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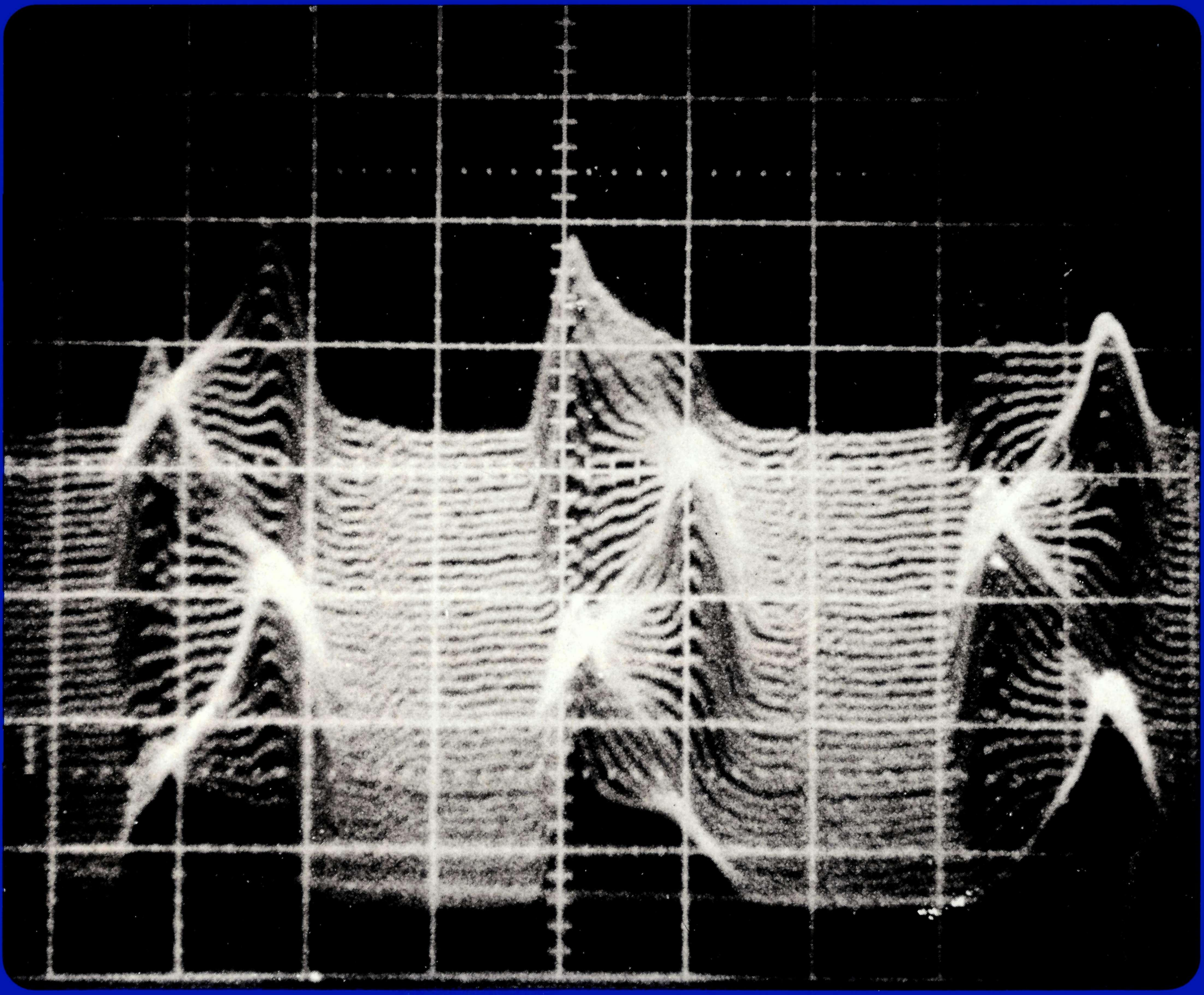

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Around the Laboratories

Physics monitor

Cover photograph: signals from a beam monitor at the Saturne synchrotron at Saclay. The coupled bunch dipolar oscillations of 1 GeV particles are being observed over several turns. When projecting this picture at the recent Washington Accelerator Conference (reviewed in the May issue) Maury Tigner of Cornell referred to it as 'illustrating the elegant dance of the beam'.

Laboratory correspondents:
Argonne National Laboratory, USA
W. R. Ditzler
Brookhaven National Laboratory, USA
N.V. Baggett
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 National Laboratory, USA
O.B. van Dyck
Novosibirsk Institute, USSR
V. Balakin
Orsay Laboratory, France
C. Paulot
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, P.O. Box 500, Batavia
Illinois 60510
General distribution —
Monika Wilson
CERN 1211 Geneva 23, Switzerland

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European Organization for Nuclear Research
CERN, 1211 Geneva 23, Switzerland
Tel. (022) 83 61 11, Telex 23698
(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

Looking for proton decay

Preparing to look for signs of proton decay:
1. – a photograph taken just before installation of the waterproof lining in the five-storey excavation in an old salt mine near Cleveland, Ohio, for the experiment by an Irvine/Brookhaven/Michigan group. The bulldozer (bottom centre) gives an idea of the scale.
2. – Assembly of a module of the detector to be used by a CERN/Frascati/Milan/Torino collaboration in the Mont Blanc tunnel.

(Photo CERN 380.12.80)

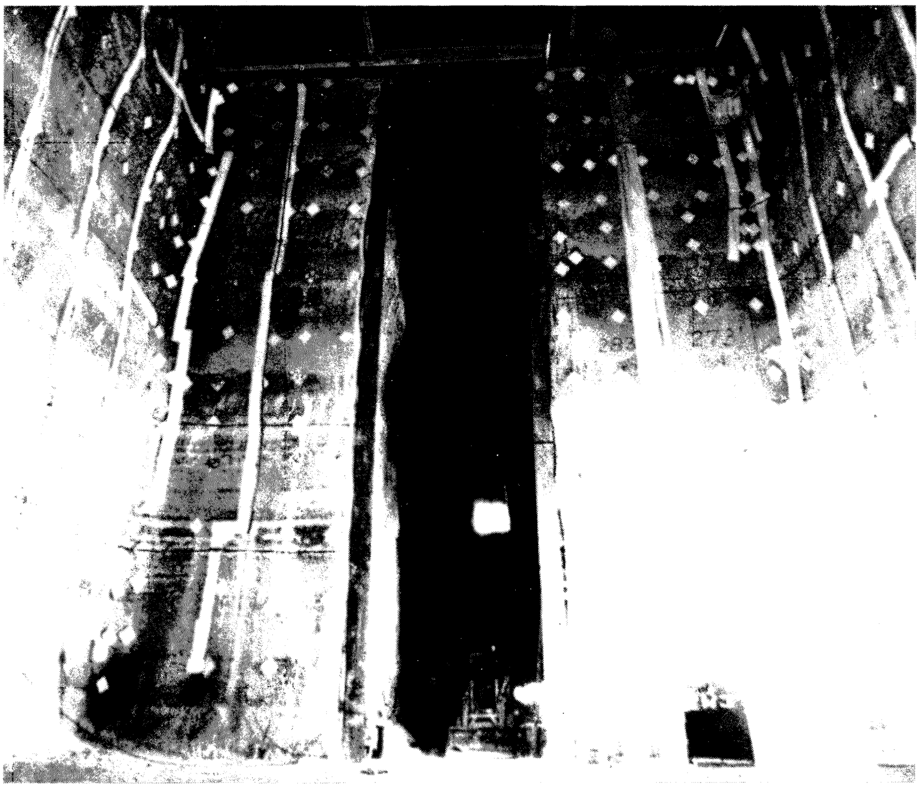
The new unification theories of physics are being put to the test. Very soon, the experiments being readied at the CERN SPS could record their first proton-antiproton collisions in a new, and possibly final, phase of the search for the long awaited intermediate bosons of weak interactions. The LEP project is being prepared to provide the new unification of weak and electromagnetic forces with ideal experimental conditions.

Meanwhile the theorists have gone a step further and, drawing on the successes of the electroweak theory, have proposed a unification of the electroweak and strong forces. One of the results of this ambitious venture is the prediction of the unstable proton. Current thinking gives the proton a lifetime of something like 10^{31} years (see May 1979 issue, page 116).

Such rare decays (about one per hundred kilograms of matter per century) cannot be detecting using conventional scattering experiments with particle beams. Instead, new 'passive' detectors are required, situated deep underground to help screen off effects due to stray cosmic muons and neutrinos. The larger the detector, the greater the chances of catching rare events.

In the US, detectors to search for proton decay and other exotic effects are being assembled by Irvine/Michigan/Brookhaven and Harvard / Purdue / Wisconsin groups, while in Europe an experiment is being prepared by a CERN/Frascati/Milan/Torino collaboration for installation in the Mont Blanc tunnel.

Meanwhile a new project, intended as a Laboratory open to an international physics community, has been officially approved by the Italian Government. To be built under the Gran Sasso mountain some 150 km from Rome, the new



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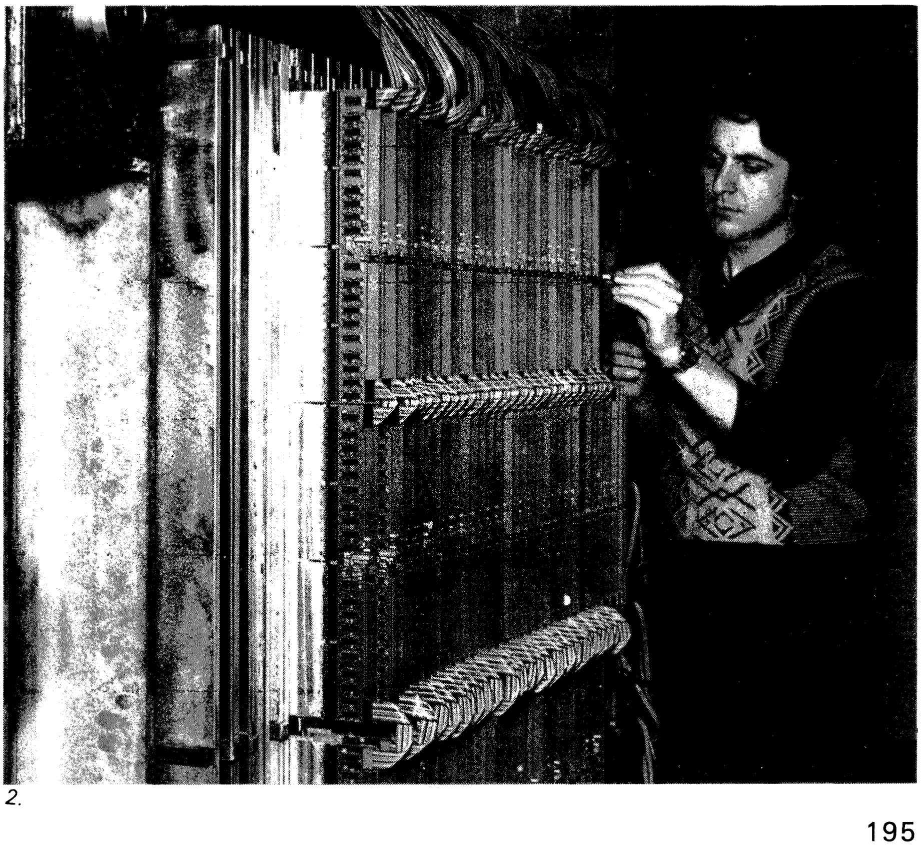


2.

facility will provide an underground experimental area measuring 50 x 50 x 20 metres, permitting detectors containing 10 000 tons of material to be assembled.

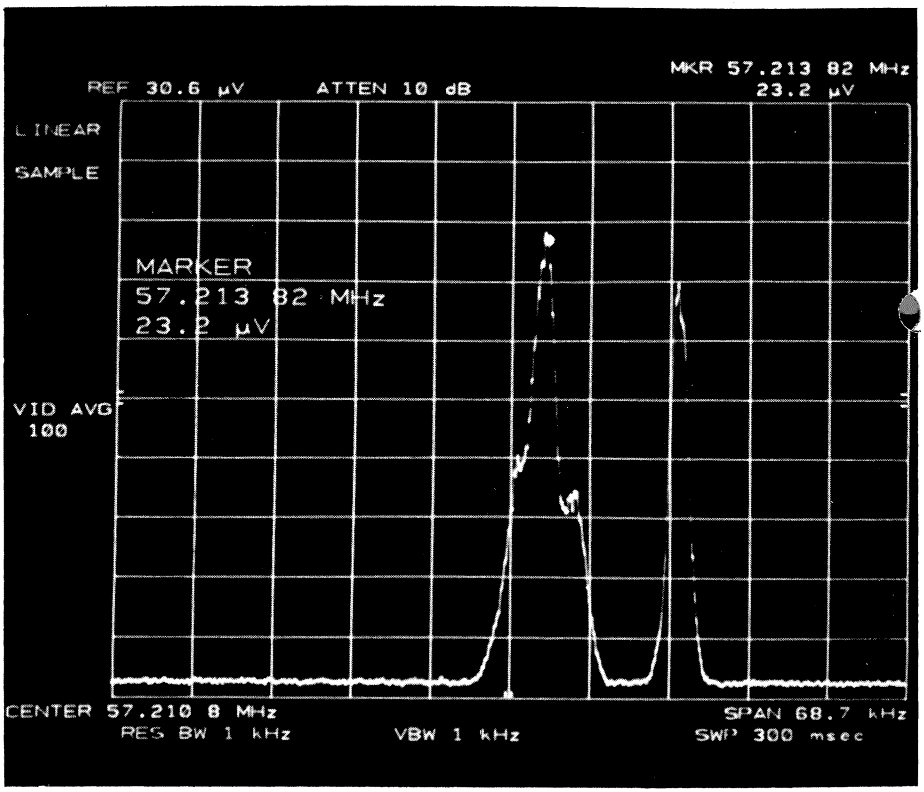
Another large new underground project is being developed in Japan by a Tokio/KEK/Tsukuba group. Containing 1000 tons of detector surrounded by specially-developed phototubes, it is expected to be operational 1000 m below ground next April.

First proton decay candidates

An announcement that proton decay events could have been found was made at the Workshop on Grand Unification held at Ann Arbor, Michigan, at the end of April. It came from the Japan/India collaboration (Tata Institute/Osaka) working at the Kolar Gold Fields. The detector contains 34 layers of detectors embedded in 140 tons of iron at a depth of 2300 m below ground. Triggering on coincidences seen in any four layers of the detector during 131 days of running gives three events which cannot be explained in conventional physics terms and are considered candidates for proton decay. Two events show two outgoing tracks, while the third has three tracks associated with it. If interpreted as proton decay, the lifetime comes out to be of the order of 10^{30} *years, which is not in disagreement with the current theoretical prediction.*

Colliding protons with antiprotons

On 4 April, an 0.61 mA antiproton beam was stacked in the CERN Intersecting Storage Rings. This picture shows the central main stack together with the latest antiproton pulse (right) still on its injection orbit several centimetres away.



As reported briefly in our previous edition, the world's first collisions between stored beams of protons and antiprotons were recorded at the CERN Intersecting Storage Rings early in April. As well as heralding a new era of physics, this achievement shows that the CERN antiproton project is progressing confidently towards its ultimate objective of high energy proton-antiproton collisions in the Super Proton Synchrotron.

After a minimum of machine development work with the precious antiprotons for the ISR team to acquaint themselves with a new kind of particle beam, the first dedicated antiproton physics run began. On 3 April, four pulses of particles from the Antiproton Accumulator (AA) were accelerated to 26 GeV in the Proton Synchrotron and provided the ISR with a modest current of 0.15 mA in one ring. A proton beam of 830 mA was quickly stacked in the other ring and the eager experimenters began to lo their first collision data.

The following day, three more AA pulses boosted the stored antiproton current to 0.61 mA, providing a luminosity of just over 10^{25} per cm^2 per s. Only minor antiproton beam losses were recorded and the experiments continued to take data for several more days, during which time the Terwilliger scheme was applied to improve the definition of the beam intersection 'diamonds' in the even-numbered intersection regions. The run terminated on 8 April.

