CERN COURIER

VOLUME 20 6 SEPTEMBER 1980

CERN COURIER
Journal of High Energy Physics
Editors: Brian Southworth
Henri-Luc Felder
Gordon Fraser
Advertisements: Micheline Falciola

Laboratory correspondents:
Argonne National Laboratory, USA
R. Arnold
Brookhaven National Laboratory, USA
N.W. 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 Scientific Laboratory, USA
O.B. van Dyck
Novosibirsk Institute, USSR
V. Balakin
Orsay Laboratory, France
J.E. Augustin
Rutherford Laboratory, UK
J. Litt
Saclay Laboratory, France
A. Zylberstejn
SIN Villigen, Switzerland
G.H. Eaton
Stanford Linear Accelerator Center, USA
L. Keller
TRIUMF Laboratory, Canada
M.K. Craddock

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

CERN COURIER is published ten times yearly in English and French editions. The views expressed in the Journal are not necessarily those of the CERN management.

Printed by: Presses Centrales S.A.
1002 Lausanne, Switzerland
Merrill Printing Company
765 North York, Hinsdale,
Illinois 60521, USA

Published by:
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

Contents

Around the Laboratories

Cover photograph: Everyone's image of Geneva — the 'jet d'eau' in action at night. This picture was taken from the lake steamer which was the scene of the formal dinner during the XI International Accelerator Conference held at CERN in July. The Conference is reported on page 231. (Photo CERN 329.7.80)

CERN Accelerator Conference

From 7–11 July the XI International Conference on High Energy Accelerators was held at CERN. It attracted some 300 specialists from all the regions of the world involved in accelerator construction. We will concentrate here on the major topics at the Conference with emphasis on those subjects which have not had detailed coverage in the COURIER in recent months.

The big machines

As usual the Conference opened with reports on the big machines newly in action, under construction or planned. Despite the financial restrictions of recent years and uninspiring financial prospects for the near future, the list is impressive — PEP, PETRA, CESR, ISABELLE, UNK, BPS, CERN proton-antiproton collider, Tevatron, HERA, TRISTAN, SLAC single pass collider and LEP.

Ewan Paterson spoke about the newcomer — the 18 GeV electron-positron storage ring PEP at Stanford — which started physics at the end of June (see July issue, page 187). Peak luminosity of 10^{32} per cm^2 per s is anticipated at 15 GeV. In the initial runs at 8 GeV (limited in energy by problems with ceramic supports in the injection kickers) a luminosity of 3.5×10^{29} was achieved, moving later to 2×10^{30} at 11 GeV with three circulating bunches in each ring. (In July the ring operated at 14 GeV and before the end of the year sufficient r.f. power should be installed to ramp to 18 GeV.)

The PETRA electron-positron storage ring at DESY, covered by D. Degèle, has been in operation for two years and since February of this year can operate at 19 GeV. Polarization at high energies has been observed (see July issue page 196) and beam behaviour is becoming better understood. There are problems in pushing luminosity above 5×10^{30} per cm^2 per s due particularly to beam-beam effects. It is intended to add strong quadrupoles near the beam crossing points, to add a second harmonic system to reduce satellite resonances and to double the number of r.f. cavities so as to push the peak energy to 20.5 GeV.

Completing the list of electron-positron newcomers, progress with the 8 GeV CESR at Cornell was reported by D. Morse. With a remarkably small team and for remarkably little money, they have managed to build and operate the machine quickly and have reached a luminosity of about 10^{30}. They presently operate at 5.5 GeV or below and have been studying the upsilon resonance. More r.f. is being installed to reach 8 GeV. Cornell are developing a 50 GeV scheme for the future.

