a proton can be thought of as scattering from the individual quarks much as we view scattering from a nucleus as the sum of scattering from the individual nucleons. The particular form of this model, as developed by A. Bialas and his collaborators in Krakow, sees the gluon cloud as clothing the point-like quark and giving it a size. The gluon cloud is transparent to the electromagnetic and weak interactions of lepton probes but not to hadrons.

Small angle elastic hadron scattering is then seen as mainly arising from the scattering of single 'clothed quarks'. In the Bialas model, the expression for the t dependence of elastic scattering contains just the products of projectile and target particle form factors times a simple expression containing only one parameter — the size of the 'clothed' quark. The form factors should correspond to the electromagnetic form factors since the electromagnetic charge distribution is based on the distribution of the point-like quarks.

The Fermilab / Yale experiment is exceedingly simple in concept. The hadron trajectory before and after a hydrogen target is measured very accurately. Wire chambers of high resolution (65 μm) were used so that angles could be determined to 30 μrad.

Data were collected at momenta from 70 to 200 GeV emphasizing he small t region. The Coulomb nuclear interference term was extracted for all six of the long-lived hadrons using the quark model parameterization of the nuclear part.

Excellent agreement was found with the predictions of dispersion relations for all the particles (and with the results of an experiment at CERN by a Clermont-Ferrand / Leningrad / Lyon / Uppsala group studying negative pion-proton interactions) except for an anomaly in proton-proton scattering. For the proton-proton case the Fermilab / Yale result for the Coulomb-nuclear interference is substantially larger than predicted. It is also substantially larger than similar measurements done at the Fermilab internal target area a number of years ago. However if the internal target group's data is reanalysed with the quark model parameterization, then the two results are in good agreement but both are somewhat higher than the dispersion relations would like. A more careful recalculation of the proton-proton dispersion relations is now in order.

CERN
Steering particles by bent crystal

A few months ago, we reported some developments at Dubna in which high energy proton beams were successfully steered by passing them through bent crystals (see November 1979 issue, page 356). These experiments exploited so-called 'planar channelling'.

In general, channelling can be axial as well as planar. It occurs when a beam of particles is shone onto a crystalline target at an angle to a crystal plane (planar channelling) or crystal axis (axial channelling) which is less than a certain critical value. For energies around 10 GeV and germanium targets, this angle is about 0.25 mrad.

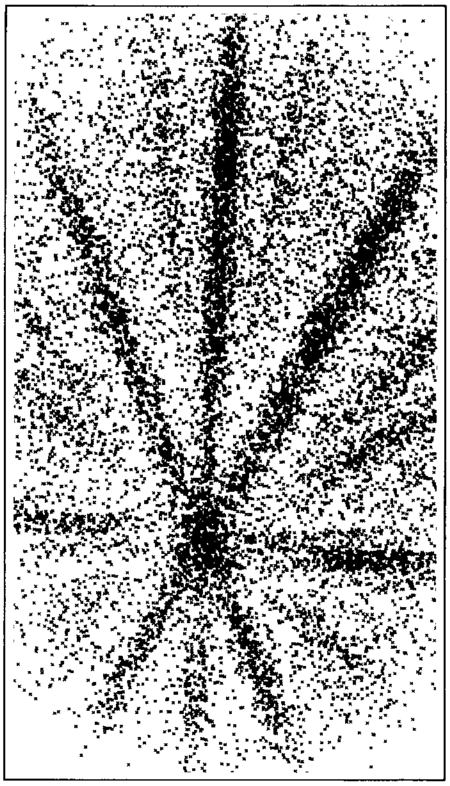
Under these conditions, collisions with target atoms become correlated so that a positively-charged particle is gently steered away from the atomic axis or plane, while a negatively-charged particle is attracted towards the positive nuclei.

In this way the nuclear interactions of positive particles are substantially reduced, resulting in a very high level of transmission along crystal axes and planes.

In addition, the correlated scattering from atoms in crystal axes also gently steers particles, so that they emerge at an essentially unaltered angle to the axis, but undergo azimuthal rotation.

The net result is that an initially parallel beam transmitted through a crystal comes out with a ring-shaped distribution centred around the direction of the axis — the 'doughnut effect'.

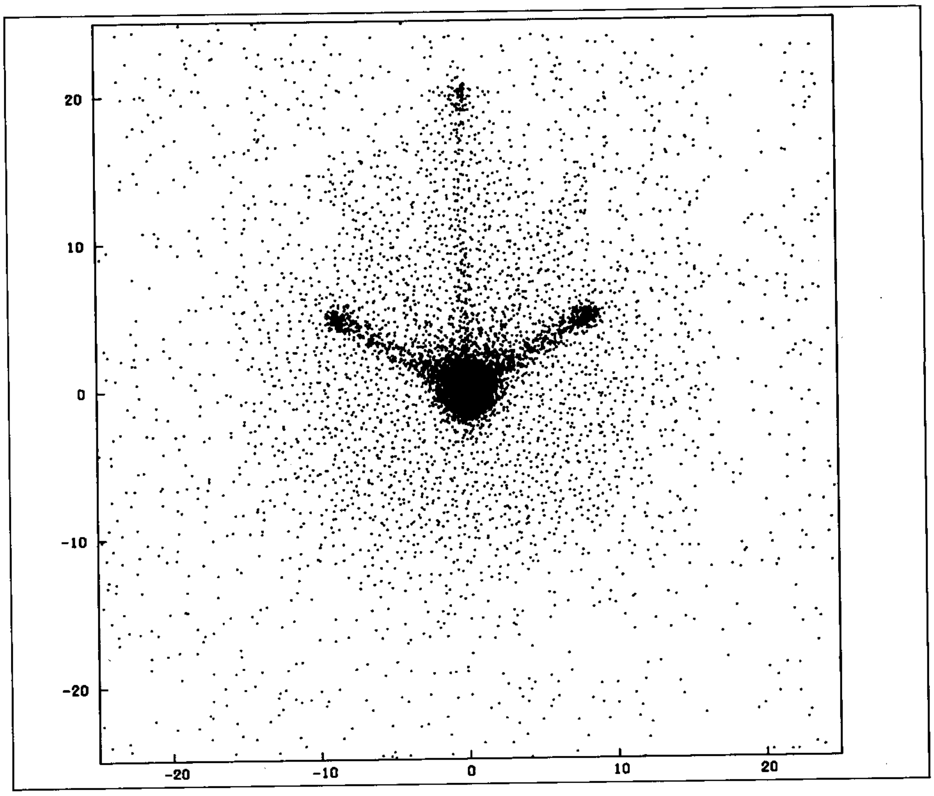
Intensity distribution of a small-angle scattered proton beam emerging from a germanium crystal 0.8 mm thick. The high intensity lines (dark areas) show the steering effect (channelling) produced by the atomic axes and planes in the crystal.