Although low, this initial luminosity should nevertheless allow experiments to look at the general features of proton-antiproton interactions such as total cross-sections and the multiplicities and angular distributions of the produced particles.

In the initial run, the proton current

was limited because the vacuum pipe in one of the intersection regions (the Split Field Magnet) had not yet been moved into the antiproton running position. Once this has been done, the next ISR antiproton run can have a proton beam of 12 A, and with only modest increases in the antiproton supply, a luminosity of well over 10^{26} is on the cards. This would be sufficient for experiments to begin their first searches for rarer events, such as those due to scattering of the quark/antiquark constituents within the colliding particles. Eventually it is hoped to obtain 100 mA antiproton beams and luminosities in excess of 10^{29}. It is planned to use all the normal rungs of the ISR energy ladder, with 11, 15, 22 and 26 GeV ejection from the PS and also subsequent acceleration to 31 GeV (per beam) in the ISR.

With the intermediate boson of weak interactions out of reach (according to all the predictions at least), ISR antiproton physics aims to compare the features of proton-proton and proton-antiproton interactions. In particular, the antiproton's antiquarks will provide a plentiful supply of hitherto rare interaction mechanisms stemming from quark-antiquark annihilation.

In the first antiproton run, six experiments were able to take data : R210, a CERN/MIT/Naples/Pisa/Stony Brook group looking to measure proton-antiproton total cross-sections through the total reaction rate ; R211 (Louvain/Northwestern) measuring the total cross-section using the 'Roman Pot' technique ; R510, an Annecy/CERN monopole search ; R608, a CERN/Clermont-Ferrand/Saclay/UCLA group using a forward spectrometer in one intersection arm ; R703T, better known as the UA5 Bonn/Brussels/Cambridge/Stockholm group using large streamer chambers to photo-

In the control room....

It is now customary at the CERN Intersecting Storage Rings to spend a minimum of time on machine development and to provide impatient physicists with new colliding beam conditions very quickly. Despite their scarcity, antiprotons proved to be no exception to this rule.

In a previous test in mid-March, an antiproton pulse narrowly missed circulating in the ISR due to a synchronization problem. This was quickly corrected and confidence was high that a steady antiproton current would soon be obtained. However a snag in the Antiproton Accumulator (AA) put a temporary end to these hopes.

Two weeks later, all was ready for the next series of tests. On 2 April, there was some initial doubt whether a small pulse of 7 x 10^8 antiprotons ejected from the PS at 26 GeV was circulating, but after 20 minutes a beam scraper revealed that the pulse was still there. More pulses were subsequently added, and everything went well, apart from the bunch length being somewhat longer than was hoped for. Combined with the low intensity, this prevented the usual r.f. trapping technique from working and the beam had to be shifted from its injection orbit by phase displacement acceleration. The stored antiproton beam reached 0.05 mA but was lost during preparations for the subsequent injection.

After three further attempts were made to use r.f. trapping, it was clear that no quick solution was available and on 3 April, during the first antiproton fill scheduled for physics, it was decided to abandon this technique temporarily in favour of phase displacement and rebunching. With a current of 0.15 mA safely circulating in one ring, protons were stacked in the other and in the early hours of 4 April, the first collisions were recorded.

Meanwhile the AA and PS teams had agreed to prepare for an additional fill of antiprotons. With injection well optimized and with the phase displacement/rebunching procedure being handled more confidently, three more antiproton pulses (2.3 x 10^9, 6.6 x 10^9 and 3.1 x 10^9) emptied the AA ring, giving a stored current of 0.61 mA. During this time, the overall transfer efficiency between the AA and the stored ISR stack reached 70 per cent.

Several days later, the beam was still circulating, having suffered minimal losses. After taking suitable precautions to protect thin-walled sections of the vacuum chamber, the ISR Terwilliger scheme was applied with no apparent losses to the antiproton beam.

For subsequent runs, a small hardware modification and higher beam intensities should ensure that the standard r.f. trapping and stacking techniques are effective.

Celebration at CERN of the tenth anniversary of first operation of the Intersecting Storage Rings. The cake cutters are the former leaders of ISR construction – Kjell Johnsen (now at Brookhaven) on the right, and Kees Zilverschoon. On Johnsen's right is Fritz Ferger, present leader of ISR Division. Just a few days after this photo was taken, the ISR had its first successes with antiprotons.

(Photo CERN 506.3.81)

graph interactions; and R807, the Axial Field Spectrometer of the Brookhaven/CERN/Copenhagen/Lund / Rutherford / Tel-Aviv collaboration.

For future antiproton runs, these will be joined by R110, a CERN/Oxford/Rockefeller group studying the production of electron-positron pairs and single photons, by R420, an Ames/Bologna/CERN/Heidelberg/Warsaw group, and by R421, a Bari / Bologna / CERN / Frascati / Rome collaboration, the latter two studies both using the Split Field Magnet. However R703T's work at the ISR is already done, and with the first visual records of proton-antiproton collisions in the bag, the experiment is being moved to the SPS ready for 540 GeV (total energy) proton-antiproton collisions.

The initial measurements on proton-antiproton interactions roughly parallel those made for the first time with high energy colliding proton beams when the ISR began operations ten years ago. However the other physics aims, and the sophisticated detectors used, reflect well the progress of the last decade.

Precision measurements of the proton-antiproton total cross-section across the energy range available with the ISR, together with proton-antiproton elastic scattering spectra, are high on the list of physics priorities. Differences between proton-proton and proton-antiproton behaviour are always interesting, and already other experiments using low energy antiprotons on fixed targets have shown that the dip seen in elastic scattering appears to set in much earlier with antiprotons than with protons.

While it is unlikely that the upsilon will be seen with antiprotons, comparison of proton-proton and proton-antiproton yields of J/psis should produce a better understanding of the production mechanism. Away from resonances, the quark-antiquark annihilations in proton-antiproton collisions will make an excellent laboratory for studying the electromagnetic production of lepton-antilepton pairs (Drell-Yan mechanism).

A relative newcomer to the physics scene is single photon production, which although difficult to isolate nevertheless provides relatively clean conditions for studying quark and gluon interactions. Proton-antiproton interactions should provide another single photon production mechanism, so enlarging our knowledge of quark and gluon behaviour. Another area ripe for investigation is the production of charmed particles.

The availability of antiproton beams should provide a rich harvest of physics results from the ISR to complement those coming from the SPS.

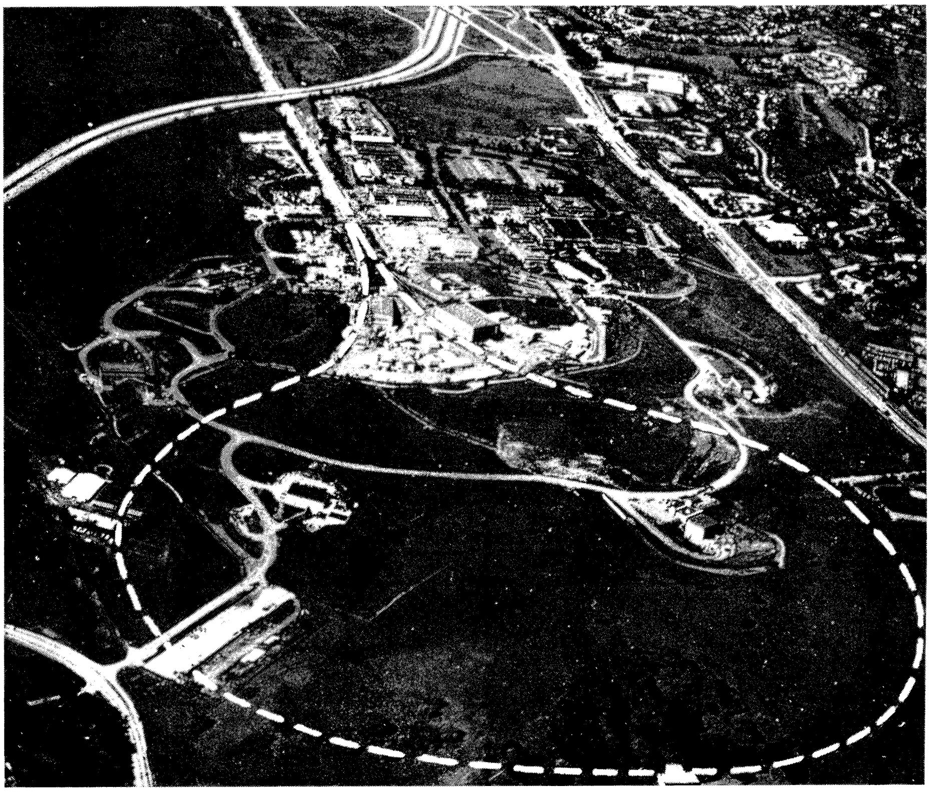
Around the Laboratories

STANFORD
Linear Collider Workshop

On 25-27 March, some 250 physicists gathered at Stanford for a Workshop on the SLAC Linear Collider (SLC), the new machine proposed for construction at Stanford. The community of particle physicists was broadly represented with about 80 SLAC participants, 150 from other US institutions, and 20 from other countries. David Leith organized the meeting, which was jointly sponsored by SLAC and the SLAC-Berkeley Users Organization.

The Workshop had several purposes. The first was to provide a detailed description of the present plans for the SLC, of the research and development programme SLAC has undertaken on the remaining issues in machine design, and of the experimental research opportunities. The second purpose was to form a number of working groups to study the challenges and opportunities of the Collider's physical environment and its prospective research programme.

Pief Panofsky discussed how the SLC is to be built and operated for research with a large number of potential users.The machine would be built by SLAC, given the relatively modest scope of the project, but individual physicists from elsewhere are encouraged to work on the many challenging problems of machine design and experimental use. It is expected that collaborations will evolve naturally as this work progresses, in a pattern similar to that followed in the CERN and Fermilab proton-antiproton projects. It was suggested that an 'anti-deadline' be set, before which no decisions on the experimental programme would be made (although proposals could of course be submitted at any time). If the SLC is authorized for construction beginning in Fiscal Year 1983, as presently requested, its three-year construction schedule would have it ready for first operation in late 1985.



Aerial view of SLAC with the linac (passing under the highway), together with the fixed target halls and the PEP ring (centre). The proposed path of the new collider is shown dashed.

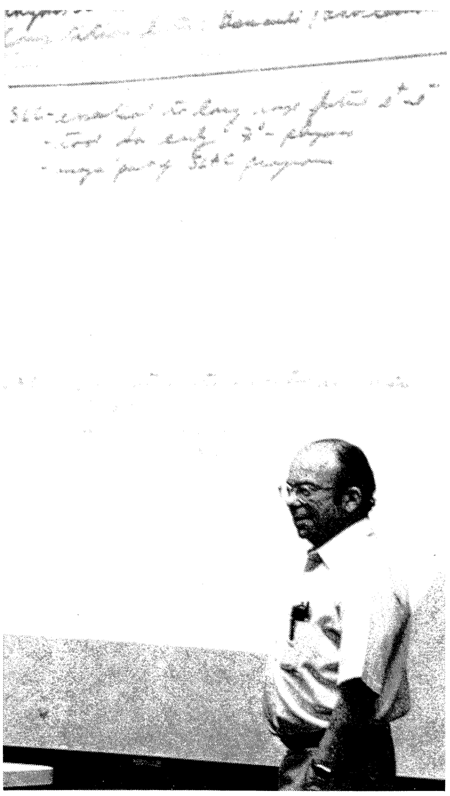
(Photo SLAC)

Rationale for the SLC

Burt Richter reviewed the development of electron-positron storage rings during the past two decades, and the remarkable physics discoveries that they have made possible. Such machines have grown from less than a metre to about 400 m in radius, and the storage rings now proposed at CERN (LEP) and Cornell would be much larger still. However it is likely that LEP would be the largest electron-positron storage ring ever built. This is because the cost scales approximately as the square of the maximum energy; thus a storage ring to collide electrons and positrons at 350 GeV, for example, would have a circumference of about 300 km and would cost about 7 billion dollars.

This is to be contrasted with 'linear colliders' (as proposed at Stanford and Novosibirsk, see December 1979 issue, page 403) in which intense bunches of electrons and positrons are made to collide with each other only once, and are then disposed of. Although this is an expensive way to produce colliding beams at low energies, the cost of such machines increases only linearly with the maximum energy. At some point, therefore, the cost curves for rings and linear colliders must cross, and linear colliders will become the preferred machines for producing the highest energy electron-positron collisions.

This crossover point is within sight, and the motivation for building



At the recent SLAC Linear Collider Conference : Pief Panofsky (left) and Burt Richter (right).

(Photos Joe Faust)

the SLAC Linear Collider is thus twofold. First, it will be a pioneer machine for developing the many new accelerator techniques that the era of linear colliders will require. Second, it will provide an early and relatively inexpensive look at collision energies of 100 GeV, where fundamentally new physics is expected to appear.

Technical challenges

Successful design and operation of the SLC presents many technical challenges, which were described by Rae Steining. An intense, polarized electron beam must be produced (for which a laser-pumped photoemission electron gun is being developed). The required positron beam will be produced from a special target, followed by a booster and transport system. Damping rings and compressors will be used part of the way down the linac to achieve the desired beam characteristics. The injected beams must be carefully centred on the linac axis (requiring new beam position monitoring and feedback devices). Acceleration to energies of 50 GeV or more requires the 'SLED II' mode of SLAC linac operation, which involves r.f. energy-storage cavities and modified operation of the klystrons. The accelerated beams must then be separated and guided around two gently curving arcs to final focusing sections where the beams are brought into collision with beam radius of only about 2 microns.

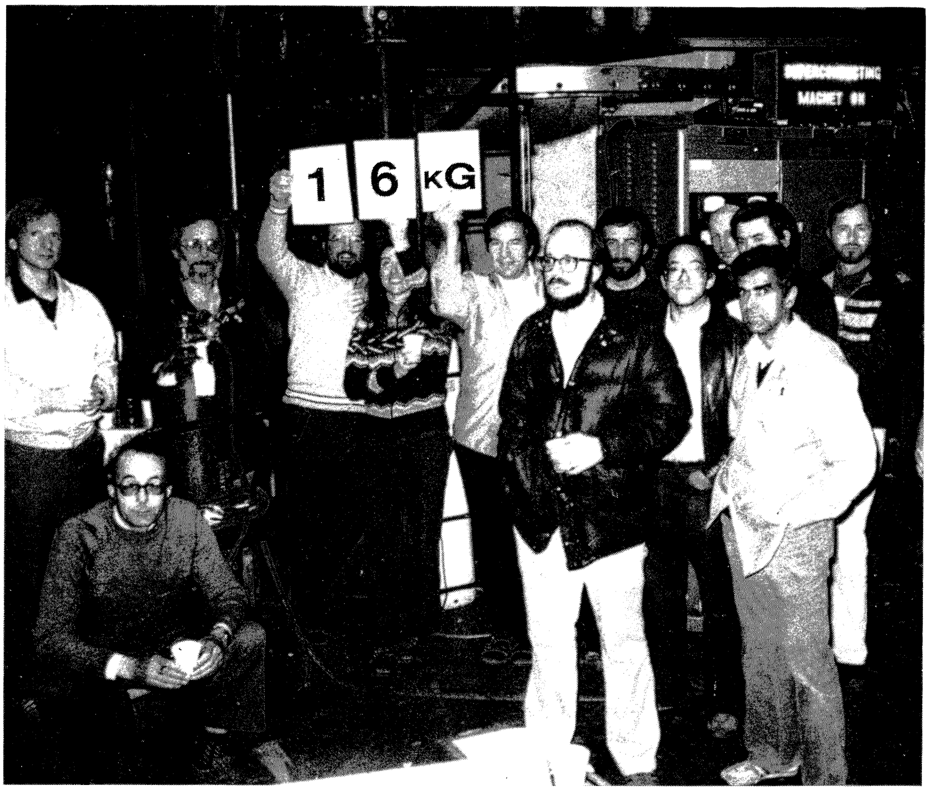
The size of the beams allows very small magnets to be used in the arcs and final focusing sections. A dipole magnet lamination was small enough to be placed directly on an overhead projector as an illustration during Steining's talk. These laminations will be placed on square aluminium conductors, like 'beads on a string' to form the dipole magnets.