Major electron-positron projects for the long-term future are the LEP storage ring for Europe (described at the Conference by A. Hutton and covered in detail in our March issue, page 5 and July issue, page 191) and the colliding linac beam projects at Stanford and Novosibirsk (covered in our December issue 1979, page 403). Burt Richter gave some recent information on the Stanford Single Pass Collider Project, SPCP. These linear schemes have interest because electron-positron storage rings are reaching the limit of 'fiscal feasibility' and, somewhat beyond LEP energies, colliding linac beams will be the only route to go higher. The SPCP could check many of the necessary techniques at lower energies quite apart from its immediate physics interest. The aim is to take beams from the existing linac, with energies increased to 50 GeV via the SLED II project (see July issue 1974), and bend them through two arcs to collide head-on a single time. A design report was produced in June and R and D work is under way at SLAC; the cost estimate is just over $ 60 million with a construction time of three years.

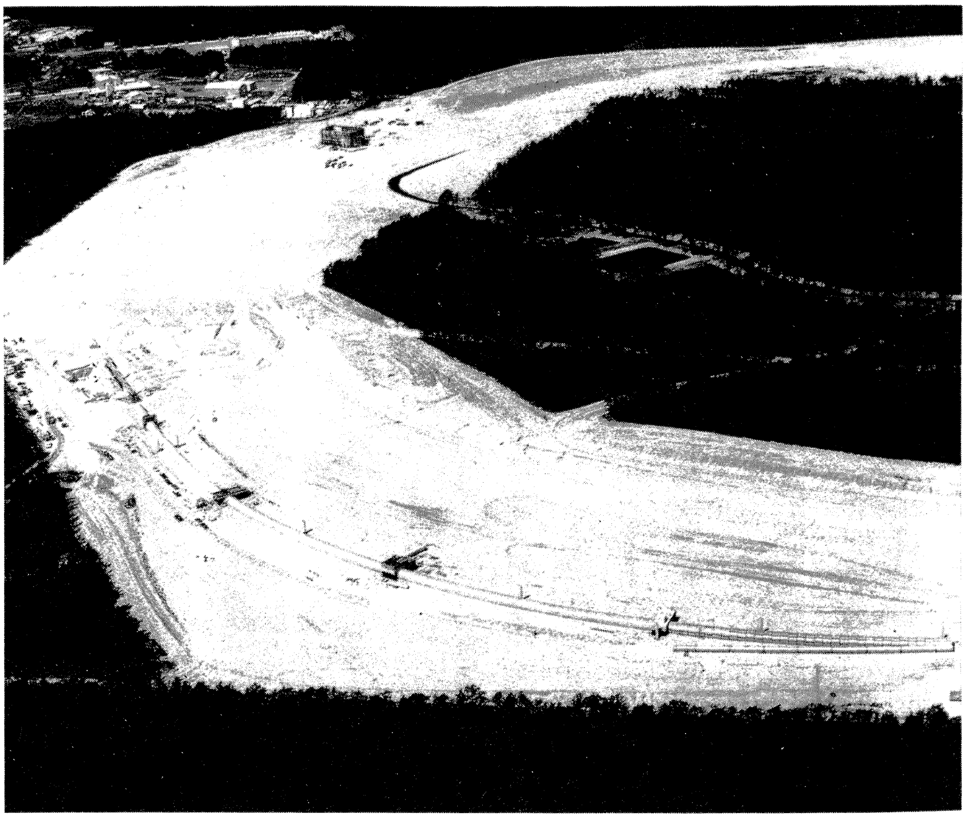
Electron-proton colliding beam schemes have been attracting a lot of interest for many years but seem to have difficulty getting off the ground. Two of the major existing contenders are the HERA project at DESY (described at the Conference by Bjorn Wiik and covered in our May issue, page 99) and the CHEER project for Fermilab (described at the Conference by R.V. Servranckx and covered in our July issue, page 205).

The Japanese project TRISTAN, reported by Y. Kimura, is now putting emphasis on the electron-proton option. They have the necessary particle sources on the Tsukuba site with the 12 GeV proton synchrotron KEK and the 2.5 GeV electron linac being built for the synchrotron radiation facility. The plan is to collide electrons with energies from 6 to 25 GeV with protons from 90 to 300 GeV in a ring of 3 km circumference with four intersection regions. Superconducting magnets and r.f. cavities are under study. Approval is hoped for in 1981 at an overall cost of about 300 million Swiss francs. Electron-proton physics could then start about 1989.