One of the objectives of a series of channelling experiments by an Aarhus / CERN / Strasbourg collaboration was to see if axial channelling also could bend particle beams.

In these studies, a 12 GeV unseparated beam of protons and positive and negative pions is used with a silicon crystal target bent mechanically by a simple thumbscrew. At appropriate orientations of the crystal, dramatic bending effects are seen for the positively-charged particles due to a combination of axial followed by planar channelling. The proportion of the beam bent is quite high — around 10 per cent — while the maximum bending angle attained so far is 54 mrad. This bending is equivalent to a magnetic field

Scattering of 12 GeV protons and positive pions transmitted through a 20 mm silicon crystal, bent through 20 mrad. The (111) crystal axis is lined up with the middle of the incident beam, and one (110) plane is initially horizontal. The lower spot corresponds to unbent beam, while the upper spot comes from particles bent through 20 mrad by the (110) plane, initially horizontal. The strongly bent beams seen at 60° to the vertical come from the other two (110) planes.



of 120 T or an electric field of 4×10^{10} V/m. A small bending effect is also seen for the negative particles in the beam.

While it is too early to say whether practical applications will follow, these latest results show that the bending of beams by crystals is more complicated than was first thought. This opens up new areas in the study of the interaction of charged particles with crystalline structures, especially at higher beam energies, such as those available at the SPS, where the loss of channelled particles in the crystal should be considerably reduced.

Tasting CAVIAR

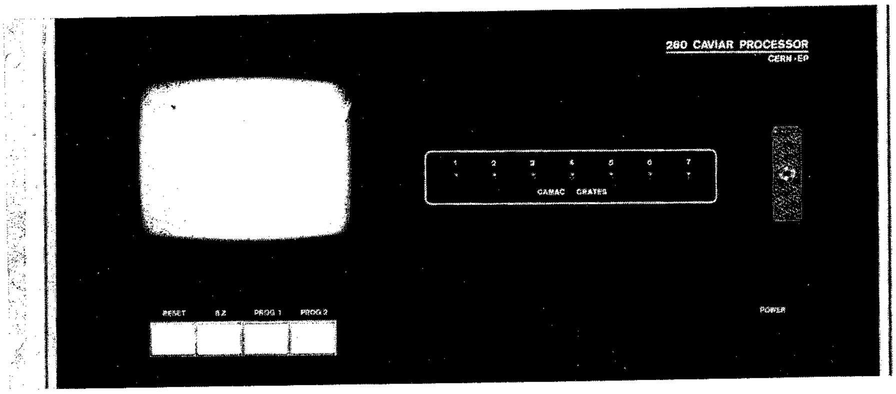
A recent addition to the range of off-the-shelf electronics equipment available for physics experiments is CAVIAR (CAMAC Video Autonomous Read-out) — a microcomputer for the interactive development, control and monitoring of experiments.

The apparatus which must be developed for large physics experiments consists of many different subsystems, ranging from intricate detector read-out to large-scale magnet control. The co-ordinated integration of these different systems into a single experiment has been greatly assisted by the availability of electronics standards such as CAMAC and the GPIB.

CAVIAR has been developed at CERN to help engineers and physicists developing or testing experimental subsystems based on CAMAC (or GPIB) equipment. It is a complete stand-alone microcomputer, incorporating a microprocessor with floating-point arithmetic and function processor, a video display with graphics capability, a CAMAC branch driver, a GPIB controller, and cassette and data communications interfaces. The standard unit incorporates 32 Kbytes of random-access memory and 29 Kbytes of system firmware in read-only memory.

CAVIAR firmware includes the minicomputer-compatible interpreter BAMBI, which decodes a conversational language similar to BASIC. Through pre-run compilation, BAMBI achieves execution speeds substantially faster than BASIC interpreters.

The system incorporates a comprehensive range of CAMAC and graphics calls, as well as GPIB and cassette operations, data communications facilities, array-handling routines and a full histogram library.

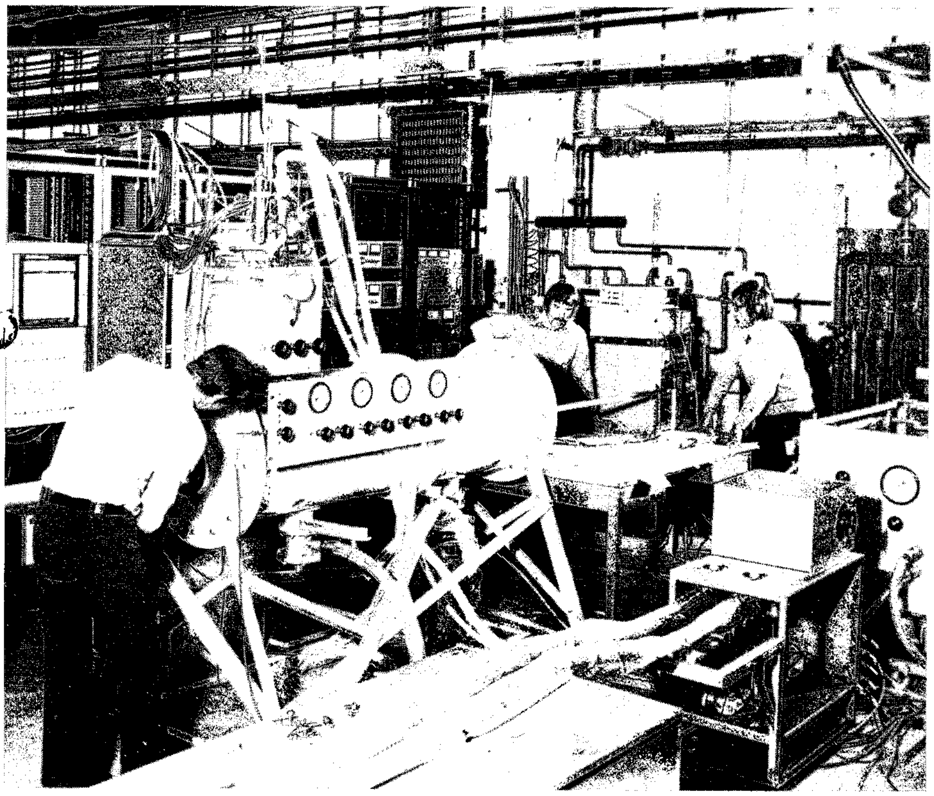


The CAVIAR microcomputer, developed at CERN as a general-purpose tool for the interactive development of experimental systems using CAMAC and GPIB electronics.