Fred Gilman described the physics opportunities that will become available within the SLC energy range. If the presently accepted 'standard' model of the weak and electromagnetic interactions is correct, then there are several important kinds of new particles to be discovered – the top quark, the Higgs boson, and especially the neutral carrier of the weak force (the Z^0). If its design luminosity is achieved, the SLC will produce more than a million Z^0 events per year, thus enabling detailed studies to be made of the production and decay modes of this vital particle. This work will include accurate measurement of the one

Malcolm Derrick (left), Karl Strauch and Pief Panofsky (right) discuss plans for the proposed SLAC Linear Collider.

(Photo Joe Faust)

4 am 28 February – successful operation of the High Resolution Spectrometer solenoid at full field brings (almost) all of the collaborators to their feet in spite of the early hour! The superconducting magnet, for an experiment being built by a Midwest collaboration for experiments on the PEP electron-positron storage ring, reached 1.6 T (16 kG). The magnet had previously served in the 12 foot bubble chamber at Argonne.



free parameter (the 'Weinberg angle') in the present theory; determination of the number of neutrino types by measuring the width of the Z^0; searches for new heavy leptons and quarks; and tests of quantum chromodynamics, the present candidate theory of the strong interactions.

If the present standard model is not correct, the SLC will still have an important role to play in sorting out the alternatives. In one of these, several different kinds of Z^0 are predicted, at least one of which would be accessible at SLC energies. Other schemes which avoid the Higgs mechanism for mass generation might lead to a different class of bosons.

Polarized electrons

Since the SLC is a single-pass machine, the beams are not subject to the depolarizing resonances that occur in a storage ring. The SLAC linac can produce highly polarized electron beams and SLC will therefore have polarized beam experiments as a unique part of its programme. Charles Prescott described some of the special physics that can be done with such beams.

Because of the left-right asymmetry of the standard model, the electroweak interactions are expected to show significant spin-dependence at high energies, such as a charge asymmetry in the production of muon pairs. For comparable running times, a measurement made with a polarized beam will reduce the error on the Weinberg parameter by almost a factor of three. Several other kinds of polarized beam experiments will provide information on weak interaction couplings available by no other means.

One of the main purposes of the Workshop was to establish working groups to study specific technical areas of SLC experimental use during the coming months. Eight such groups were formed – Polarization, Parametric study of detectors, Tracking, Calorimetry, Particle identification, Fast electronics and computing, Support for two detector scenario, and Interaction region. The 'two' detector scenario is particularly interesting. It involves adding a bypass to the arcs so as to allow another interaction section in parallel with that initially proposed, and costs are under investigation.

Each of the groups will prepare a report for the next meeting of the Workshop, scheduled for October.

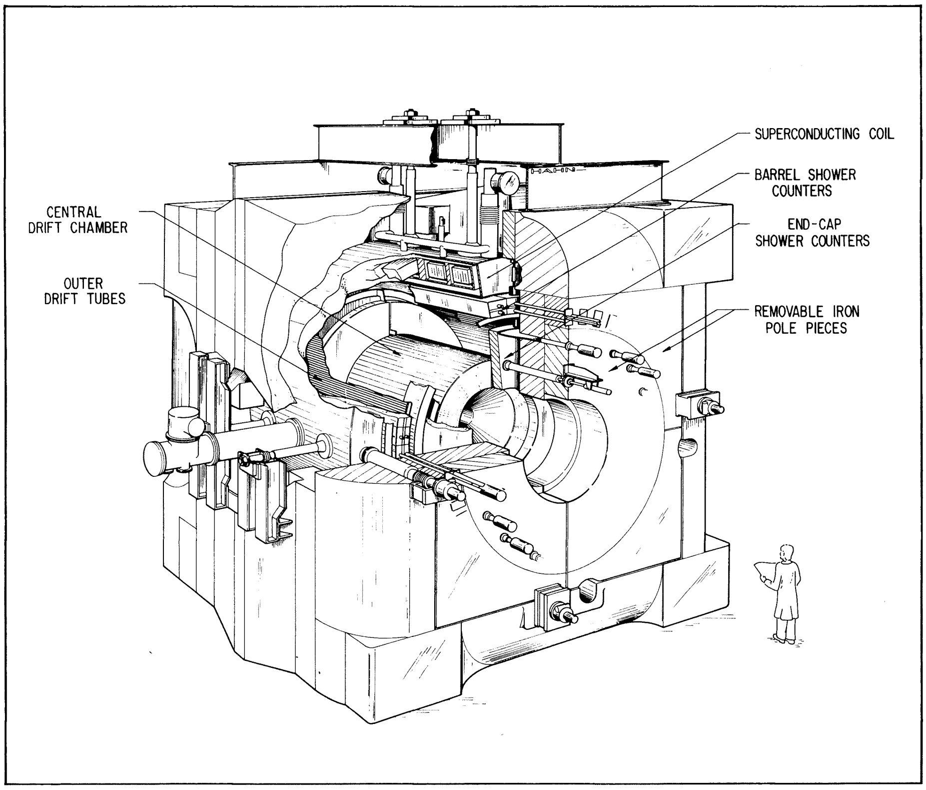
Progress with big PEP detectors

When the PEP electron-positron ring at SLAC came into operation last year, most of the beam intersections already had experiments ready to take data (see September 1980 issue, page 245). To complete the PEP arsenal, construction work for two big detectors – the High Resolution Spectrometer and the Time Projection Chamber – is well advanced.

An important milestone for the High Resolution Spectrometer was reached on 28 February when its superconducting magnet attained the operating field of 1.6 T. The HRS is being built by a Midwest consortium (Argonne/Indiana/Michigan/Purdue) with additional collaborators from Berkeley and SLAC.

The detector, based on the large superconducting magnet originally built for the Argonne 12 foot bubble chamber, is equipped with the usual array of drift chambers and shower counters. The magnet is 4.45 m in diameter and, with the addition of

Cut-away sketch of the High Resolution Spectrometer. Not shown are the Cherenkov counter system, which fits between the central drift chamber and the outer drift tubes, and the muon chambers that will cover all faces of the iron.



some iron to the return legs, the distance between the pole tips has been lengthened to 3.99 m. For its new role, the magnet has been rotated 90° from the original vertical field configuration, requiring substantial modifications to the coil support structure. The transport of the coil from Argonne to SLAC (see April 1980 issue, page 57) was the largest load ever carried by road over such a distance and caused quite a stir.

Charged particle tracking is provided by an inner drift chamber, built by the Michigan group, that has fifteen layers of alternating axial and stereo wires. The trajectories of the high momentum tracks are then measured again in an outer drift chamber system at a radius of 1.88 m. These chambers, designed and built by the Indiana group, consist of two concentric layers of thin-walled, stainless steel tubes. Momentum precision, with a 200 micron setting error on the drift chamber coordinates, will be better than 1 per cent at 15 GeV. This accuracy, which is more than five times better than any other detector for electron-positron physics, will allow excellent discrimination of narrow resonances against background.

Outside the outer drift chambers, but still inside the magnetic field volume, are the forty modules of a barrel shower counter, built by the Argonne and Purdue groups. These counters have eleven radiation lengths of a lead scintillator sandwich. Lucite guides channel the light through the end iron to 160 phototubes located in two concentric circles on each end. The three space coordinates of the showers are measured by a series of proportional chamber tubes, located three radiation lengths into the counter. The magnet pole tips are covered by endcap shower counters built by the Argonne and Indiana groups. These give good electron to pion rejection and, since both the PEP vacuum pipe through the detector and the inner cylinder of the drift chamber are made of beryllium, pair production backgrounds will be minimal.

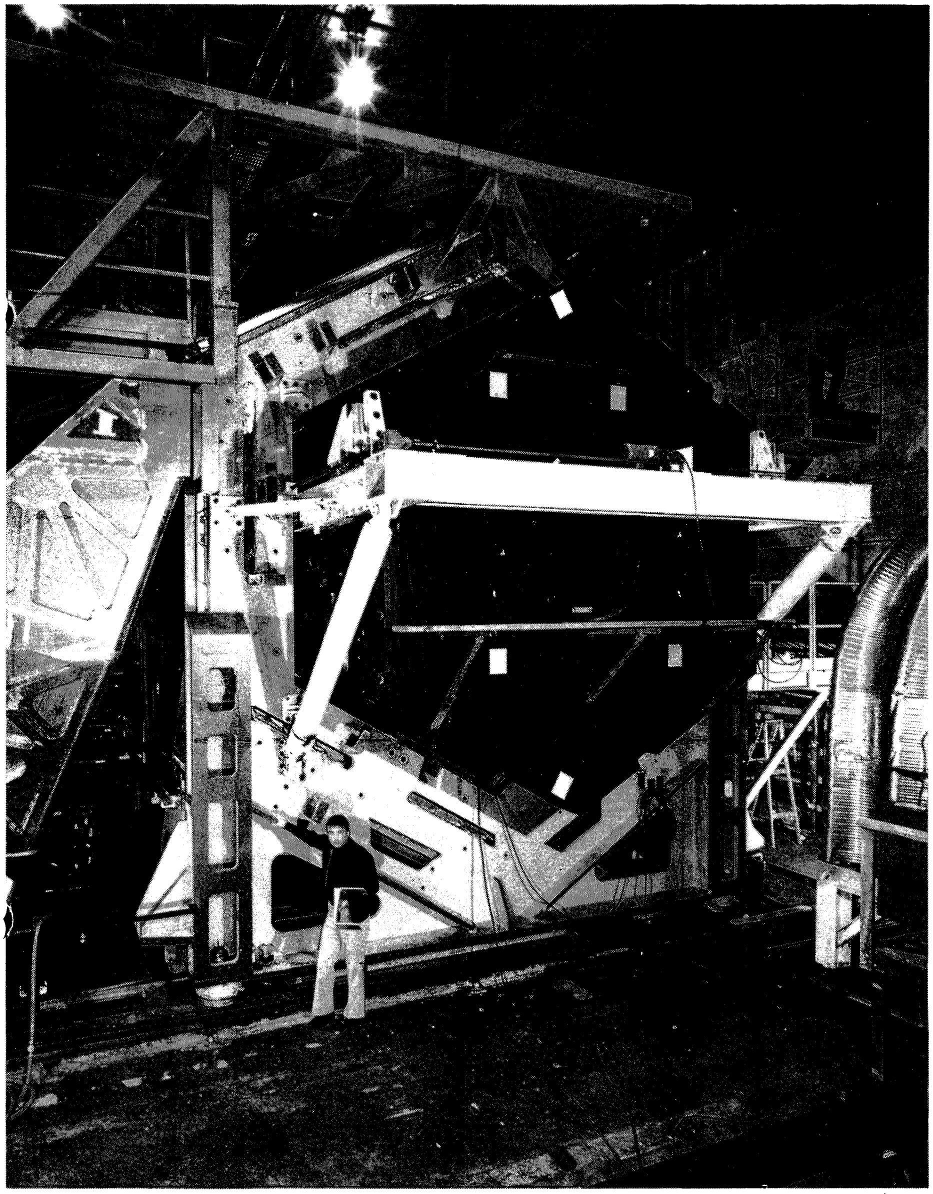
The 75 cm of radial space between the inner and outer drift chambers will be occupied by a set of aluminium toroids. The Cherenkov light, emitted by particles traversing the gas in these tubes, is detected by the photoionization of benzene in small proportional counters. The development of this technique by the Michigan group of Don Meyer and Neville Harnew gives the HRS good particle identification capability. The use of photoionization to detect the Cherenkov light means that the counters will operate in the magnetic field and no complicated light guides are needed. When pressurized to 16 atmospheres, pions will be separated from kaons and protons from 1.1 to 4 GeV. The system will have good segmentation thanks to 800 individual counters. Time-of-flight measurements made by the inner layer of the shower counter will ensure pion separation from heavy particles over the whole momentum range populated by hadrons coming from annihilation events at the highest PEP energy.

For initial operation, part of one face of the magnet iron will be covered by muon chambers, and the Purdue group has proposed construction of muon detectors to cover all the exterior iron. If approved, this will be added in 1982.

The drift chamber system has been under test, tracking cosmic rays, for several months and the reconstruction accuracy is good. The barrel shower counters were individually calibrated and installed in the magnet in December.

Assembly of the Time Projection Chamber detector of a Berkeley/Johns Hokpins/ Riverside/Tokyo/UCLA/Yale collaboration which will occupy the central area of intersection 2 at PEP.

(Photo Berkeley)



First cooldown of the magnet started late January and helium was introduced into the cryostat on 21 February. After minor tuning of the refrigeration system, 2 kA of current gave a field of 1.6 T on 28 February. The test went unusually smoothly, the heat load on the cryostat was as predicted, and the stresses on the axial and radial support rods were well within tolerance. Detailed mapping of the magnetic field at several excitations shows the field shape is close to the calculated value.

The next step is to install the drift chamber array, connect all the phototubes to the shower counters, and have a full-scale test with cosmic rays. The detector will then be rolled into position during the PEP shutdown in July and August so that the physics programme can start in late September.

Also using a superconducting magnet is the Time Projection Chamber, a sophisticated detector being built for PEP by a Berkeley/ Johns Hopkins/Riverside/Tokyo/ UCLA/Yale collaboration.

Its central element is a charged particle detector covering large solid angles and providing excellent pattern recognition with three-dimensional nonprojective tracking information, good spatial and momentum resolution, and excellent particle identification over the full PEP momentum range.

The chamber is in a uniform magnetic field generated by a thin superconducting solenoid, and is surrounded by an electromagnetic calorimeter, followed by one metre of iron, segmented with muon proportional chambers.

The project suffered a setback last August when the superconducting coil was damaged during an induced quench at about half the design current. Extensive analysis indicated that the most probable cause was a stray iron chip producing a short between the bore tube and the aluminium winding. The coil will be redesigned and rebuilt, paying special attention to reliability and control. It should be available in the spring of 1982 and installed at PEP a few months later. In the meantime, a conventional coil, capable of providing 0.4 T, is being constructed for use in the initial tests and running of the detector at PEP.

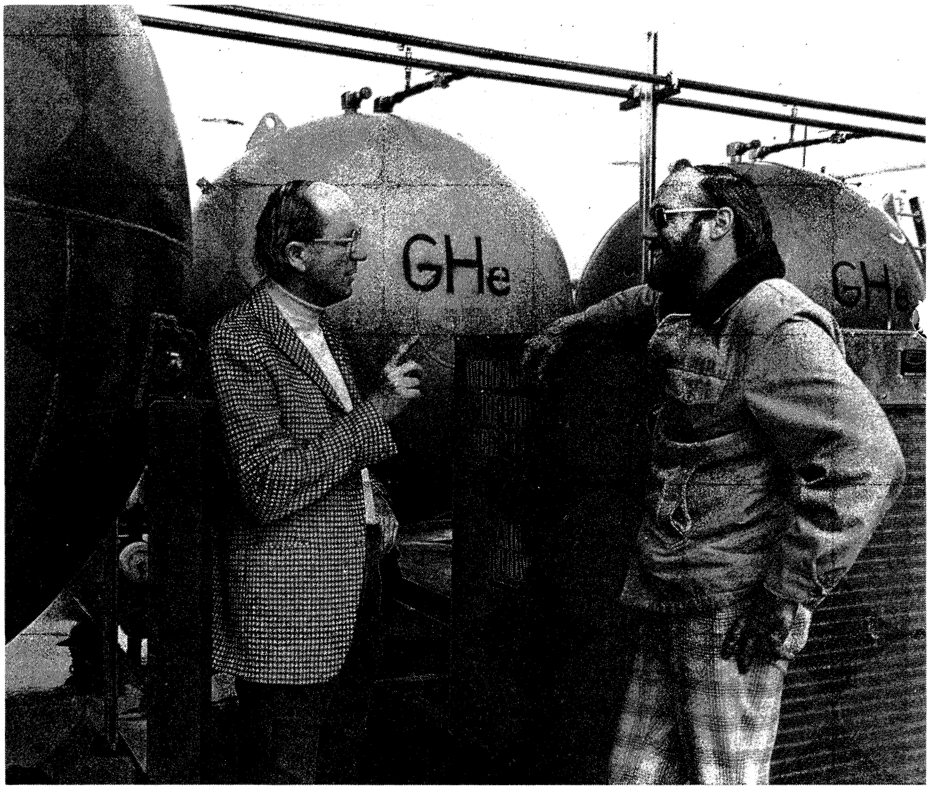
The fabrication, testing and assembly of the detector components have progressed significantly. Assembly of the magnet yoke, iron absorber for the muon detector, cable trays, electronics house and other elements of the main frame are essentially complete. Checkout of the electronics is in progress and over half of the individual circuit cards have been produced.