Turning to proton-proton storage rings, the 400 GeV ISABELLE project at Brookhaven was covered by Harold Hahn. Construction of the ring tunnel and experimental halls is advancing rapidly and is scheduled for completion in September 1981. The first arcs are available for component installation. Problems remain however with the superconducting bending magnets and we shall return to this topic later.

The tunnel to house the ISABELLE 400 GeV proton-proton storage rings advances round the Brookhaven site. The tunnel is scheduled for completion in September 1981.

(Photo Brookhaven)



The proton-antiproton collider project for the CERN SPS, described in our June issue page 143, was covered by J. Gareyte. It is proceeding well on its rapid schedule and the passing of the latest milestone is described below under the topic of beam cooling. The equivalent work at Fermilab is going more slowly because the immediate priority is on achieving the superconducting ring. Dave Cline covered the latest calculations on antiproton yield in the Fermilab scheme which indicates fluxes of up to 10^{12} antiprotons per day with optimized energies, target geometries and beam optics.

Jim Griffin reported on the Fermilab projects. It is hoped to complete installation of the ring of superconducting magnets in the Spring of 1982 and to have it in operation by 1983 (the Energy Saver). A year later the addition of more refrigeration should allow 1 TeV beams and open the 1 TeV proton-antiproton collider option (Tevatron Phase I). The fixed target programme at 1 TeV is covered by Tevatron Phase II. It is significant that experimental proposals are pouring in for the 1 TeV fixed target programme. For the distant future some thought has been given to the possibilities of a ring to achieve 10 TeV, filling the whole existing site. Such 'site-fillers' have become common parlance in many Laboratories and here CERN has a particular advantage. Given the underground construction technique, the first geographical limitation to CERN's site-filler may well be the English Channel.

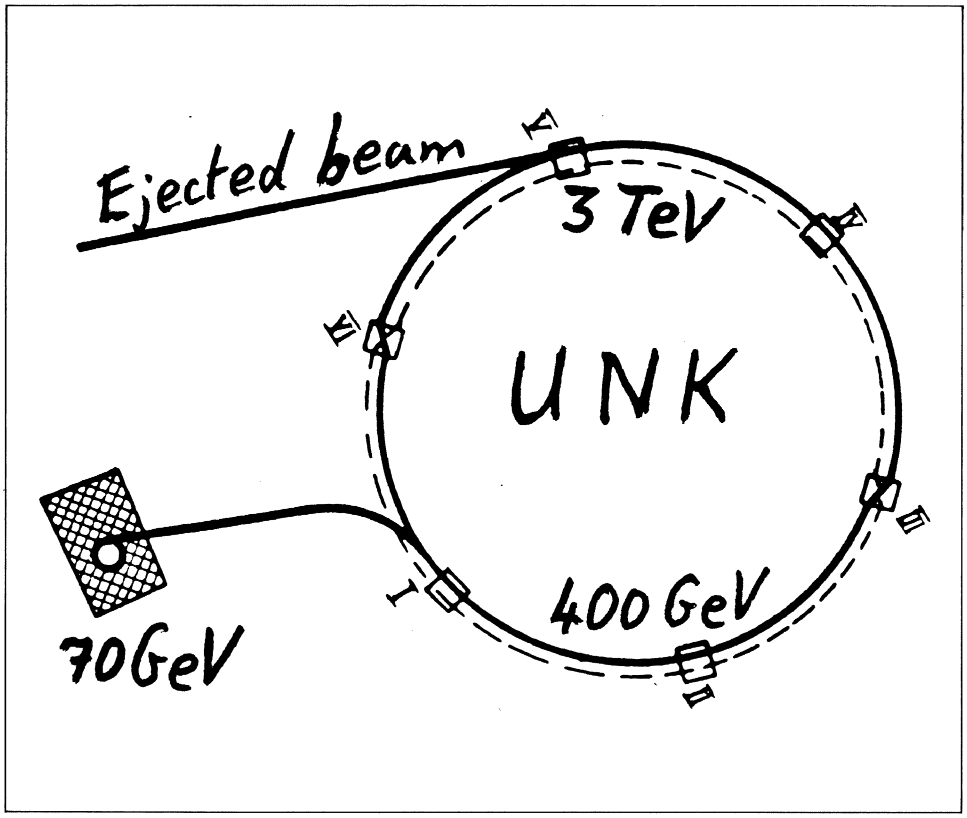
The highest energy fixed target machine likely to be in operation in the next decade is the UNK 3 TeV proton synchrotron, at Serpukhov, reported by K.P. Myznikov. They are increasing the intensity of the existing 70 GeV machine to 5×10^{13} protons per pulse to serve as injector into a 400 GeV ring of conventional magnets serving as a slow cycling booster. This will then feed a ring of superconducting magnets to reach full energy. Colliding beam options obviously include 400 GeV protons on 3 TeV protons and six long (485 m) straight sections are incorporated in the ring to facilitate beam intersections. The tunnel will be made wide enough to allow the addition of another storage ring and permit 3 TeV on 3 TeV proton-proton physics at a later date. Much prototype work is being carried out and it is expected that construction will be fully under way next year.