(Photo CERN 128.3.78)

The high accuracy superconducting magnet built at Rutherford for the European Muon Collaboration at CERN, seen here undergoing field measurement.

(Photo Rutherford)



CAVIAR was originally designed by Sergio Cittolin and Bruce Taylor for the Initial Cooling Experiment CE). Over 40 CAVIARs are now in use, and there is a growing demand for this versatile and powerful development tool for experiment preparation.

RUTHERFORD High accuracy superconducting magnet for CERN

As part of the physics programme of the European Muon Collaboration at CERN, a large polarized target is to be installed in the 280 GeV muon beam in the North Area at the SPS. The target will be used to measure the dependence of the muon interaction on the direction of alignment of the 'free' polarized protons in the target. In order to polarize the target, which is 1 m long and 50 mm diameter, a magnetic field of 2.5 T accurate to one part in 10^4 over the target volume is required. Technology Division at Rutherford, in collaboration with the University of Liverpool, have built and tested a superconducting solenoid system which meets these requirements.

The magnet system now delivered to CERN comprises a main solenoid winding and twelve independently powered trimming solenoids concentric with and spaced equally along the main winding. The main solenoid is 1.6 m long, and has internal and external diameters of 200 and 225 mm respectively. Made of 1 mm diameter Niomax wire, it has a stored energy of 140 kJ and uses a current of 180 A with a current density of 16 000 A/cm^2.

The magnet system has at least two innovations incorporated into its design. It employs a copper bore tube not only as a winding mandrel, but also to make the windings inherently safe from damage when the superconductor goes normal. The tube acts as a shorted turn and causes the normal region on quenching to spread rapidly through the windings so that the magnet's stored energy is dissipated uniformly throughout the winding matrix.

New winding techniques were developed to give a significant improvement in the geometric tolerances of the solenoids. This improvement is required if the accurate field specified was to be achieved. The technique involves winding a layer and filling the spiral valley formed by the round wire with a resin containing finely divided aluminium oxide. The excess resin is wiped off, and curing gives a dimensionally accurate cylinder on which the next layer of the solenoid is wound.

The magnet system is assembled in a cold horizontal bore cryostat capable of holding 75 l of liquid helium at a boil-off rate of some 4 l/hr. The vapour boiled off from the cryostat is used primarily to cool the current leads but is also used to cool the radiation shield.

The magnet system has been supplied to CERN complete with all the required instrumentation, including power supplies, quench detection systems, temperature and liquid level monitoring, current leads and shield flow control, forced warm-up and vacuum pumping.

Before delivery to CERN the system underwent full magnetic and cryogenic tests and was found to be substantially within the requirements of its specification. The field was found to be accurate to one part in 10^4 over a volume some 40 per cent larger than that required. Further tests carried out at CERN have confirmed the results.

Physics monitor

Physics goes underground

To test the new unification theories of physics, many new projects are being prepared. To hunt the long-awaited intermediate bosons of weak interactions, experiments are being prepared for the proton-antiproton collider at CERN. To put the new electroweak theory really to the test, the LEP project is being proposed to open up a new energy range with ideal experimental conditions.

Although the electroweak theory is not yet textbook material, its recent successes have made theorists confident enough to tackle 'grand unifications' to merge strong interactions with the electroweak force. One of the predictions of this newest theory is that the proton can decay (see May 1979 issue, page 116).

According to these theories, the proton has a lifetime of some 10^{31} years, which means that a man would have to live for more than a century before he could say that there was a good chance that just one of the protons in his body had disintegrated.

Such rare decays cannot be detected using traditional scattering experiments. To try to detect them, some physicists are turning away from accelerator Laboratories and looking towards specially-equipped 'passive' experiments installed deep below ground to minimize the effects of cosmic rays.

Underground experiments are not new, and some installations have been looking for a long time for signs of proton decay and other unusual phenomena, with no success (see December 1979 issue, page 415). However with the theory now giving an indication of the expected proton decay rate, experimenters can scale their apparatus to optimize their chances.

One detector is being built by an Irvine / Michigan / Brookhaven collaboration for an experimental site 600 metres underground in a salt mine on the shores of Lake Erie. It will contain a Cherenkov-type detector consisting of 10 000 tons of pure water monitored by 2400 photomultipliers.

Another detector is under construction by a Harvard / Pennsylvania/Wisconsin group for use in a Utah silver mine. In this experiment, photomultipliers will be immersed in a smaller volume of water.

Despite being 600 metres underground, cosmic ray products could still pose problems, and the experiments plan to use additional means to filter out the background due to hadrons produced near the detectors by cosmic rays. This can be done either by interposing shielding (Harvard / Pennsylvania / Wisconsin) or by using the outer region of the detector itself as a hadron shield (Irvine / Michigan / Brookhaven). The proton decays would give back-to-back cones of Cherenkov light in the inner detectors.

In Europe, a nucleon stability experiment is being prepared by a CERN / Frascati / Milan / Torino collaboration and an initial version of a detector, weighing 150 tons, will be installed some 3000 metres below ground in a shaft off the Mont Blanc road tunnel which links France and Italy. Instead of using a large homogeneous detector, this experiment plans a finely-grained apparatus. Another experiment is being planned by a French collaboration using the Frejus tunnel. In addition, it is hoped that soon a European experiment will be started using apparatus weighing several thousand tons.

Giant magnetic monopoles

The apparent absence of magnetic monopoles in a world where the equations of electromagnetism are symmetric with respect to electric and magnetic charge has long intrigued physicists, and from time to time new theories have given fresh impetus to the experimental search for free magnetic charge.

One major industry among present-day particle theoreticians is the search for the 'grand unification' of the strong interactions with the electroweak force (see May 1979 issue, page 116).

As well as simplifying the picture of the forces at work in Nature, these ambitious theories also account for the quantization of electric charge and fix the otherwise free parameter in the electroweak theory which relates the electrically neutral carrier particles — the photon of electromagnetism and the Z^0 of the weak neutral current.

Another spin-off prediction o grand unification is the unstable proton, and experiments are now being prepared to search for signs of proton decay (see previous article). In addition, in these theories the existence of magnetic monopoles can also be argued from quite general grounds.

However these monopoles are expected to be extremely heavy, heavier even than the bosons that are held to be responsible for proton decay, which are usually attributed with a mass of 10^{15} GeV, or 10^{-9} grams, much heavier even than a bacterium!