The electromagnetic calorimeters,

which cover the pole tips inside the 10-atmosphere pressurized volume, the chambers for the muon detector, and the drift chambers for triggering are complete, and installation and preliminary checkout with cosmic rays is under way. In addition, several of the endplane sectors which carry the sense wires and cathode pads have been constructed. Tests at full operating voltage and pressure indicate very satisfactory performance.

The high voltage system began final tests in January and full voltage of 100 kV in a 10-atmosphere environment has been achieved and operated stably for several weeks. Following final mechanical alignment, the high voltage system and sectors will be integrated in preparation for TPC cosmic ray tests.

Production of the hexagonal electromagnetic calorimeter, which is located outside of the solenoidal magnet coil, started in April. This calorimeter consists of forty layers of sense wires operated in the Geiger mode sandwiched between 0.2 radiation-length sheets of lead converter. The first of six modules should be complete in July and all modules should be ready for installation later this year.



Win Baker (left), new head of Fermilab's Meson Department, and new associate head Alan Jockheere at the cryogenic area of the Meson Laboratory.

(Photo Fermilab)

FERMILAB
Second colliding area

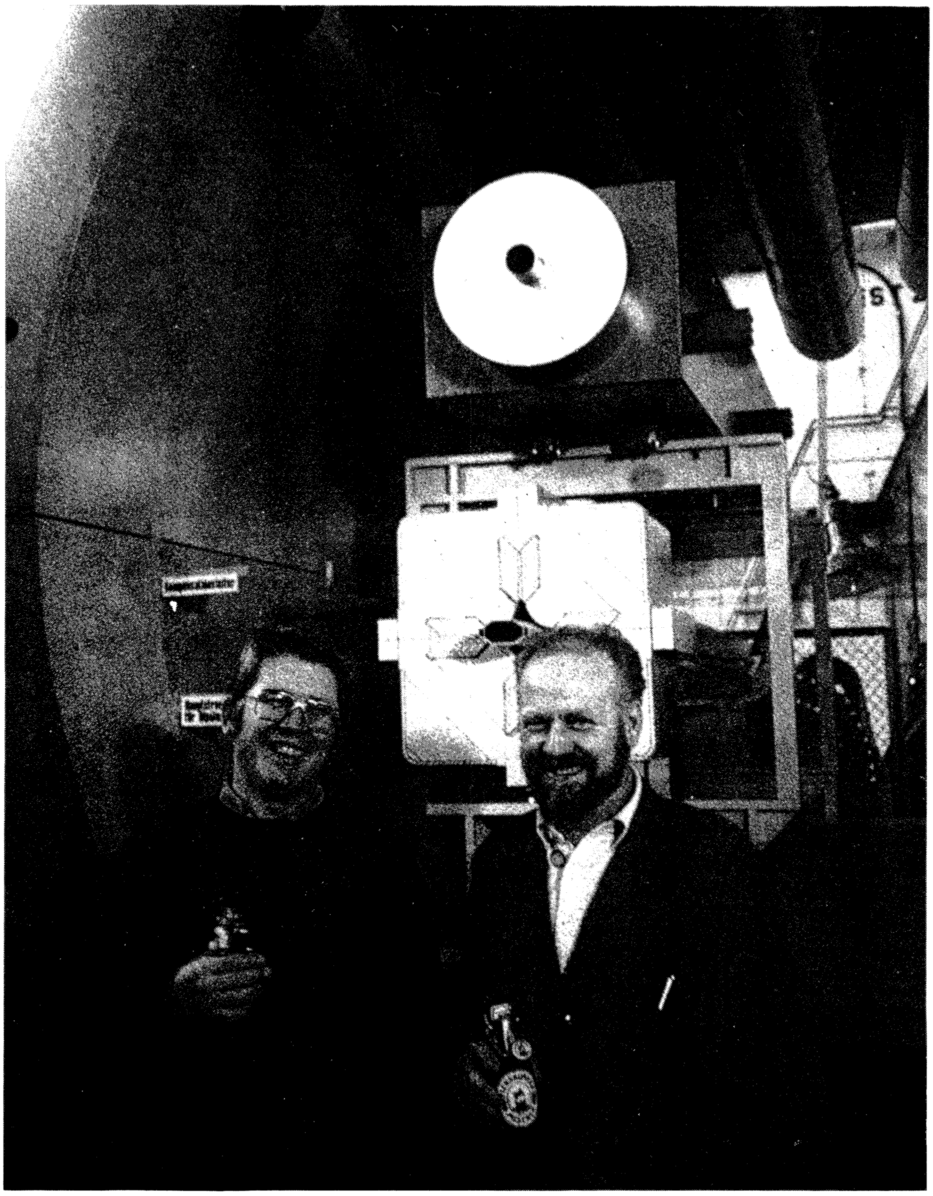
With a view to enlarging the experimental capacity of the Fermilab antiproton project, possibilities are now being explored for a second proton-antiproton beam intersection.

In 1978, a Colliding Dectector Facility (CDF) group was commissioned to design Fermilab's first major detector for proton-antiproton collisions at 2 TeV. This collaboration, under Alvin Tollestrup and Roy Schwitters, is close to completing the design of a large solenoid-calorimetric detector to be installed in the B0 interaction region.

The second collision area now being considered is D0, normally envisaged for extraction from the Tevatron during fixed-target running. Both time and funding constraints place serious limitations on the size of the interaction and staging area around D0. For these and other reasons, Fermilab is interested in user reactions to a proposal to construct a second area with overall dimensions 7 m x 7 m around the Tevatron beam pipe and 10 m parallel to the pipe.

Any detector designed for this region would have to be removed during fixed-target operation and contend with the Main Ring vacuum pipe (21 in above the Tevatron) as an additional obstruction. The detector could be removed by rolling sideways and dismantling it into 20-ton units for crane removal to a staging area, or by direct dismantling and lift. The outer dimensions of the detector would have to fit comfortably into the interaction hall with acce space all around. The present understanding of the collider mode indicates a somewhat lower luminosity for D0 than for B0.

Fermilab is interested in reactions from the user community in order to refine the area drawings. Preliminary ideas should be forwarded immediately. This could be in the form of a comment, a letter of intent, or a criticism, constructive or otherwise. These letters would be useful feedback, but would not be treated as proposals. Actual proposals for a D0 colliding beam detector will be called for by a date yet to be set. Fermilab stresses that the small D0 area calls for a modest detector built by a modestly sized group, with the emphasis on ease of installation, minimum debugging time, and max-



Bjorn Wiik (left), coordinator of the HERA proposal, with Werner Holler, builder of the 4 metre-long model of the HERA tunnel seen in the background.

(Photo DESY)

imum innovation. The effort would be modest enough to be discontinued after one or two runs (or 3 to 4 months) to be replaced by a newer device. Proposers are invited to consider the virtue of being ready for possible low-luminosity measurements of collisions at about 2 TeV by the end of 1983.

This new possibility is seen as a challenge to the high energy community to come up with an imaginative solution that is complementary to or competitive with the present colliding beam detector project at Fermilab.

DESY

HERA ahead

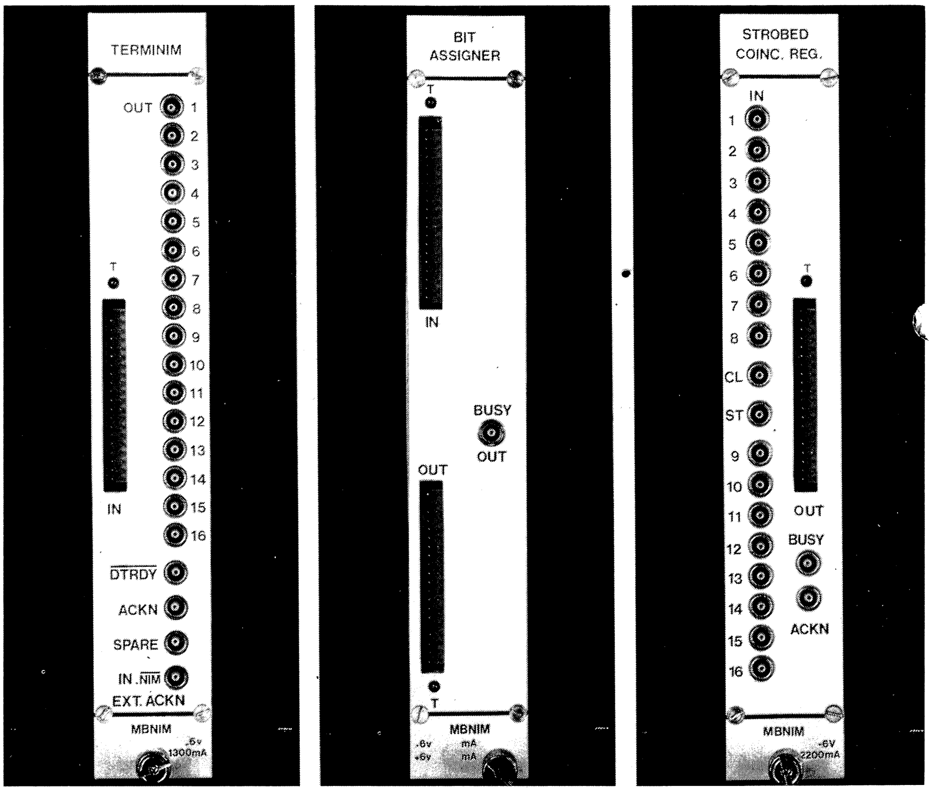
Preparation of a detailed proposal for the construction of the HERA electron-proton storage ring was the subject of a meeting at DESY on 7-8 April, third in a series. A longer work-

New electroweak tests at PETRA

One of the special attractions of electron-positron annihilation is that all the accessible quarks are produced 'democratically'. At the energies available in the PETRA electron-positron storage ring at DESY, five species of quark (up, down, strange, charmed and bottom) are involved in the annihilation into quark and antiquark and subsequent production of hadrons.

In addition, the effects of the weak neutral current are larger at PETRA energies, making it possible to study the weak couplings of the heavier quarks as well as the basic up/down doublet. This means that the standard electroweak model, which accurately describes the low energy weak interactions of the first 'generation' of quarks (u and d) and their associated leptons, can be put to the test both at higher energies and in the context of the weak neutral current couplings of the heavier quarks.

Recent analyses of data from the JADE and Mark-J experiments have concentrated on a careful measurement of the total cross-section for hadron production throughout the available energy range. The results give values for the weak coupling constants of the quarks which are in agreement with the predictions of the standard electroweak model. A value of 0.22 was obtained for the standard mixing parameter ($\sin^2\theta$), in fair agreement with the value obtained from scattering experiments with electron and neutrino beams, even though at PETRA the majority of the annihilation cross-section into hadrons is due to contributions from the heavier (s,c and b) quarks. This result is consistent with the hypothesis that the weak couplings of the heavier quarks are the same as those of their lighter counterparts, indicating that the pattern of both the weak and electric charges of the quarks are repeated in successive generations.



The MBNIM electronics package has been developed at CERN to improve trigger logic.

(Photo CERN 125.7.6.78)

shop was held between 15 February and 7 March. About 50 physicists and engineers from 22 institutes are actively participating in this work, and as was expected, significant contributions are coming from outside DESY.

In the latest meeting, the original HERA proposal (see May 1980 issue, page 99) was re-examined and found to be essentially sound. Nevertheless several improvements were made. The interaction regions were redesigned, particularly with regard to the magnets used to 'turn' the particle spins and obtain longitudinal polarization. This provides an elegant way of studying parity-violating weak interactions between quarks and leptons. The new position of the polarization magnets makes it possible to simplify the layout of the four interaction regions. Both machines are now totally independent in energy and the amount of synchrotron radiation which reaches the interaction region has been considerably reduced.

Another improvement concerns the superconducting bending magnets of the proton ring. Careful investigation has shown that it is possible to use a 'cold bore' instead of the 'warm' vacuum chamber previously proposed. This makes it possible to reduce the coil diameter from 100 to 75 mm, while keeping the same beam aperture and reducing the energy stored in the superconducting magnets by a factor of nearly two. The magnets required for HERA are now practically the same as those successfully built at Fermilab. The time required to organize industrial production of these magnets can now be considerably reduced and would not delay the project. A first written version of the detailed HERA proposal, including all these new aspects, will soon be ready.

Particular encouragement came from the recent publication of the final report of the Advisory Committee for future planning of large projects in fundamental research, appointed by the German Ministry of Research and led by K. Pinkau (see page 210). The very clear statement recommending both LEP and HERA was received with great satisfaction. Preliminary work for HERA should be started immediately in order to clarify all the potential problems of superconducting magnet production and the building of the underground ring.

CERN
Fast trigger logic off the shelf

These days increasing use is being made of general purpose spectrometers which can be readily adapted for a wide range of different experiments and cater for a wide base of users. A good example is the Omega spectrometer in the West Experimental Area at CERN (see December 1980 issue, page 400).

To help make Omega as user-friendly as possible, the electronics team decided to develop a triggering package to handle a wide variety of different experimental requirements. With such improved trigger logic, the rate of taking data could be minimized as early as possible in the decision-making process, providing refined data samples and minimizing the need for subsequent off-line computer power.

The result is MBNIM (Multi-Bit Nuclear Instruments Modules), covering the basic functions required nowadays for experimental trigger logic. As well as Omega, it has now also been incorporated at CERN into triggers for the Split Field Magnet at the Intersecting Storage Rings, for

Physics monitor

the UA2 experiment for the SPS proton-antiproton collider, and for the European Hybrid Spectrometer in the North Experimental Area.

The design of MBNIM was the result of many years' experience at Omega. As time went on, several requirements had become clear:

1 – because they require a lot of space and extensive wiring and are expensive, conventional interface modules and miniature coaxial cables are inconvenient for handling large arrays of counters;

2 – visiting teams do not always have sufficient knowledge of the detector to develop their required triggering system;

3 – trigger logic for different experiments at the same detector frequently requires the same components (coincidence registers, memories, arithmetic/logic units, etc.);

4 – trigger modules designed elsewhere can encounter unexpected problems when brought to the spectrometer.

A distinguishing feature of MBNIM is the replacement of conventional miniature coaxial cables by a 40-wire flat-cable bus. This is a single-ended ECL 10K bus terminated at both ends and carrying 16 data lines, a data ready line, an acknowledge line, and a read/write line. Standard connectors permit fast and convenient custom wiring.