In China the 50 GeV Beijing (Peking) proton synchrotron, BPS, is under construction and progress was reported by Fang Shou-Xian. Prototype work on many machine components such as linac cavities, booster magnets and main ring magnets is well advanced. A 750 keV preinjector, using a negative hydrogen ion source built in collaboration with Fermilab, and a 10 MeV linac section is being installed at the Peking Institute. Completion of the machine is now scheduled for 1987 — a more temperate rhythm than the extremely rapid schedule initially proposed. It was a pleasure to see the Chinese physicists at the Conference and very impressive to see how rapidly they have absorbed the stringent requirements of modern accelerator technology.

Superconducting magnets and r.f. systems

The use of superconducting magnets and radiofrequency systems in accelerators has been a separate topic in our reports of International Accelerator Conferences ever since the Cambridge Conference of 1967.

Proposed layout of the 3 TeV proton synchrotron to be built at Serpukhov. Bottom left is the existing 70 GeV machine which will be used as injector into a 400 GeV conventional synchrotron, followed by a 3 TeV superconducting synchrotron in the same tunnel. Six long straight sections would allow the possibility of colliding beams at a later stage.



Normally such technologies earn 'separate topic' status when they first emerge and are being mastered (like beam cooling) or rejected (like electron ring accelerators). They are then swallowed into the body of accelerator gospel or disappear from the scene. But superconductivity goes on forever, neither fully mastered nor rejected — an experience which the Chairman of the superconductivity session, Kjell Johnsen, described restrainedly as 'frustrating'. The review talks were given by G. Horlitz on magnets and A. Citron on r.f. systems.

The magnets at last look as if they have reached the stage of refinements rather than anything fundamental. For the mass production of bending magnets, and their use in an operating system, Fermilab are furthest along the line for the Tevatron project. They have about ninety completed magnets; about five dipoles are built per week and achieve the required 4.5 T field in up to five quenches. Their design has cold bore, within the cryostat, and warm iron and their major outstanding problem was vertical twist of the magnet coils due to minimizing the supports so as to keep heat transfer as small as possible. The latest cryostats have had additional supports incorporated, at a cost of about a 0.5 W increase in heat load per magnet, which is tolerable.

These magnets have exhibited no measurable rotation. Magnets have been operated in beamlines and in the ring tunnel, positioned under the conventional magnets, which has provided valuable operating experience both of cryogenic systems and quench protection. A cryoloop of 32 dipoles and 2 quadrupoles has worked well. A large helium plant has operated at the rate of 3000 litres per hour.