While such superheavy monopoles do not have much implication for experiments at accelerators, present or planned, they should have been produced in the extreme tem-

People and things

peratures of an initial 'Big Bang' during the formation of the Universe. If they were indeed formed, such primordial monopoles should still be around, and the continual non-observation of free magnetic charge in experiments provides additional constraints on the theory.

Volodya Gribov

On people

Both CERN Directors General were honoured in March. John Adams was awarded a Doctorate Honoris Causa by the University of Milan as 'originator and devoted constructor of powerful accelerators which have made fundamental discoveries in elementary particle physics possible, in the framework of collaborations of which he has always been a strong advocate'. Leon Van Hove received one of Belgium's highest honours — the Commandeur de l'ordre de Léopold — 'in recognition of many distinguished services in diverse fields and contributions to science and international collaboration'.

David A. Shirley has been appointed Director of the Lawrence Berkeley Laboratory with effect from 1 April, succeeding Andy Sessler, who announced last September his intention to return to physics research. Shirley, 45, has been from 1975 associate director at Berkeley and Head of the Laboratory's Materials and Molecular Research Division.

The Max Born Prize, awarded in alternate years to British and German physicists, goes this year to Helmut Faissner of Aachen for his work in elementary particle physics.

The 50th birthday of Volodya Gribov was celebrated on 25 March. He has had an important influence on particle physics theory leading the Leningrad school at Gatchina. His name is associated with many theoretical developments — the Froissart / Gribov transformation and Gribov / Pomeranchuk singularity in Regge theory, Gribov reggeon field theory, Abramovich / Gribov / Kancheli cutting rules, Gribov / Lipatov approach to deep inelastic processes, Gribov ambiguity in gauge theory, etc.

SLAC Summer Institute

The eighth annual SLAC Summer Institute on Particle Physics is being held this year from 28 July to 8 August. The topic is the weak interaction, covered first in a seven-day school with formal lectures and discussion sessions on Gauge Theories of Weak Interactions (M. Veltman), Quarks and Leptons (H. Harari), Neutrino Reactions (F. Sciulli), Strange and Heavy Quark Decays (D. Hitlin) and Lectures on Detectors (D. Ritson). From 6–8 August, a topical conference will cover experiments on heavy hadron decays, limits on decays of leptons and strange particles, technicolour and grand unification, neutrino scattering, and composite quark and lepton theories. Further information from

The Vacuum Ultraviolet Section of the building at Brookhaven to house the National Synchrotron Light Source is now occupied. The first magnets of the VUV storage ring can be seen being moved into the building during a snowfall, under the supervision of Hank Hsieh — engineer responsible for their design and fabrication. The vacuum beam pipe has been installed together with the focusing magnets and much of the electrical equipment required to power them. A vacuum of the order of 10^{-8} torr was achieved in the completed chamber in tests prior to bakeout.

(Photo Brookhaven)

the co-ordinator of the institute, Ann Mosher, SLAC, P.O. Box 4349, Bin 62, Stanford, California 94305, USA.

Meetings

From 23-27 June, an Intermediate Energy Nuclear Chemistry Workshop will be held at the Los Alamos Scientific Laboratory. Further information can be obtained from B.J. Dropesky, Mail Stop 824, LASL, Los Alamos, New Mexico 87545, USA.

From 9–12 September, a Europhysics Conference on Computing in High Energy and Nuclear Physics wil be held at Bologna. Further information is available from F. James, CERN Division DD, 1211 Geneva 23, Switzerland.

Cold for ISABELLE

The contract for the refrigeration system for the ISABELLE 400 GeV proton-proton storage rings at Brookhaven was awarded in March to Helix Technology Corp. for a sum of 6.5 million dollars. The helium refrigerator, to hold the 1100 ISABELLE magnets at superconducting temperature, will be the biggest in the world. It must supply 55 kW at

Beneath a canopy of European flags, an inauguration ceremony was held at CERN on 6 March for the STELLA project. STELLA will test high speed, large volume data transmission between high energy physics Laboratories using the OTS satellite of the European Space Agency (ESA). The project is supported by the European Economic Communities (EEC) and European PTTs. Speakers at the ceremony were, left to right: J.B. Adams (CERN Executive Director General), R. Gibson (ESA Director General), F. Braun (Director General, Internal Market and Industrial Affairs, EEC) and L. Van Hove (CERN Research Director General). Participants later saw a demonstration of the satellite link to the Rutherford Laboratory.

(Photo CERN 105.3.80)

55 K for the magnet heat shields, 13.5 kW at about 3 K for the supercritical helium to cool the magnets (a flow rate of 4 kg/s) and liquid helium to cool the power leads (a flow rate of 0.1 kg/s). Delivery is scheduled for mid-1982.

Aesthetics and Science

A limited edition of 'Aesthetics and Science', a burgundy leather-bound volume containing the proceedings of the International Symposium in honour of Robert R. Wilson, held at Fermilab on 27 April 1979, has recently been published. Leonardo Da Vinci's inspired knot design is embossed in gold on the front and back covers of this small keepsake. The 120 page volume contains the complete texts of the Symposium speakers: L.M. Lederman on 'Wilson and Fermilab'; W. Paul on 'Early Days in the Development of Accelerators'; S. Chandrasekhar on 'Beauty and the Quest for Beauty in Science'; H. Bethe on 'Los Alamos and Cornell' and V.F. Weisskopf on 'Art and Science.' The subject matter should appeal to a variety of interests and intellectual pursuits. The text is printed on heavy paper stock that displays the full page, black and white photographs to their best advantage. The price of this volume to honour Wilson on the occasion of his retirement from Fermilab is $20, and prepaid orders can be placed with Ms. Judy Ward, Fermilab, P.O. Box 500, Batavia, IL 60510 USA.

Damping for stability

Another step in the progress towards higher intensity, better quality beams from the CERN SPS has been taken with the recent introduction of a 'Landau damping cavity' in the ring. The cavity is powered by two 225 kW amplifiers operating at 800 MHz, supplied by Valvo. The system worked so well in stabilizing the beam that, for some purposes, instabilities will have to be fed back in artificially!

A second cavity is scheduled to be installed later this year.

The technique of Landau damping is a general attack on a category of beam instabilities which removes the instabilities before they grow sufficiently large to harm the beam. It acts by introducing a slight spread in the number of oscillations individual particles make on each turn around the machine.

Octupoles (for the transverse direction) and cavities (for the longitudinal direction) are powered so as to give refined control, introducing just enough Q-spread to kill instabilities due to too small a Q-spread.