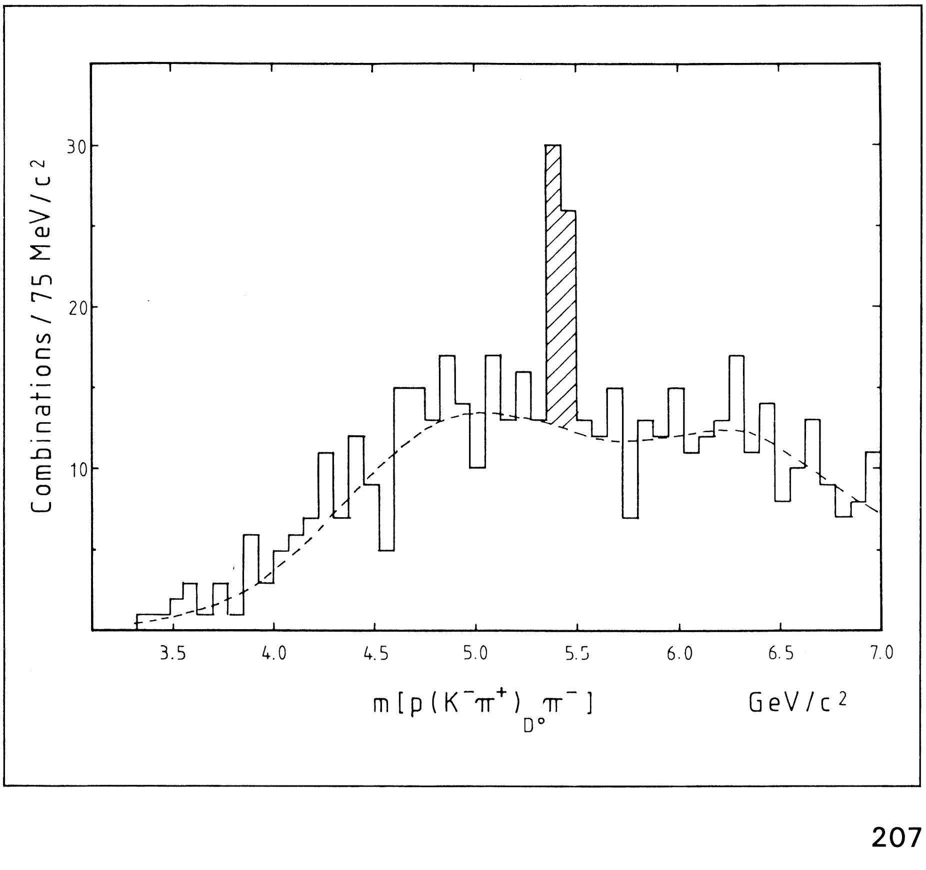
The basic modules include a strobed coincidence register sensitive to the leading edge of pulses, a bit assigner for handling coincidence matrices, the ALU-16 16-bit arithmetic and logical unit capable of handling 16 logical and 16 arithmetic operations, the RAHM 1K x 16-bit random access high speed memory for handling look-up tables, MISTER, a 32 bit 40 event-deep pattern unit, and MIMOSA, a 32 channel 40 MHz 24 bit single width CAMAC scaler.

These modules use specially developed standard NIM and CAMAC interface boards. Up to 10 ports can be connected to the same bus without seriously affecting data transmission. All units offer easy access to sockets. MBNIM is five times cheaper to wire than miniature coaxial cable, although complex applications might benefit from experience in handling flat ribbon cables. It has a 5 ns resolving time, short propagation delays and provides an economical alternative to other ECL trigger systems. For further information, contact F. Bourgeois, A. Corré, H. Pflumm and G. Schuler, CERN EF Division.

'Beautiful' evidence

Ever since the discovery of the upsilon particle at Fermilab four years ago, physicists have been searching for signs of naked beauty, the fifth quark flavour. Just as the J/psi, a bound state of a charmed quark and a charmed antiquark, ushered in the era of charm, so the upsilon indicated that there should be a fifth layer of hadron spectroscopy waiting to be discovered.

Now a CERN/Bologna/Frascati group working with the Split Field Magnet at the CERN Intersecting Storage Rings has seen a signal which is interpreted as the lightest baryon carrying beauty. This baryon is electrically neutral and decays into a neutral charmed meson, a proton and a negative pion. Evidence has been collected for another decay mode giving a charmed lambda baryon and three pions.



Evidence for 'naked beauty' – the signal seen by a CERN/Bologna/Frascati group in their analysis of proton/neutral charmed meson/pion production spectra using the Split Field Magnet at the CERN Intersecting Storage Rings.

According to the standard (Glashow / Iliopoulos / Maiani) model of quarks, beauty is a 'down-like' quark, as compared with charm, which is up-like. This means that the lightest beauty baryon, like the lightest strange baryon and unlike the lightest charmed baryon, is expected to be electrically neutral. It should also decay into a neutral charmed meson (D^o), producing in turn a negative kaon and a positive pion. A naked beauty baryon can only be produced in high energy proton-proton collisions if it is accompanied by an antiparticle carrying equal but opposite beauty. According to the quark model rules, the weak decays of such an antiparticle are characterized by emission of positrons, rather than electrons, as in the case of charm.

Thus the experiment, led by Antonino Zichichi, concentrated on looking for final states doubly forbidden by the rules of charm, but highly suggestive of beauty. These states would have to contain a proton, plus a negative kaon and a positive pion (produced by the decay of a neutral charmed meson) and a negative pion – all these from the decay of a beauty baryon – together with a positron characteristic of the weak decay of a beauty antiparticle. To help suppress background, the positron had to have more than 800 MeV energy. Additionally, selected events were restricted to those in which one proton carried a large proportion of the available energy, ensuring that it was the 'leading' particle of the secondary shower. To further refine the sample, selected events had to contain more than four additional charged particles.

The raw mass spectrum of proton, negative kaon and oppositely charged pion pair shows little, however when the kaon and positive pion effective mass is restricted to the mass of the neutral charmed D^o meson, a signal is seen at 5.425 GeV. This is interpreted as the lightest (neutral) beauty baryon and its mass looks about right.

Other mass distributions containing an additional pion show some signs of more beauty baryons, carrying electric charge and about 300 MeV heavier than the neutral baryon. This could be the first glimpse of a rich spectroscopy of beauty particles to be investigated and explored in the years to come. Because the beauty quark is so heavy, other particles containing more than one beauty quark may not be seen until much higher energies are available.

For some time, a CERN / Collège de France / Heidelberg / Karlsruhe group, also working with the Split Field Magnet at the ISR, has been seeing a similar signal in a positively-charged particle combination. However the group is 'not convinced' that this is new physics and is hoping to go on and collect more data.

Measuring the neutrino mass

The neutrino, one of the most elusive of all the known particles, was proposed by Pauli to fix up apparent anomalies in observed beta-decay spectra of nuclei. With the basic parameters of the neutrino again in question (see January/February issue, page 21), beta decay spectra are now back in vogue for neutrino physics.

Although long considered a massless particle, this has never been conclusively proved, and physicists are now asking whether the neutrino does in fact have a vestigial mass. The answer to this intriguing question would be of interest to particle specialists and astrophysicists alike.

Last year, an ITEP (Moscow) experiment investigating the beta decay of tritium reported a neutrino mass in the range 14 to 46 electron volts (see July/August 1980 issue, page 190). Now experiments are to be run at the ISOLDE on-line isotope separator of CERN's 600 MeV synchro-cyclotron to make a precision measurement of the neutrino mass from the photon spectra (inner bremsstrahlung) accompanying electron capture beta decay.

Standard beta decay with emission of an electron gives a nucleus with an extra electric charge, however nuclear transitions are also possible in some cases with the release of a positron (anti-electron), giving a nucleus with one charge less.

Equivalent to such positron beta decays are electron capture processes where an inner orbital electron is swallowed by the nucleus. Instead of having to generate the rest mass of a positron, these processes liberate the rest mass of the captured electron as energy. Decay with low energy release may thus proceed by pure electron capture.

All beta decay processes are accompanied by a continuous spectrum of bremsstrahlung radiation from the produced or absorbed electron. However the spectrum of this radiation has a particularly simple form in the case of electron capture and in principle its shape near its high energy limit gives a direct handle on the mass of the neutrino.

The best possible conditions, minimizing troublesome atomic excitation effects, are provided by heavy nuclei with low energy electron capture beta decays. Although the bremsstrahlung intensities in these cases are small, they should nevertheless be detectable. This is due to a resonance mechanism pre-

People and things

dicted in 1956 by Glauber and Martin which boosts the bremsstrahlung near to atomic X-rays.

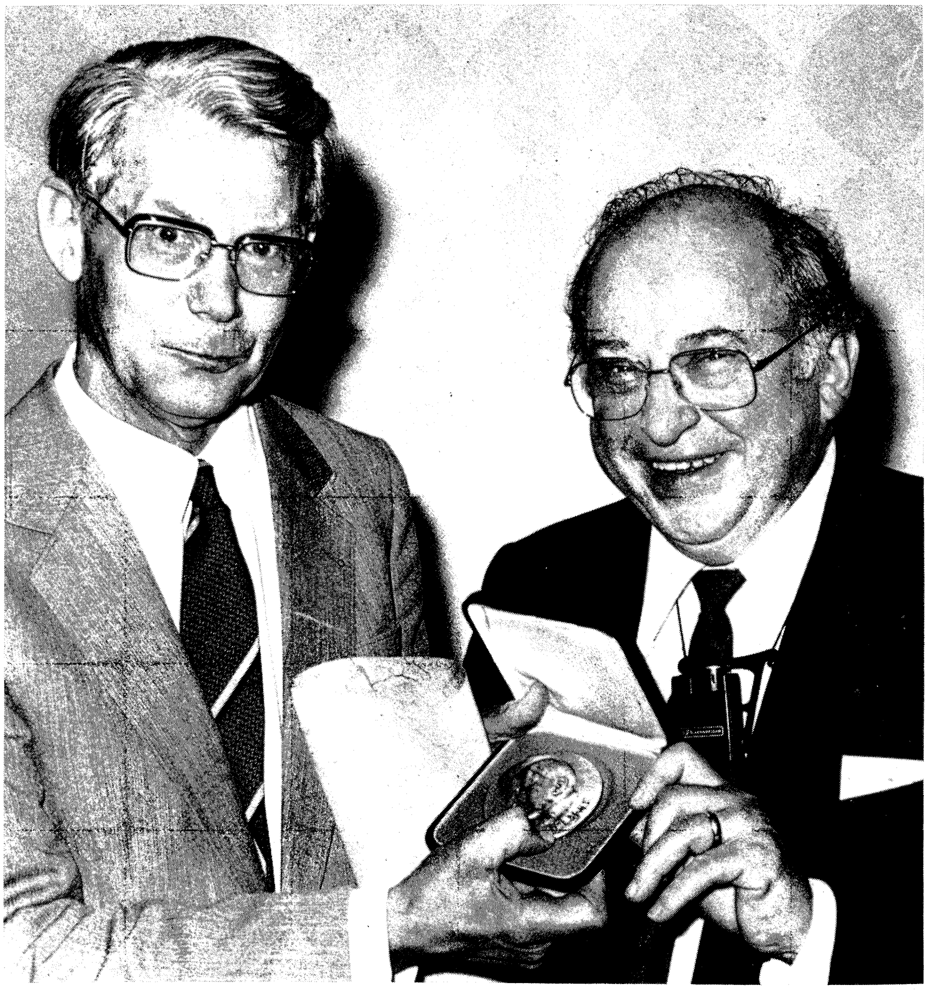
The best candidates are platinum-193, holmium-163 and terbium-157, while a search could also be made for other suitable, and as yet undiscovered, electron capture processes. Such experiments are in principle straightforward, using conventional electron and photon spectrometers and coincidence techniques to measure the radiation spectrum to a specific final atomic state. However a good deal of preparatory work is required at ISOLDE to perfect the production of the necessary initial samples and techniques required to furnish the required beams.

Work is beginning straight away to develop these techniques and to measure some new nuclear parameters. Once this has been achieved, several experiments could be run in parallel in the attempt to provide a precision result on the neutrino mass.

On people

The Max Planck Medal – the highest distinction of the German Physical Society – has been awarded this year to Kurt Symanzik of the University of Hamburg and, since 1968, a senior staff member at DESY. The first medals were given to each other by Max Planck and Albert Einstein in 1929, and the award is made to theoreticians continuing in the tradition of Planck.

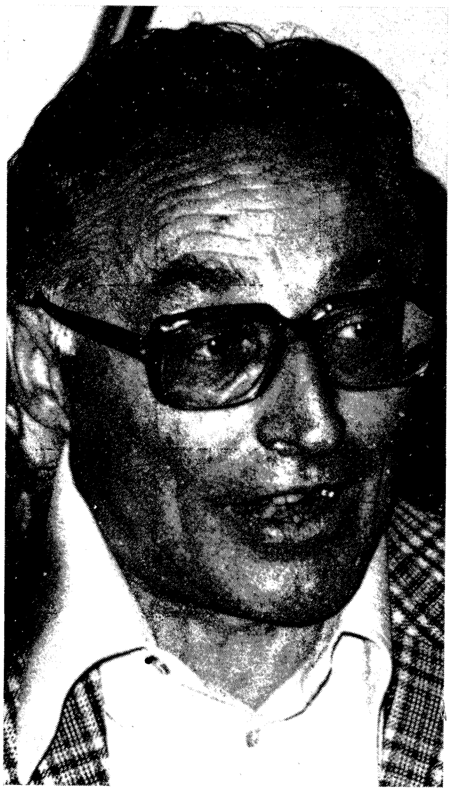
Kurt Symanzik obtained his doctorate under Werner Heisenberg in Göttingen. As well Hamburg and DESY, he has worked at several important research centres in Europe and in the USA, including the Courant Institute of the University of New York. His scientific work has had a direct bearing on quantum chromodynamics, the (so far) successful candidate theory of inter-quark forces. Symanzik pointed out the possibility of the existence of so-called 'asymptotically-free' theories, now an integral part of quantum chromodynamics dogma. His work in the sixties on the relation between field theory and statistical mechanics is of great importance in present attempts to explain the absence of isolated quarks. Also playing an important role in modern field theory is the Callan-Symanzik equation, developed independently by Symanzik and by Curtis Callan.



Kurt Symanzik (left) receiving the Max Planck Medal from Horst Rollnick, President of the German Physical Society.

(Photo Deutsche Presse-Agentur)

Yurii Borisovich Rumer



Hans Willax

Yurii Borisovich (Georg) Rumer, the oldest scientist at the Novosibirsk Institute for Nuclear Physics, celebrated his eightieth birthday on 28 April. His scientific interests have been mainly concentrated on the general theory of relativity and quantum chemistry. His early work on quantum chemistry (particularly in collaboration with E. Teller and G. Weihl) were pioneering and helped form this field of science. In addition to his scientific achievements, his talents and profound knowledge have been evident in lectures on all fields of theoretical physics which during half a century have helped produce several generations of noted scientists.

Hans Willax

Hans Willax, who headed the building of the ring cyclotron at SIN, the Schweizerisches Institut für Nuklearforschung, died on 17 April after a severe illness courageously borne. He joined SIN in 1959 and developed the concept of the ring cyclotron to achieve the high proton beam intensities necessary for the new generation of meson factories. He was Head of the Accelerator Department from 1974 and spent the past two years working with the Study Group set up in the Federal Republic of Germany to develop an intense spallation neutron source (being concerned with a novel type of accumulator ring at Jülich). Hans Willax was highly regarded for his expertise in the field of accelerators, for the originality of his thinking and for his energy and enthusiasm. His great achievements stand as a lasting tribute at the SIN Laboratory.

Big projects in Federal Republic of Germany

Recommendations have been made by a Committee set up by the Federal Government, under the Chairmanship of K. Pinkau, to study the various large projects in fundamental research in which Germany is involved, including those in the high energy physics and accelerator sectors.