Like Fermilab, Brookhaven have about a thousand superconducting magnets to build for ISABELLE. Their design for the bending magnets, involving warm bore and cold iron, is not finalized and the latest models produced in industry were not satisfactory. The average fields went from 3.7 to 4.2 T after many quenches. It begins to look increasingly difficult to achieve the 5 T fields corresponding to 400 GeV operation but 4.5 T should be within reach. The latest design modifications aim to reduce excessive inbuilt tensile stress. Kapton is being incorporated on the major slip planes. More copper is being used to increase magnet stability. Improved helium flow and wider braid are being tried.

The model magnets for UNK are being built by Serpukhov in collaboration with Saclay and Leningrad. They are hoping for 5 T with a two layer coil geometry and a 7 cm bore. Results from Saclay were reported in our April issue, page 62. A magnet test facility is being assembled at Serpukhov and production is scheduled to start mid-1981. A model magnet for TRISTAN has been built at KEK closely following the Fermilab design. It reached 4.2 T after ten quenches. At Berkeley, as reported by Bill Gilbert, attention has turned to higher field magnets using lower temperatures and different superconductor (niobium-tin).

On a different scale, another contribution to the Conference from the CERN group of Lorenzo Resegotti reported the production of eight superconducting quadrupoles for an ISR high luminosity insertion. What is significant about this exercise is that, for the first time to our knowledge, industry has successfully provided a series of superconducting magnets for an accelerator. A good omen for the future.

Leon Lederman (standing) and Phil Livdahl examine the superconducting magnets installed beneath the conventional magnets in the Fermilab ring tunnel. Fermilab has made considerable progress in the development of pulsed superconducting bending magnets and hope to have their superconducting ring complete in 1982.

(Photo Fermilab)

Superconducting r.f. cavities have been less intensely pursued until recently, with the exception of some devotees particularly at Karlsruhe, Cornell and Stanford. Now there is a considerable clamour for them as the conventional r.f. systems of the high energy electron-positron storage rings soak up large amounts of power.

A. Citron reviewed a Workshop on r.f. superconductivity held at Karlsruhe which revealed a growing understanding of the complex phenomena involved. The two quantities of interest in an accelerating structure are the Q value (which effectively measures the power losses) and the limiting field (which gives the accelerating field gradient obtainable). Q values some ten thousand times those of conventional copper cavities are hoped for and the values presently obtained depend in part on the operating frequency.

Limiting fields are connected with cavity structures (cylindrical, spherical, muffin tin...) and generally go down with the number of cells which are joined together. Probably the higher the number of cells in operation, the higher the probability that 'in some unfortunate corner' of the structure the actual field reaches breakdown level. The possibility of obtaining improvements has been demonstrated however, for example a 65 cell structure was 'chemically tuned' to achieve the same limiting field performance as a 3 cell structure.

Accelerating fields of 3 MV per m are attainable at any frequency with care. Up to S band frequencies the limitations seem to be due to electron phenomena (multipacting). Cavity shaping and surface treatments help but resonance phenomena can be a problem. Beyond S band the limitations seem to have their origin in thermal phenomena where parts of the superconducting structure go 'normal'.

Surface conditions are much more complicated than might appear on the surface! Rather than a simple niobium to vacuum situation there are oxide and absorbed hydrocarbon layers which change the secondary emission coefficient. This needs some fundamental research. Another approach which should prove fruitful is to improve the cooling conditions so as to reduce or eliminate the thermal phenomena.