The CERN cavity system has been tested and the instabilities under attack were cured. However the 'brighter' beam now makes extraction more sensitive. A technique of introducing noise into the beam at extraction to give a smoother spill of particles to the experiments is now being considered.

GMELIN — **Handbook of Inorganic Chemistry**
Uranium Supplement Volume A 1

Uranium Deposits

An important prerequisite for the long-term use of nuclear energy is information on uranium ore deposits from which uranium can be economically produced. In contrast to petroleum and other fossil fuels, uranium has wide geographic distribution.

This Uranium Supplementary Volume A 1 of the Gmelin Handbook describes commercially significant uranium deposits. Unfortunately, the information currently available on deposits in the COMECON countries is relatively sparse and imprecise, and they have not been included. The geology and mineralization of the individual deposits are described in detail. Special attention is paid to the concentration and quantity of the deposits and to the economic aspects of working them.

Since there has been no previous really comprehensive description of the metallogeny and tectonic occurrence of uranium, or of the regions where uranium deposits occur, these particular aspects are covered in greater detail than is otherwise customary in the Gmelin Handbook. Literature Closing Date: 1979.

Survey of Contents

Target and Scope. Types of Deposits. World Reserves. Uranium Production. Geographic Distribution of Deposits. Classification of Uranium Deposits and Ore-Forming Processes. Geologic Characteristics of the Types of Economic Deposits. Grades and Reserves. Potential Types of Deposits for Future Resources. Geochronologic-Stratigraphic Positions of Uranium. Influence of Paleoclimate and Paleoweathering on the Formation of Uranium Deposits. Position and Succession of the Various Generations of Deposits. Synopsis on the Formation of Uranium Deposits. Description of Individual Deposits.

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At present the description of uranium and its compounds is covered by **8** volumes of the Gmelin Handbook, and further volumes are in preparation.

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Department of Physics

Applications are invited for the post of Research Assistant/Senior Research Assistant in the Department of Physics. Applicants should be experimental physicists with research interests in the field of high energy physics. Experience in electronics systems would be advantageous. Candidates must be prepared to spend a substantial part of their time at CERN Geneva.

The appointment is for a maximum period of two years and the initial salary will be at a point on scale 1A, or 1B of the salary scales for research and analogous staff according to age, qualifications and experience of the successful candidate.

Applications, together with the names of three referees, should be received not later than 15th May, 1980, by The Registrar, The University, P.O. Box 147, Liverpool, L69 3BX, England, from whom further particulars may be obtained. Quote Ref: RV/965/CC.

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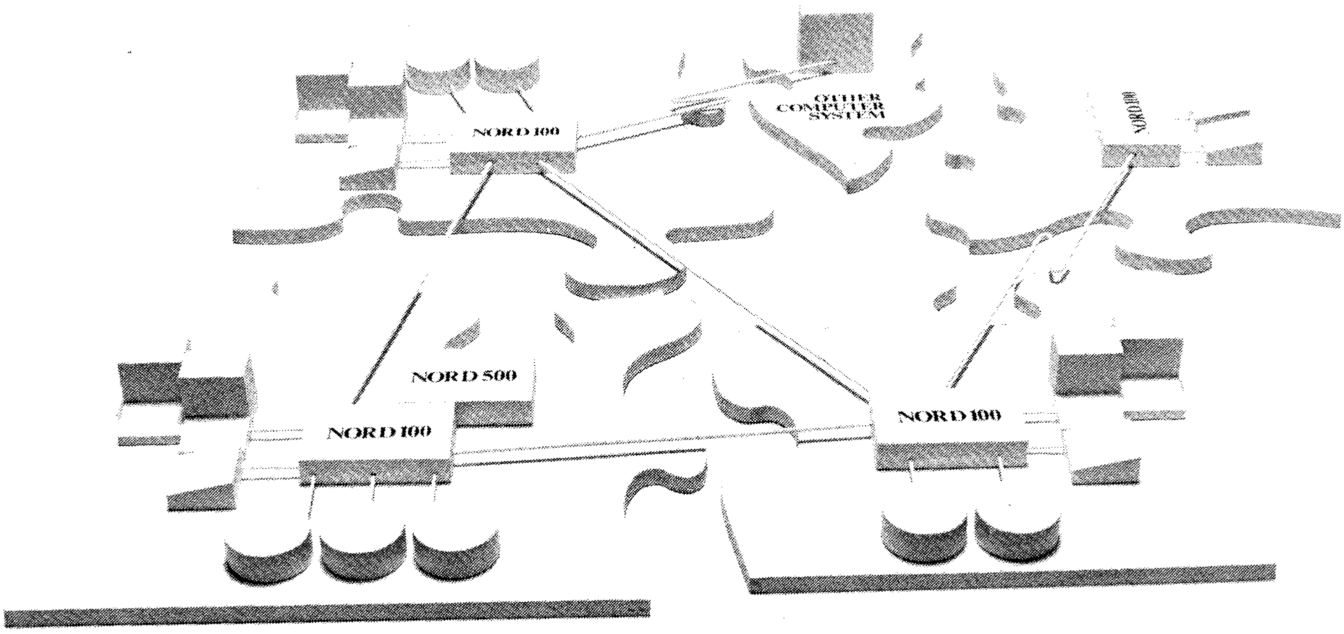

renforce le système d'ordinateurs décentralisé

Un système informatique décentralisé pour Norsk Data est fondé sur une relation homme-machine, dont l'axiome de base est que tout besoin de capacité de calcul est local. Nos systèmes d'ordinateurs sont ainsi adaptés aux besoins locaux comme support et outil dans la production, la recherche et l'administration.

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  have built-in battery back-up
- **PROM stores up to 128k-bytes**
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- **Direct Memory Increment or Modify features**
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- **Multi-user access**
  via front-panel and dataway
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  keep pace with Camac
- **Data compression**
  saves memory volume
- **Parity checks and handshake**
  ensure safe data handling
- **Mailbox memory with unlimited depth**
  for multiple-access multi-user organisation, non-volatile RAM

Module type	1624	1625	1626	1627	1631	1632	1633	1634	1635/8	1635/16	1641	1642	1643/8	1643/16
Type of memory	RAM	RAM	RAM	RAM	RAM	RAM	RAM	RAM	RAM	RAM	PROM	PROM	PROM	PROM
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						
Module width	1	1	2	2	1/2/3	1/2/3	2/3	2/3	1	1	1	1	1	1