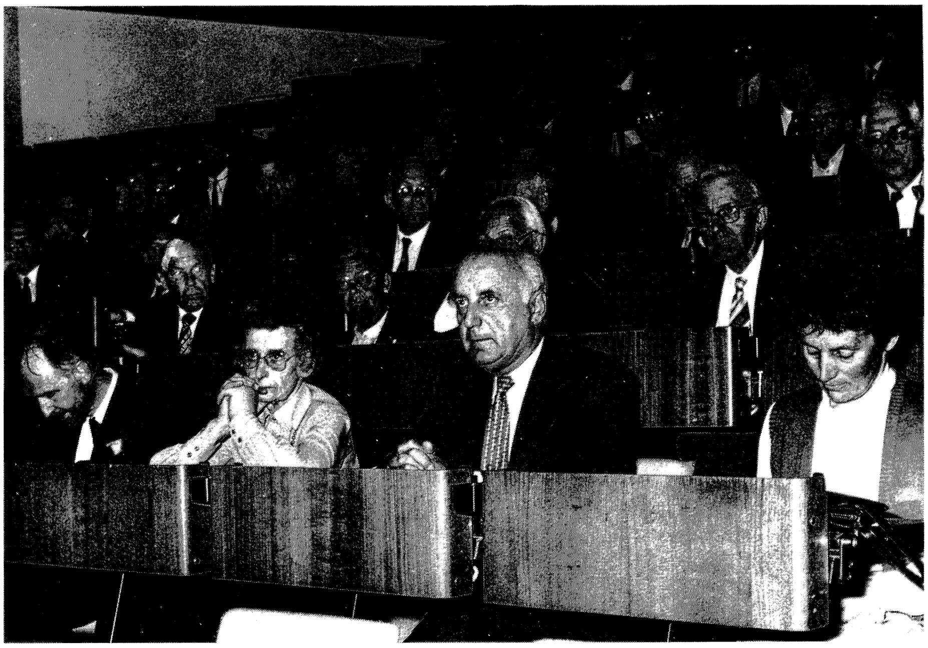
The Committee recommended the CERN electron-positron storage ring project, LEP, for approval in June 1981 and execution as planned, expressing the hope that the project would go ahead following a positive decision from the other CERN Member States.

The Committee recommended, in principle, the DESY electron-proton colliding beam project, HERA (see May 1980 issue, page 99), but did not encourage construction to start before 1984 although preliminary studies and planning should begin. It was emphasized that HERA should be an electron-proton collision machine – the electron-positron option should not be pursued. The desirability of having a second thriving international high energy physics Laboratory in Europe in addition to CERN was recognized, and the Committee urged international participation not only in its use but also in its construction by any means (financial, personnel or equipment) to ease the burden on the Federal Republic. The proposal to delay authorization for several years is made in the light of the exploitation and upgrading of the PETRA storage ring at DESY and of the further time which will be needed to pursue the development of superconducting magnets.

The Committee also recommended in principle the construction of an intense neutron source as proposed by the Karlsruhe/Jülich collaboration (the SNQ – Spallations-Neutronenquelle – project, see October 1980 issue, page 299). Again a delay of several years prior to authorization was recommended to allow for further studies and to benefit from experience gained in the construction of British and Swiss spallation sources. The project is also under examination by another Committee.

The rapid development of the SuSe superconducting heavy ion cyclotron, proposed by Munich, was recommended by the Committee in line with the Lindenberger report, with the proviso that certain conditions are met and use of the facility by outside groups could be guaranteed. SuSe is a four sector cyclotron designed to accelerate medium-heavy ions to 300 MeV per nucleon (up to sulphur ions) and heavier ions up to 25 MeV per nucleon.

The Committee did not recommend the construction of the superconducting cyclotron proposed by



On 30 April a ceremony was held at CERN in memory of Wolfgang Gentner, the scientist from the Federal Republic of Germany who played an important role in the development of CERN. In the front row of the photograph, left to right, are DESY Laboratory Director V. Soergel, Mrs. Gentner, President of CERN Council J. Teillac, and Ms. H. Langevin-Joliot who spoke at the ceremony.

(Photo CERN 204.5.81)

Jülich, was hesitant about the urgency of the European Synchrotron Radiation Facility (with HASYLAB at DESY and BESSY in Berlin coming into action) and felt that it was too early to pronounce on the relativistic heavy ion proposal from Darmstadt (see October 1980 issue, page 298). In view of the internationally recognized importance of this project, it is suggested that some preliminary experiments at CERN would be helpful to enable a special committee to arrive at an early decision.

HERA workshop

In view of the HERA electron-proton project, a workshop on physics with electron-proton facilities is being organized on 2-3 October. Further information from Peter Von Handel, DESY, Notkestrasse 85, D2000 Hamburg 52, Federal Republic of Germany.

Conference

The Ninth International Conference on Atomic Collisions in Solids will be held at the Université Claude Bernard Lyon-I, from 6-10 July. Further information from Institut de Physique Nucléaire, Université Claude Bernard Lyon-I, 43 boulevard du 11 Novembre 1918, 69622 Villeurbanne-Cedex, France.

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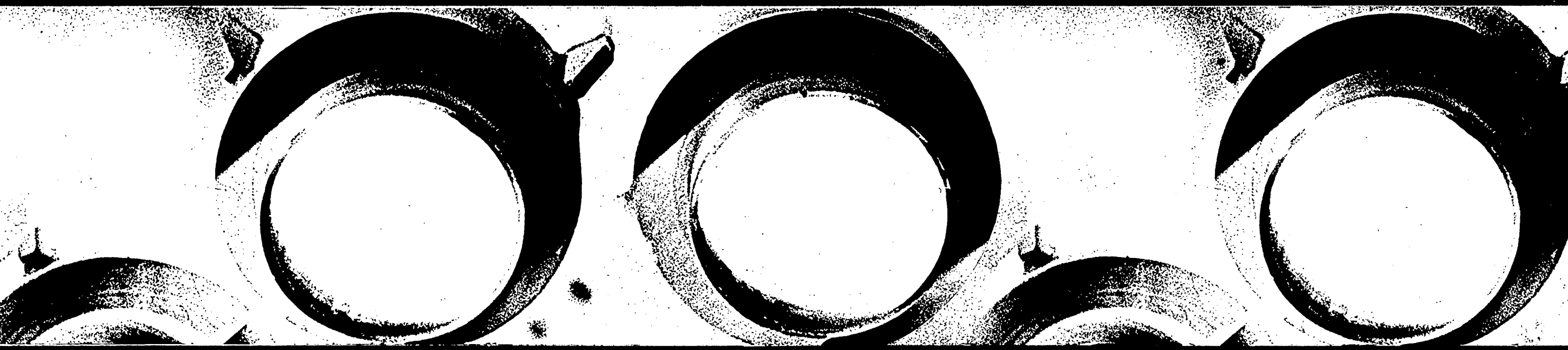

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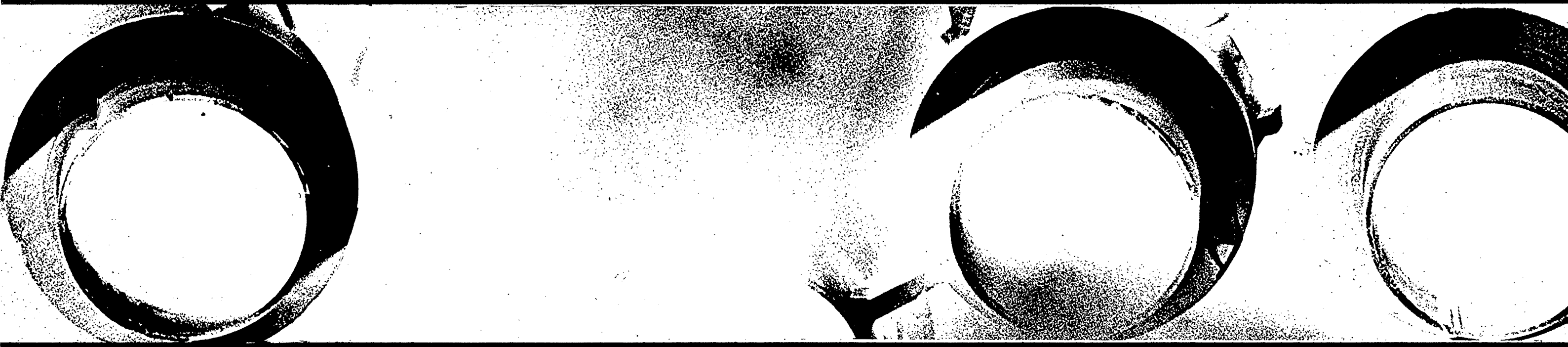

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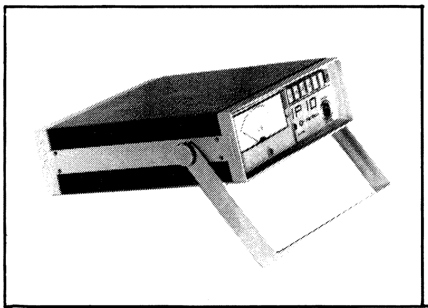

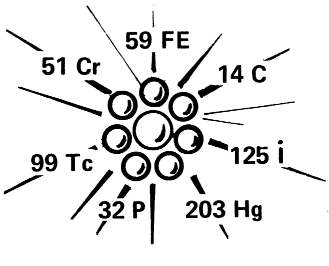

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- **5 PROBES :**
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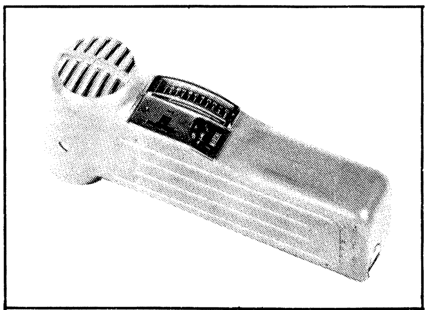

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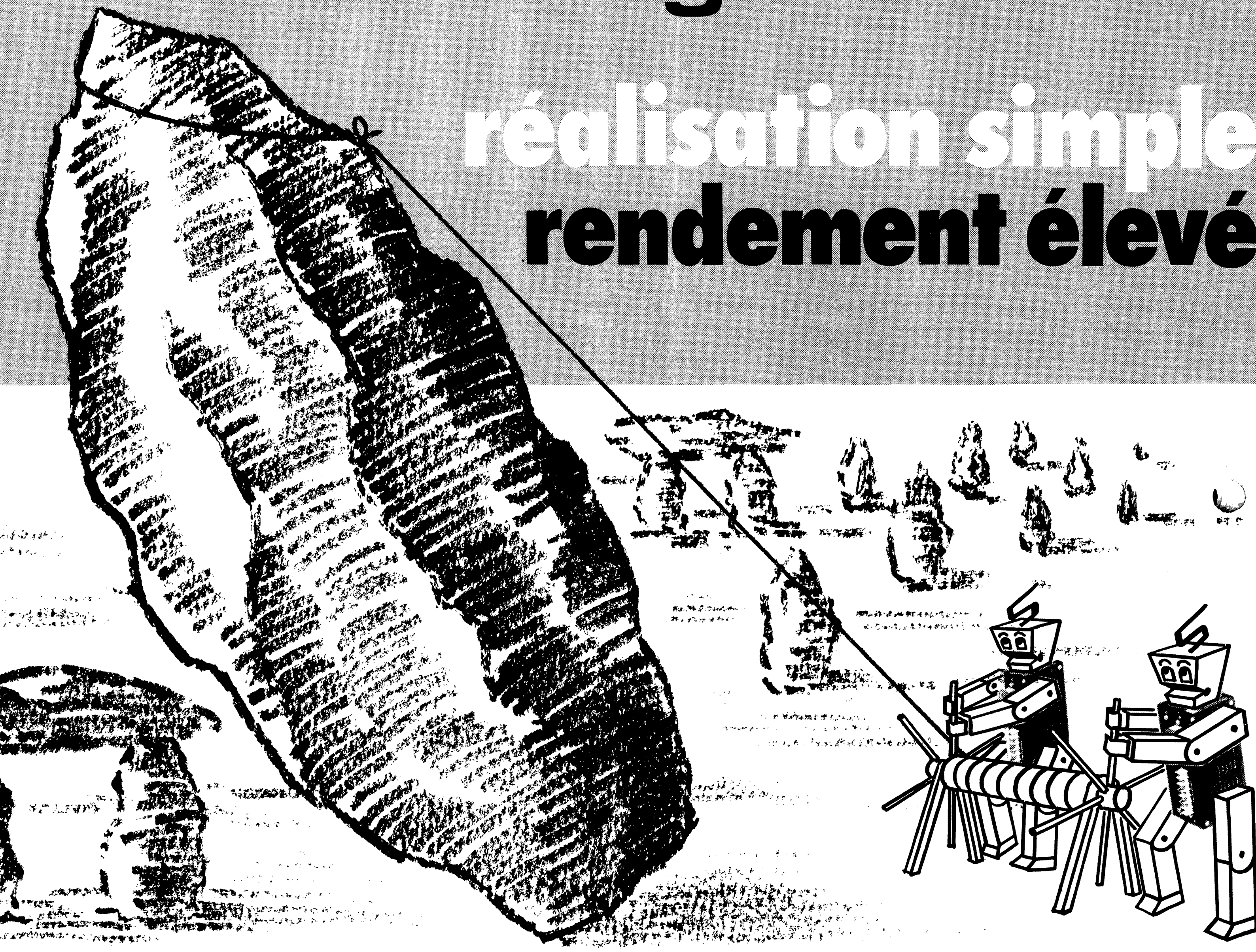

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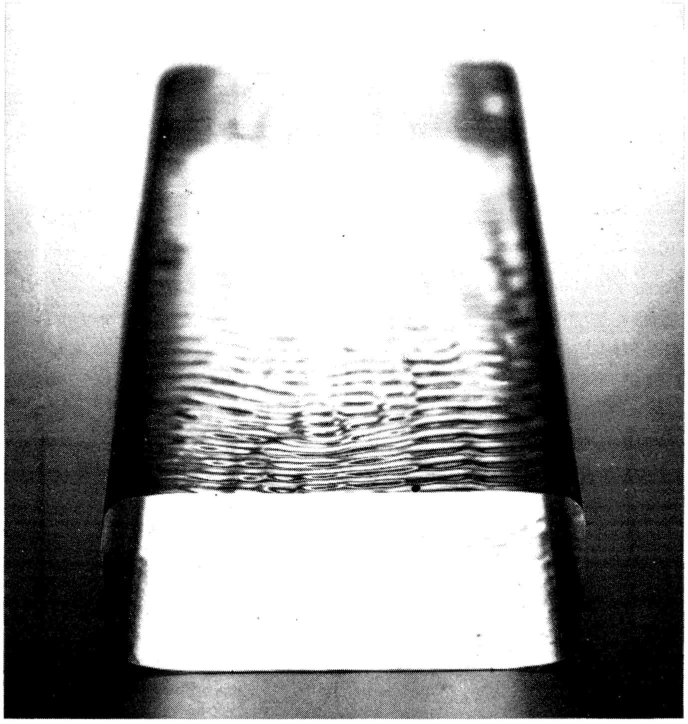