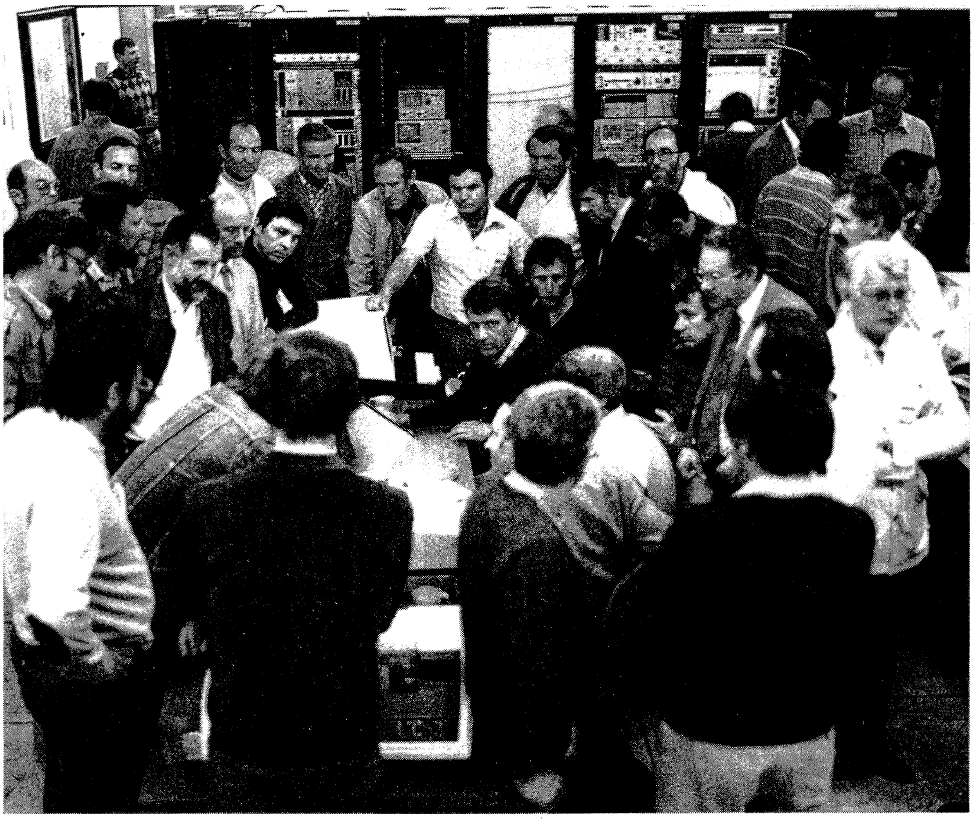
Certainly now that there is greater interest in mastering r.f. superconductivity, there will be a greater attack on the problems. In the near future a Karlsruhe-built cavity will be tried in the DORIS storage ring, much research work will be done in the context of the LEP project and Cornell are pursuing a 1500 MHz cavity (reported by H. Padamsee) for their 50 GeV electron-positron scheme.

Beam cooling

At the last International Conference at Serpukhov in 1977, beam cooling was the newcomer to the list of accelerator technologies whose early impressive tests were greeted with enthusiasm.

At the CERN Conference beam cooling was obviously regarded as a well mastered technique and is already incorporated in major projects. It should be added however that we may not yet have realized many of the potential applications.

Simon van der Meer presented the latest 'state of the art' on stochastic cooling which he invented. Frank Krienen reviewed the work in the ICE storage ring at CERN which did much to confirm belief in both the stochastic cooling technique and the electron cooling technique invented by the Novosibirsk team of Gersh Budker. It was the ICE work which gave such confidence in beam cooling that the exotic projects to achieve high intensity antiproton beams could be launched at CERN.



Roy Billinge (and, just visible, Simon Van der Meer and Eifionydd Jones) at the control console during commissioning of the Antiproton Accumulator at CERN, surrounded by many of the construction team who completed the ring in two years. First operation came just before the start of the Accelerator Conference.

(Photo CERN 77.7.80)

The 'hot news' at the Conference was the spectacular first operation of the CERN Antiproton Accumulator reported in a special intervention by Roy Billinge who led the AA ring construction. The ring, one of the most demanding ever built from the point of view of accelerator technology, was completed in less than two years.