* either/or

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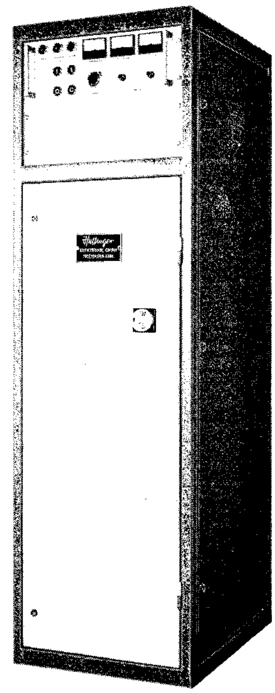

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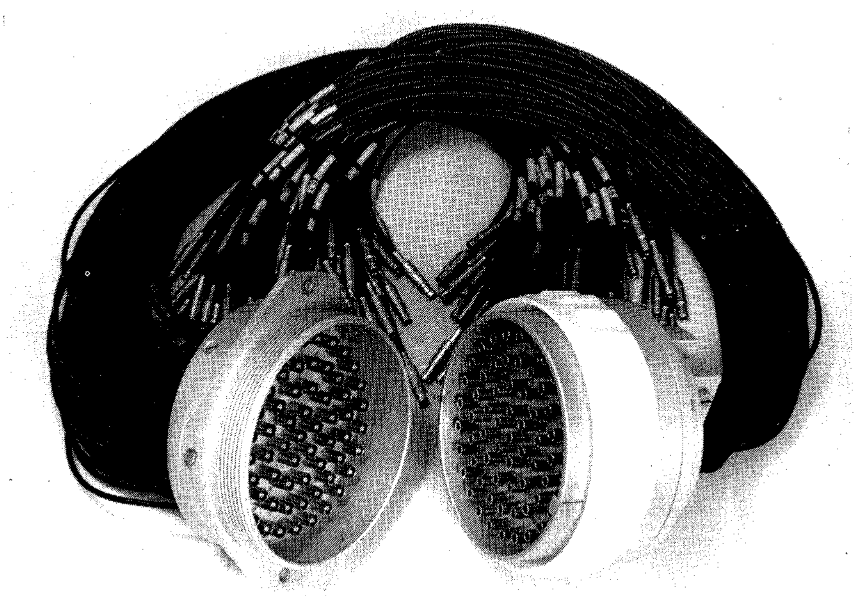

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FISCHER electric connectors with self-locking satisfy the most exacting requirements of modern technologies, such as nuclear research, atomic energy, space research, etc. Their main characteristics are:

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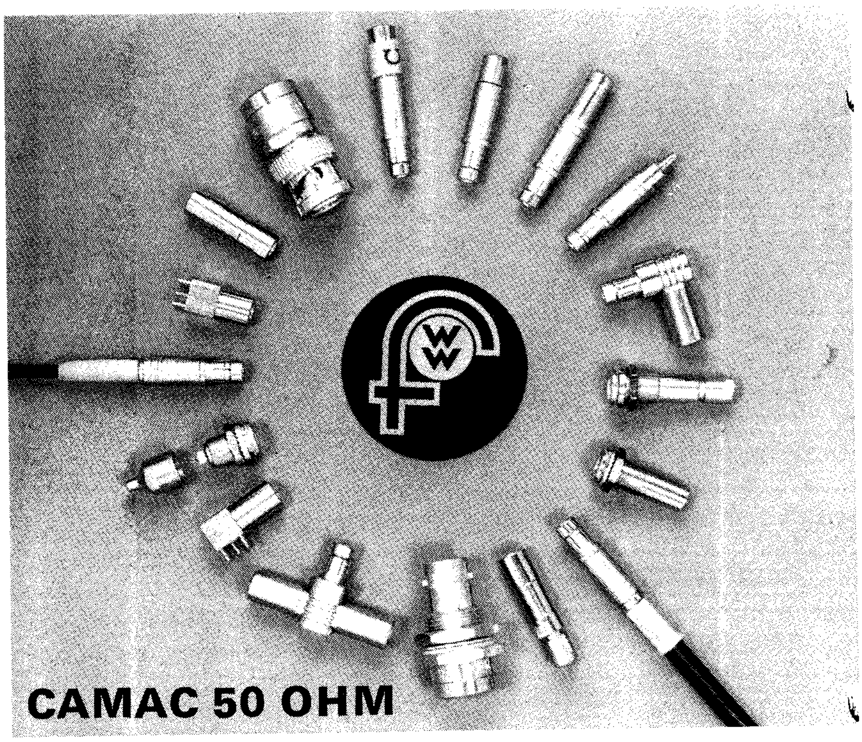
- simple keying
- simple and trouble-free mounting
- reliable positioning on different elements guaranteed by two half-shell shaped metallic guides
- high quality insulation, normally of P.T.F.E.
- pressure tight and high vacuum sealed designs
- sealed models resistant to radiation up to 10^8 Rad. and temperatures from -60 to $+150\,°C$
- construction with ceramic insulating material resistant to radiation and to high temperatures
- special connectors for thermocouples



FISCHER connectors with self-locking can now be supplied in 8 different sizes and come in a very wide range:

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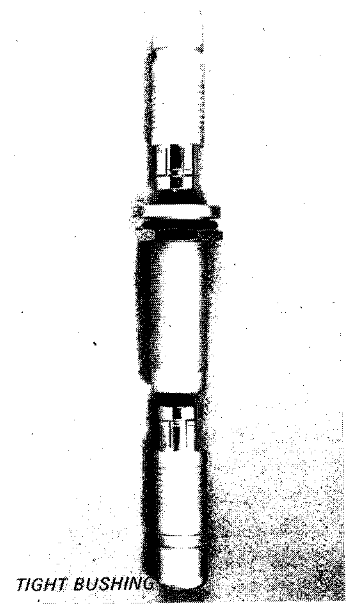
- multiple connectors for high voltages
- compound connectors: high frequency and low voltage
- connectors for thermocouples
- connectors for Camac-Modules