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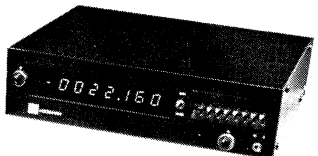
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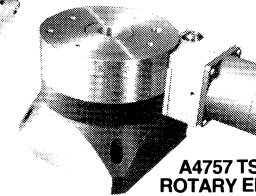
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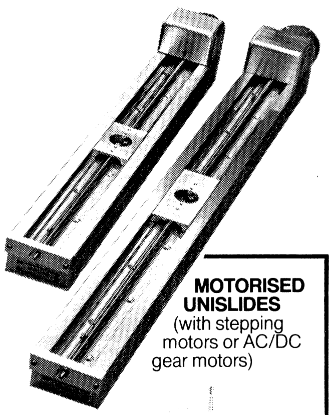
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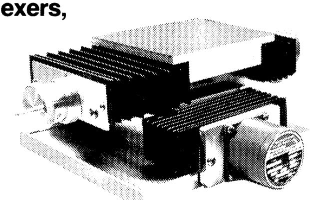
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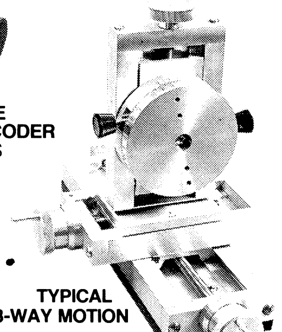
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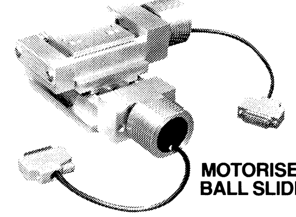
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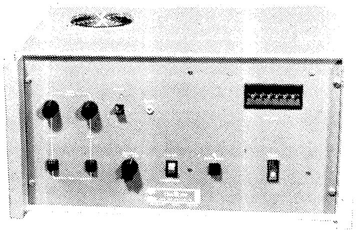
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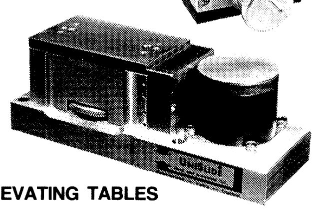
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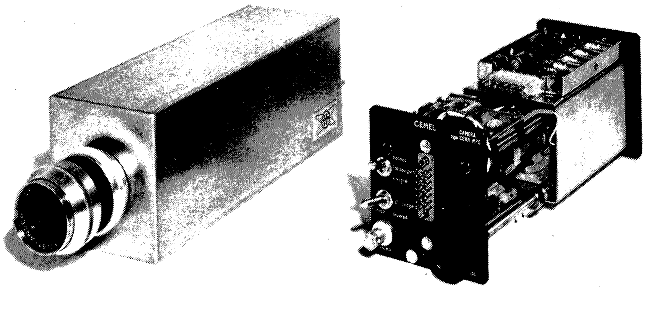
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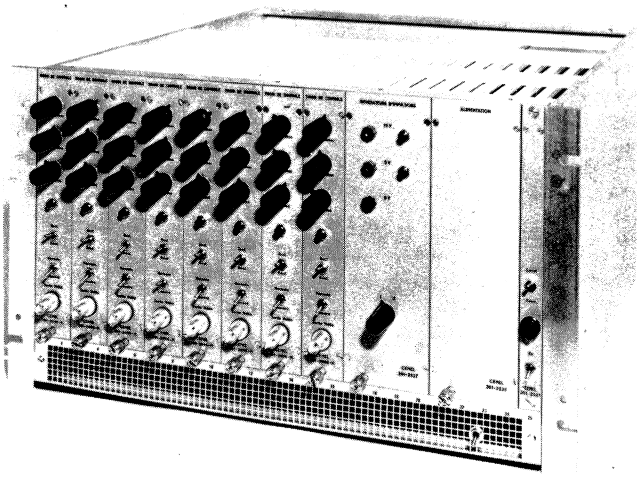
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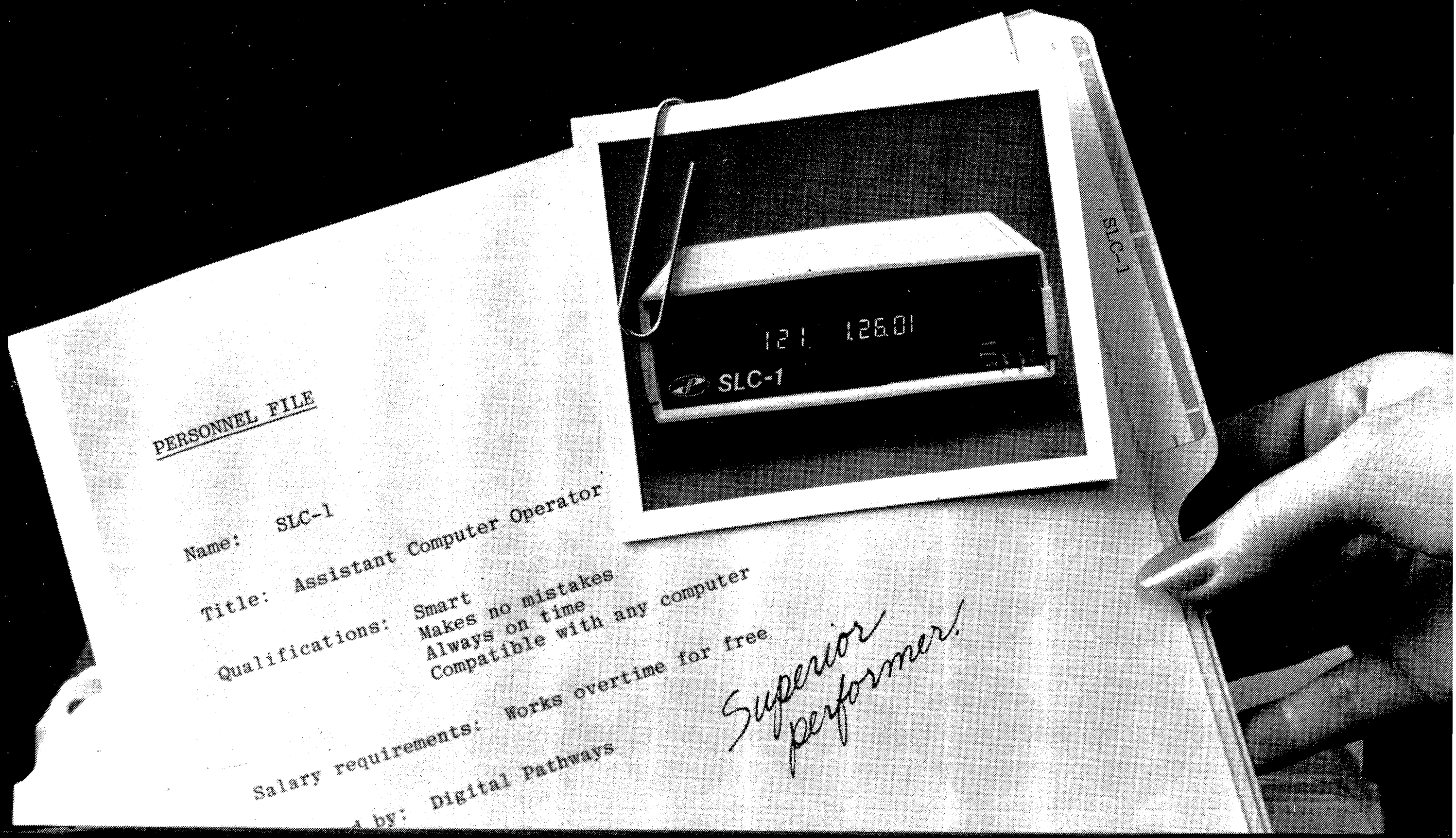

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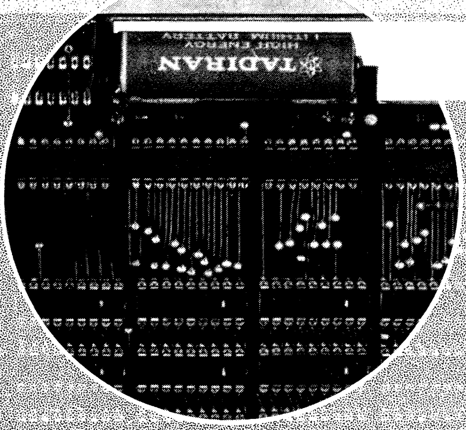

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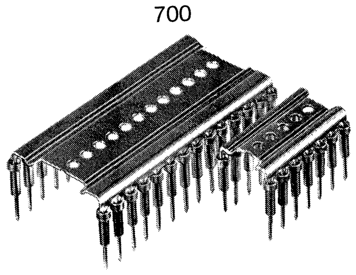
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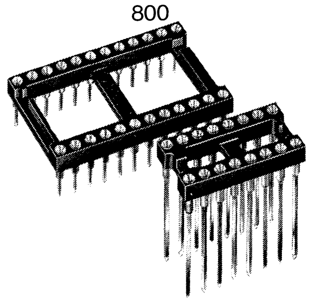
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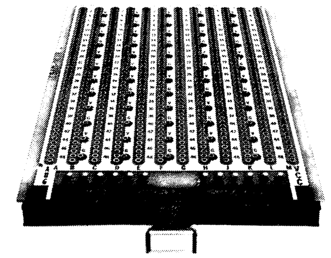

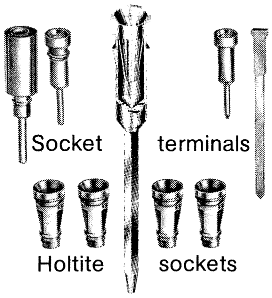
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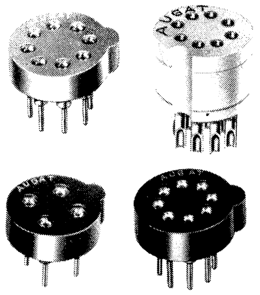

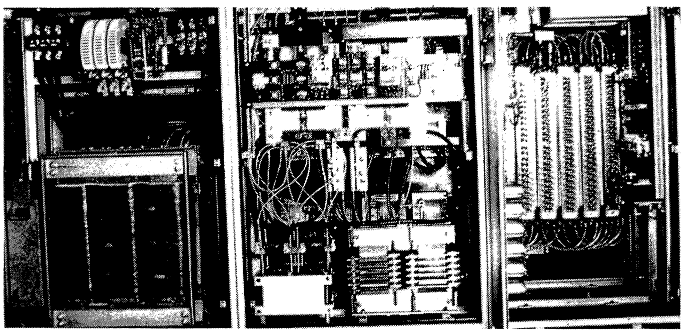

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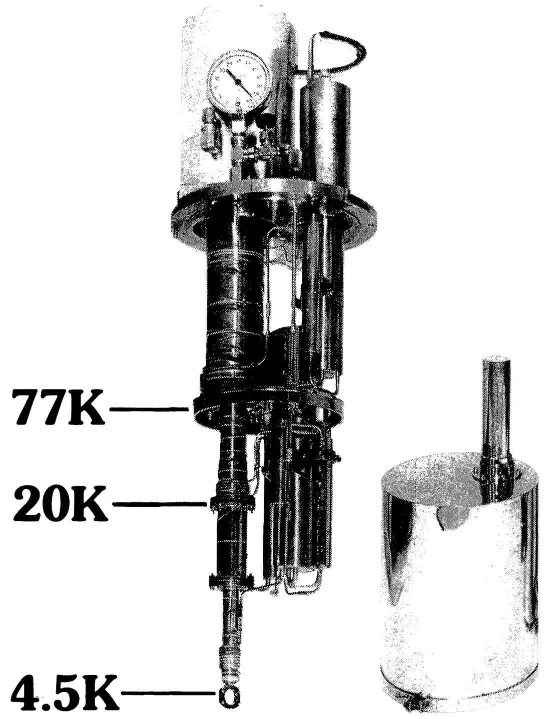
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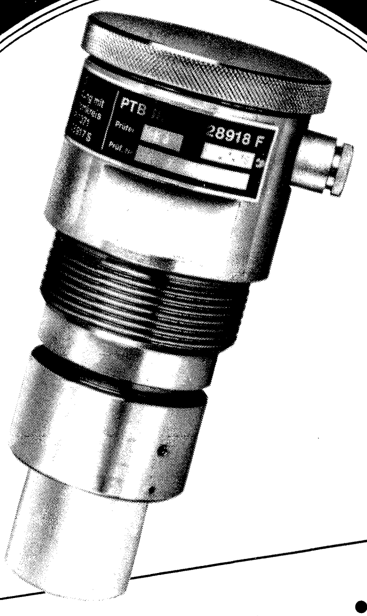

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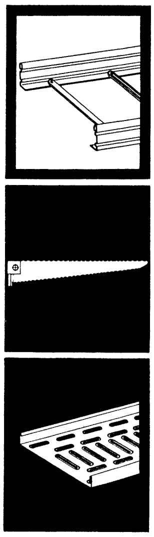

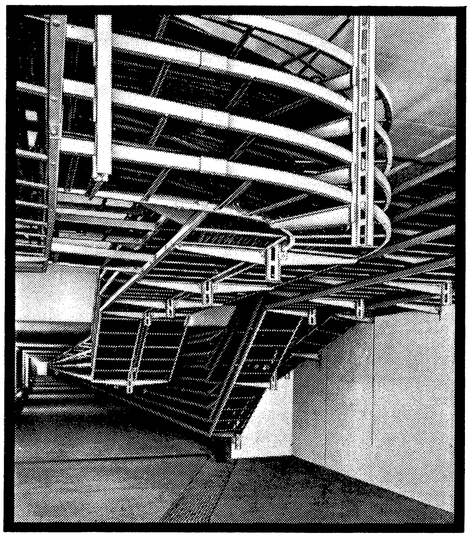

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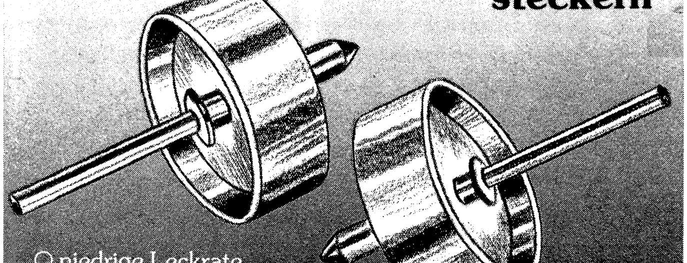
mit EMC

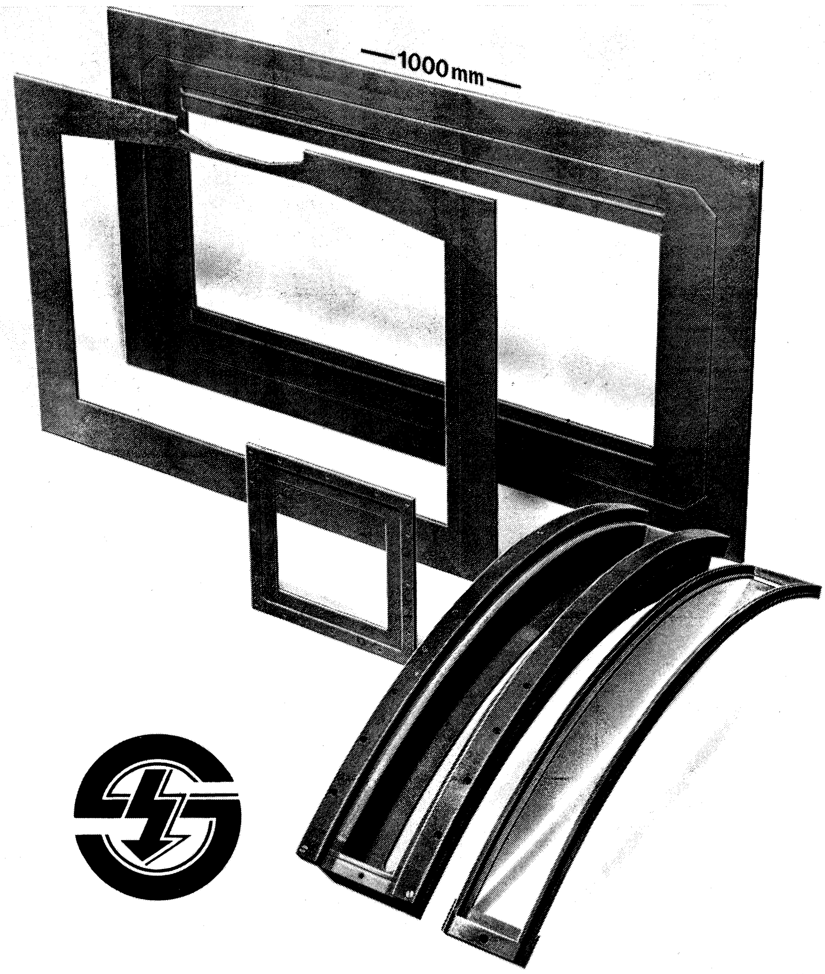
hermetisch dichten Übergangssteckern

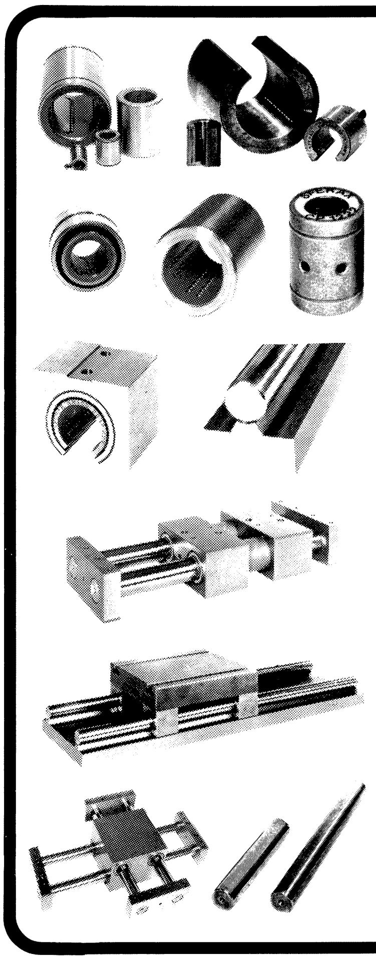


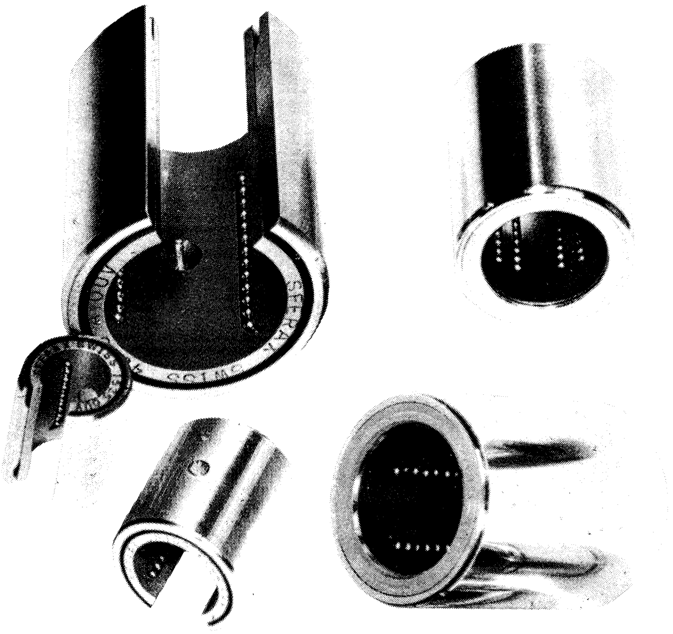
○ niedrige Leckrate
○ unkompliziertes Bauteil
○ optimale Kontaktsicherheit
○ kleines VSWR
○ Übergangsstecker verbinden die Schaltung ohne mechanische Belastung.
○ EMC-KATALOG MIT ANWENDUNGEN KOSTENLOS ANFORDERN!

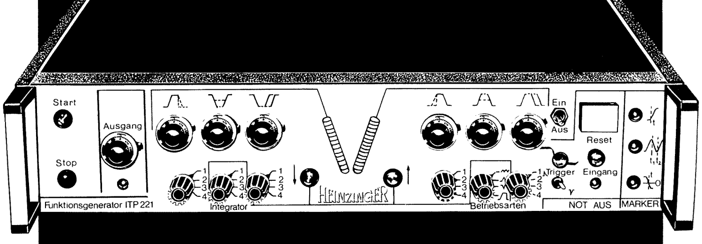
Übergangsstecker einpressen oder
löten – Flanschstecker oder
-abschluß montieren: ergibt
die optimale HF-Verbindung!

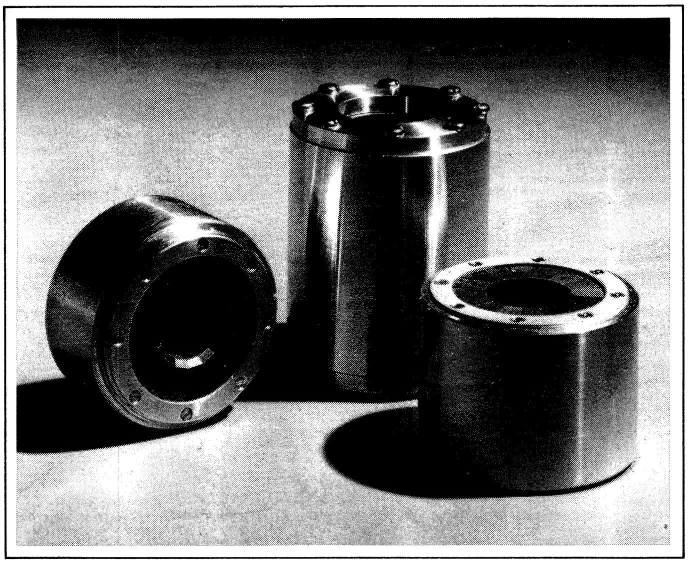
E. PARZICH + Co
D-8911 Puergen
Karwendelstraße 8
Tel. 08196 - 511
Telex 05-27142


1000 mm

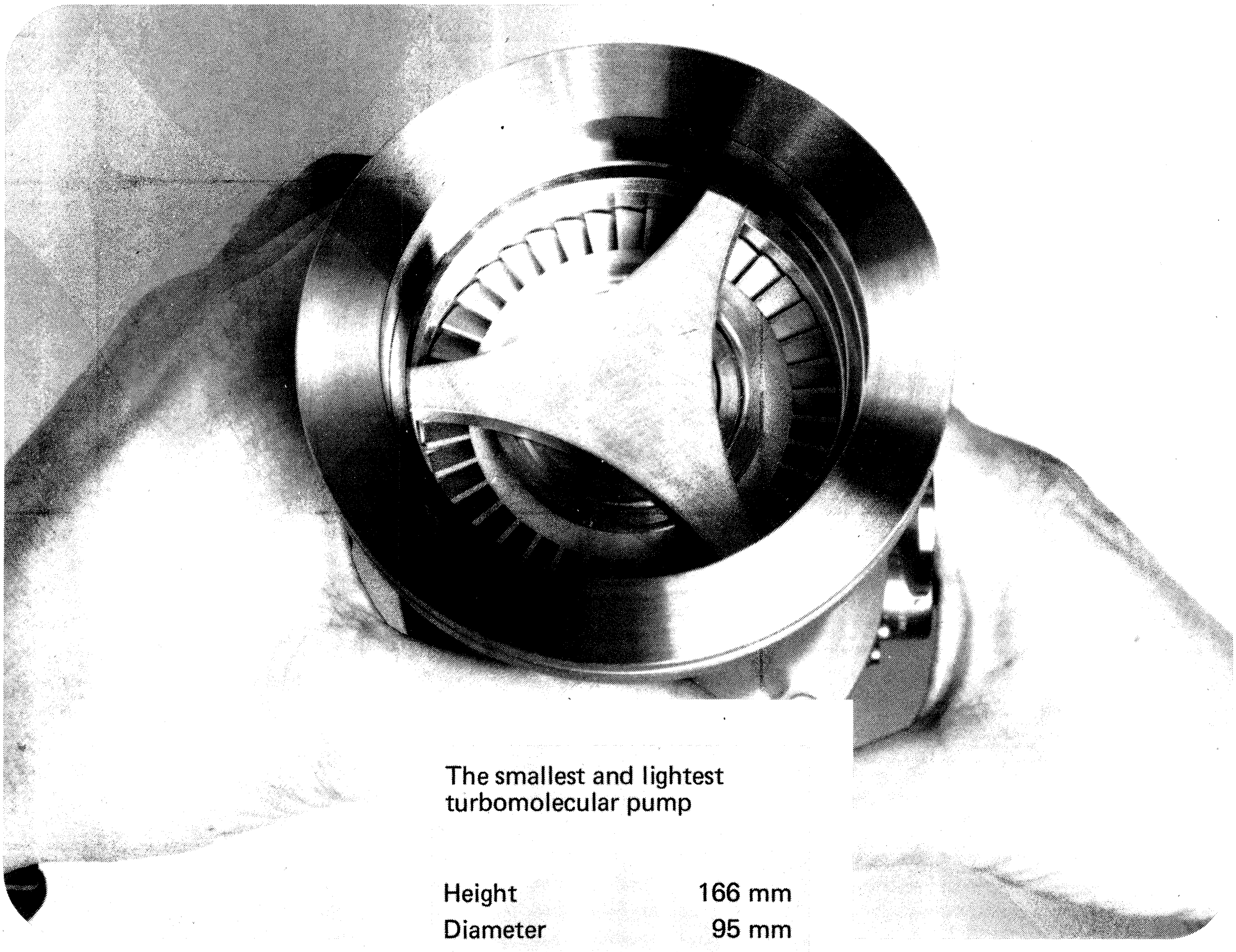





Start
Stop
Ausgang
Ein
Aus
Reset
Trigger
Eingang
Funktionsgenerator ITP 221
Integrator
HEINZINGER
Betriebsarten
NOT AUS
MARKER



PFEIFFER TURBO 040 High-Vacuum Pump



The smallest and lightest turbomolecular pump

Height	166 mm
Diameter	95 mm
Weight	2,5 kg
Volume flow rate for N_2	40 l/s

The TURBO 040 produces hydrocarbon-free high vacuum at a low volume flow rate. It is therefore the ideal pump for modern analytical work as for example for the mass spectrometer and for industrial use in the manufacture of tubes and light bulbs.

The applications of the TURBO 040 are numerous. The high vacuum connection can be supplied to order, either to KF, high vacuum flange to ISO-K or ultra-high vacuum flange to CF standards. The pump can be fitted in any position from the vertical to the horizontal. The TURBO 040 is the first pump of its kind without forced cooling and therefore operates problem-free. Its remarkably low level of noise and vibration helps to make it the universal high-vacuum pump for all types of use. Noteworthy in comparison with other high-vacuum pumps is its low energy consumption.

BALZERS

A. PFEIFFER
Vakuumtechnik Wetzlar GmbH
Postfach 1280
D-6334 Asslar, BRD
Tel.: 06441/8021
Telex: 48 3859

The '81 Range

The 1981 TURBO range comprises six pump sizes. The choice can be considerably increased owing to possible modifications such as flanges for high and ultra-high vacuum, positioning of the high vacuum connection and choice of coolant. The range of the volume flow rate from 40 to 5000 l/s gives the best possible solution for every kind of application.

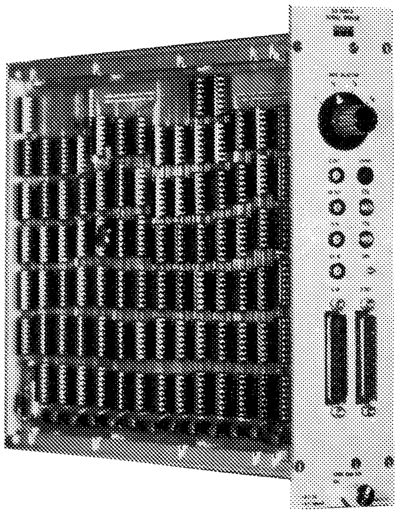
PM 800 046 PE DN 7338

CAMAC

FOR CONTROL APPLICATIONS TRY THE

SERIAL HIGHWAY SYSTEM

SD 2087 Serial Driver

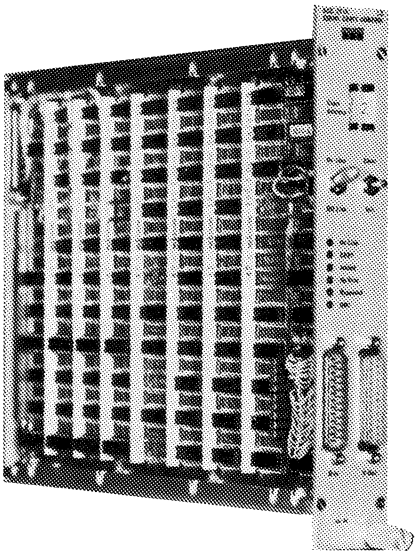


FEATURES

- Can function as a module in a CAMAC system or be directly linked to the computer.

  Functions in bit or byte mode.
- Perfected data transfer control, thanks to an elaborate LAM detection.
- Possibility of 16 and 24 bit READ/WRITE.
- Switchable frequency select up to 5MHz on the front panel.

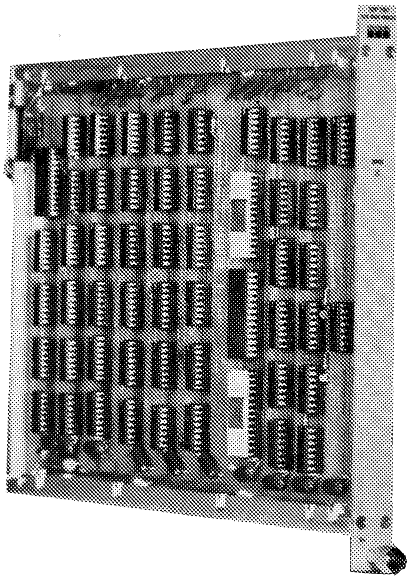
SCC 2115 Serial Crate Controller



FEATURES

- Functions at speeds up to 5 Mbit/byte/sec.
- Increased system reliability thanks to a "Loop Collapse" and a "Bypass Control".
- Error detection logic.
- An auxiliary connector permits the use of a LAM Grader or an auxiliary controller.

SDP 2101
Serial Demand Processor



FEATURES

- Buffer for the demands arriving from the Serial Highway.
- Interfaces directly with the SD 2087.

France: **EG&G Instruments;** Zone Silic 428; Tel. (1) 687 25 71 - Tlx 202553F, F-94583 RUNGIS CEDEX – **Germany:** **SEN ELEKTRONIK GmbH;** Brandstücken 11; Tel. 041 80 20 46 - Tlx 2163705d, D-2000 HAMBURG 53 – **DIDAS Digital System;** Radspielstrasse 8; Tel. 089 91 67 10 - Tlx 529167d - D-8000 MÜNCHEN 81 – **Switzerland:** **SEN ELECTRONIQUE SA;** CP 39; Tel. (022) 44 29 40 - Tlx 23359ch - CH-1211 GENÈVE 13 – **SEN ELEKTRONIK AG;** Austrasse 4; Tel. (01) 945 51 03; Tlx 58257ch - CH-8604 VOLKETSWIL – **United Kingdom:** **SEN ELECTRONICS LTD;** London Street; Chertsey; Tel. 9328.66744 - GB - KT16 8AP SURREY – **OFFICES THROUGHOUT THE WORLD.**

Headquarters:
SEN ELECTRONICS S.A.; Avenue Ernest-Pictet 31; Tel. (022) 44 29 40 - Tlx 23359ch - CH-1211 GENÈVE 13.

SEN
ELECTRONIQUE

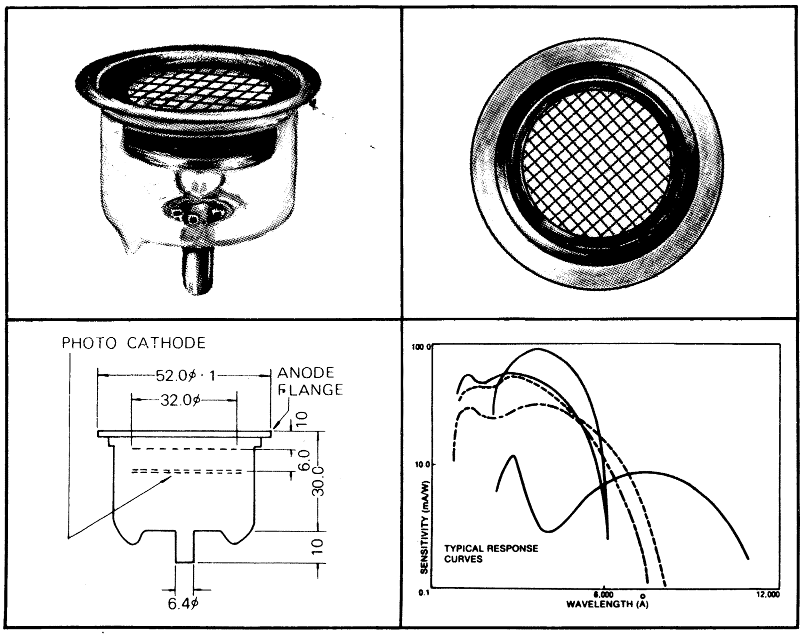


PHOTO CATHODE
52.0ϕ · 1
32.0ϕ
ANODE FLANGE
10
6.0
30.0
10
6.4ϕ
100.0
10.0
0.1
SENSITIVITY (mA/W)
TYPICAL RESPONSE CURVES
6,000
12,000
WAVELENGTH (Å)