Residual leakage:
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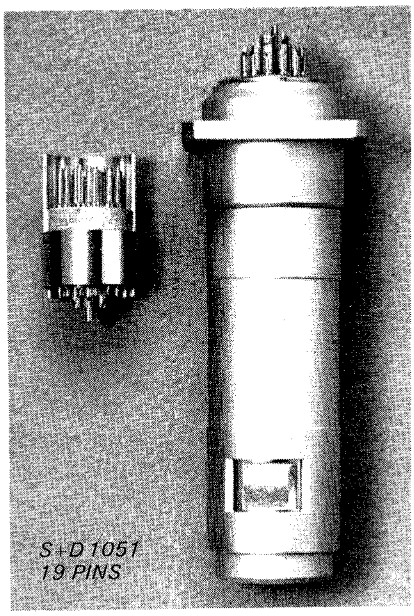
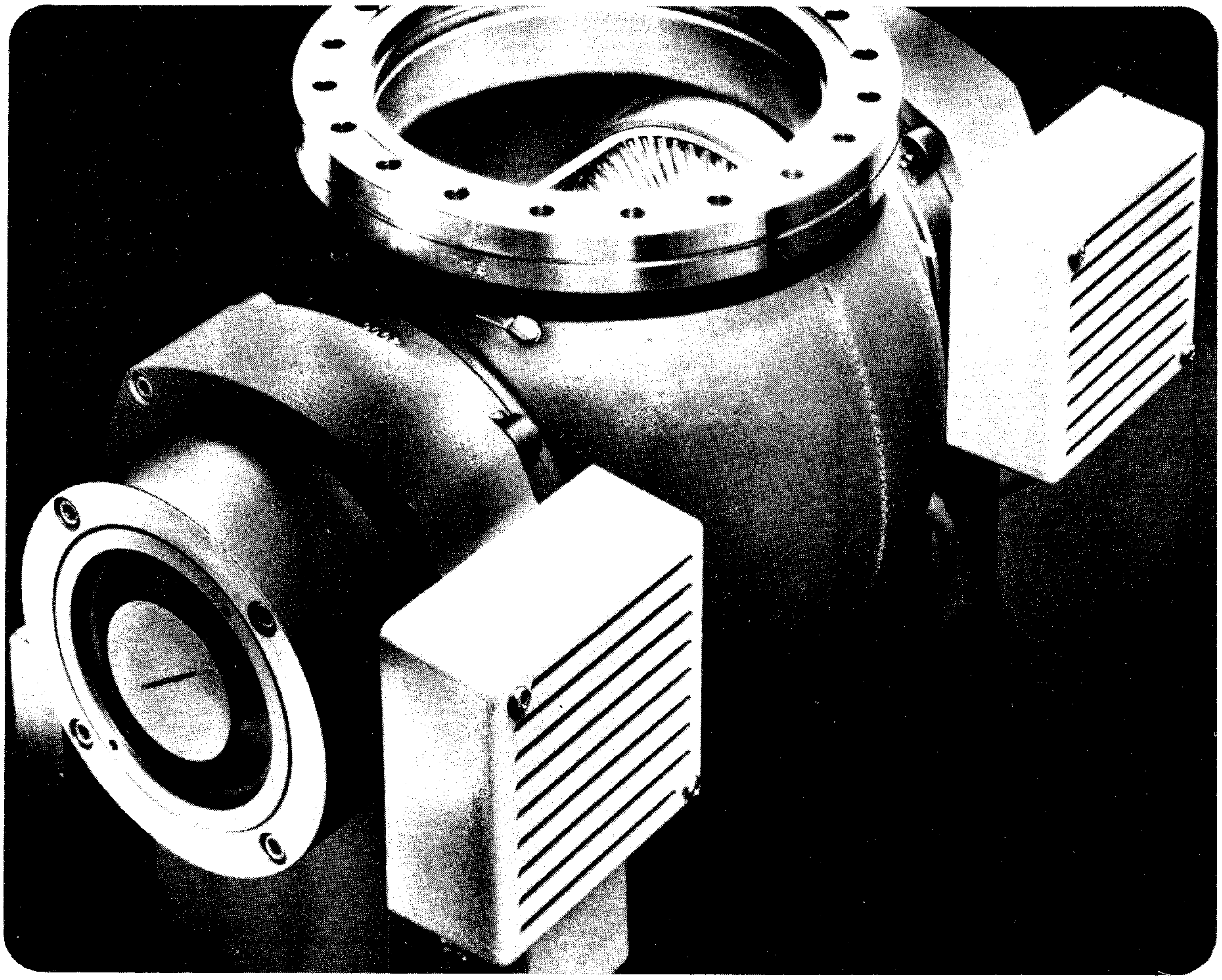
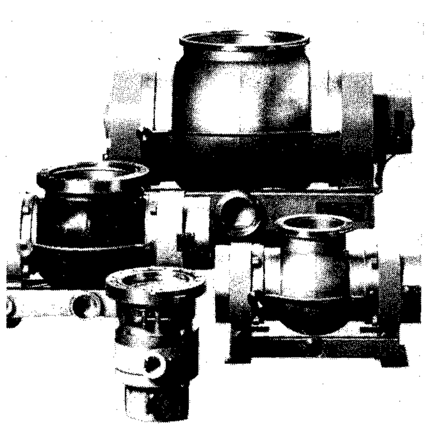


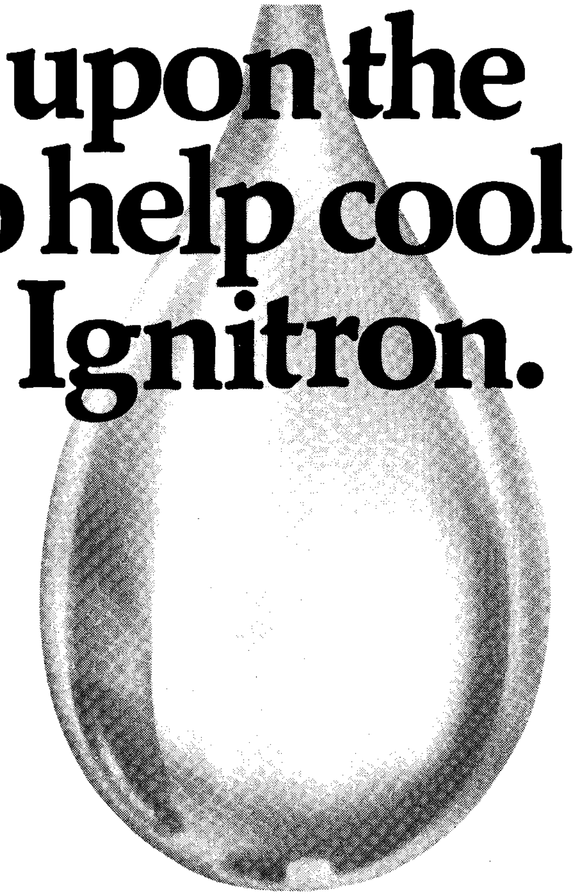
Connectors with CERAMIC insulatin[g] material resistant to radiation and t[o] high temperatures

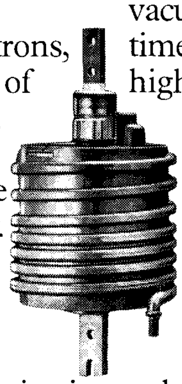
Certain connectors for thermocouples can be supplied with contacts of special materials, e.g. chromel, alumel, iron, constantan, copper, etc.

Rapid and reliable construction of special connectors.









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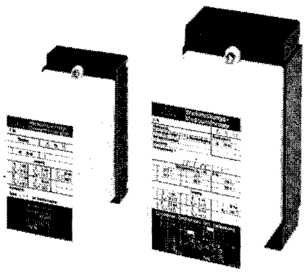

Pour des données électriques et non électriques telles que courant, tension, puissance, cos. φ, fréquence, température, nombre de révolutions

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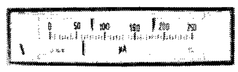

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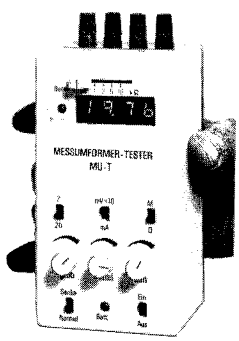

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Combinaison d'instrument de lecture et de source pour mA = et mV = avec lecture digitale

Autres appareils:

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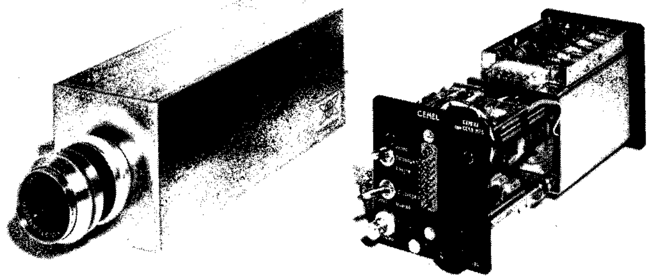

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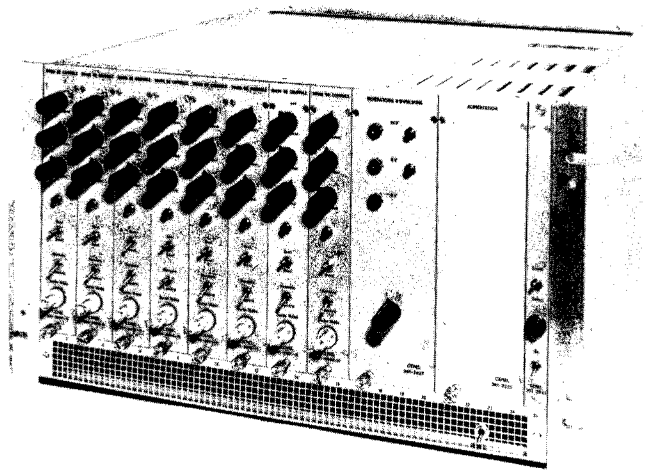

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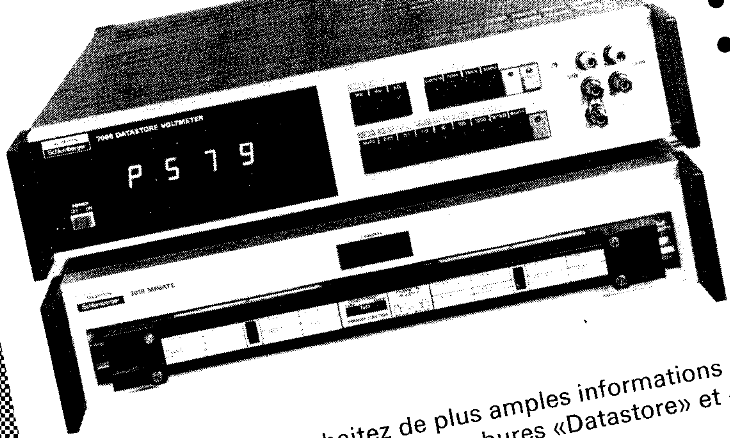

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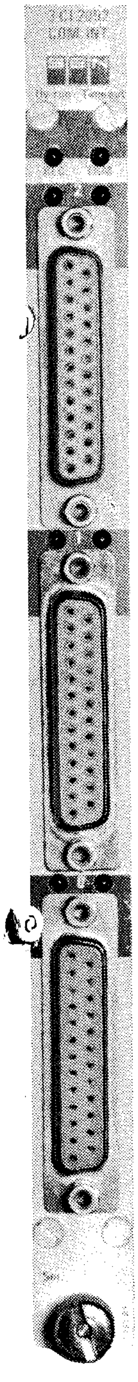
from SEN ELECTRONIQUE



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- ★ **high speed data links (50 to 19200 bauds)**
- ★ **buffered operation (1 K byte)**
- ★ **no jumpers, but a powerful microprocessor for speed and data-format control through CAMAC**

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This single-width CAMAC module contains 3 independent channels with high speed UARTS and buffered inputs/outputs.

It has been specifically designed as the universal interface for microprocessor controlled CAMAC systems where at least one high speed data link with the host computer and one medium speed data link with local interfaces are essential.

The use of an internal microprocessor provides significant flexibility and speed of operation: its role is to pass information from the CAMAC buffers to the input/ouput memory working with the UARTS, and to control the data flow.

Speeds and data-format are CAMAC programmable to allow best utilisation of the unit. Transmission standards are 20mA current loop or EIA RS 232 C, jumper selectable. Outputs are standard 25 pin CANNON connectors.

Front panel Leds indicate the status of the module (Transmit/Receive) on each channel plus Overrun and Time-out are common to all channels. A rear panel trigger signal is available for DMA transfer synchronisation.

applications

— Crate to crate communications

— CAMAC/external devices interfacing

— Front-end I/O processor for Intelligent Crate Controllers
This unit is specifically useful when connected with our ACC 2099/ACC 2103 Auxilliary Crate Controllers to speed-up the I/O transfers when processing time is critical.

— main computer/Intelligent Crate Controller link, etc, etc.

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High-performance digital interface—rock-solid operation with 16 in a daisy chain, even in a noisy environment.

Versatile I/O—the CAMAC and TTY of the HV4032 and more—improved TTY shorthand, complete interlock reporting, software notchdown, etc.

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Built-in ADC—reads the actual voltage, NOT the demand setting.

Human-engineered—easy to use, easy to understand.

Continuous Memory eliminates loss of voltage settings upon power failure or temporary shutoff.

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3.3 kV positive or negative—any combination of 4-channel supplies.

Remarkable stability, typically 50 ppm/°C with low ripple even at the rated **2.5 mA** output per channel.*

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*Up to 6.5 watts/channel, 200 watts/chassis.

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Model 2132

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