The AA has a very unusual form. The bending and focusing requirements in themselves are modest, since the ring has to cope with antiprotons at only 3.5 GeV, but the requirements of injecting and storing as intense a beam as possible result in very large apertures. The need to deal separately with the uncooled beam at injection and the cooled stack led to the introduction of a shutter to separate injection orbits from the stored beam orbits. Precooling of the injected beam takes place before the shutter is lowered and fresh particles moved into the tail of the stack. Pick-ups and kickers of the cooling systems litter the ring to cater for injected and stacked beams, low density and high density conditions, momentum and betatron cooling, horizontal and vertical planes. Refined diagnostics equipment is present in profusion.

On 3 July proton beams were injected and stored for two hours before being dumped. The lifetime was as expected given the prevailing vacuum. (The vacuum chamber was the only thing that was half-baked about the machine!) During the following days the first evidence of cooling in the precooling orbit position and then in the stacked beam position was obtained.

(Subsequent to the Conference, magnet polarities were reversed and antiprotons were successfully injected and stored. Intensities were initially a factor of 40 down on design but even in the short time available this was improved to a factor of 6. Work then concentrated again on protons for which the beam diagnostics problems are much easier. By now three of the ten cooling systems have been brought successfully into operation. A tremendous amount of detailed work remains to be done to tame the ring before the end of this year but the start of operation has gone better than was ever expected.)

A couple of spin-off ideas from the initial cooling schemes were also mentioned at the Conference. H. Herr reported his work with Carlo Rubbia to develop the parameters of a small electron ring which would allow a 147 MeV electron beam to travel with a 270 GeV antiproton beam along a length of 25 m in the SPS ring. A cooling time of the order of less than 20 minutes is calculated.

Werner Hardt reported work on 'stochastic extraction' another Simon van der Meer idea (related to that invented for stochastic acceleration in synchro-cyclotrons twenty years ago) to use the statistical technique to allow steady spills of particles over very long times. The particular CERN interest is for the LEAR low energy antiproton project where spill times of an hour are desirable but it could be readily applied on other synchrotrons. R.f. noise is fed into the beam around the slow extraction resonance frequency and serves to smooth out spill irregularities due to ripple. Theoretical and practical studies have confirmed the usefulness of the technique. Spills over 9 s were achieved with 98 per cent duty cycle at the CERN PS.

Some Conference faces: 1. Gus Voss with Helmut Reich, 2. Gregg Loew with F. Netter, 3. Leon Lederman with V.P. Dzhelepov and Leon Van Hove, 4. Matt Sands with Burt Richter, 5. Herwig Schopper with Emilio Picasso, 6. Marshall King with Al Maschke.

1.

2.

3.

Heavy Ion Fusion

The possibility of using beams of heavy ions from accelerators to implode deuterium-tritium pellets in a viable fusion reactor remains a big HIF. There are, however, many able accelerator physicists who are convinced of the feasibility of the technique and convinced that this is the optimum route to the fusion reactors of the future. Dennis Keefe gave a review of the present situation (prepared in collaboration with Andy Sessler).

The parameters for power production in a realistic plant now look clear. The energy must be between 1 and 10 MJ, the power between 100 and 600 TW, the driver efficiency multiplied by the pellet gain must be at least 10. Pulse shaping of the heavy ions will be necessary, pulse repetition rates will need to be between 1 and 10 per s and the beams will need to be focused over some 5 to 10 m to diameters of a few mm. Reliability of the plant will need to be over 80% with about a 30 year lifetime. The cost would need to be in the range of a few hundred M$ per GW of output electrical power.

Translated into requirements for the accelerator (assuming a beam of uranium ions) this implies delivering a beam of 2×10^{15} ions at 10 GeV in a 20 ns pulse to give 15 kA and 150 TW of power at the pellet. Two accelerator schemes have been retained to meet this specification. Both use a bank of ion sources and low beta linacs with their beams being brought together to achieve the required ion intensity. One scheme, being pursued at Argonne and Brookhaven, then uses r.f. (Alvarez) linacs to feed storage rings which then eject to bombard the target from opposite directions. The other, being pursued at Berkeley, uses an induction linac and bombards the target via two arcs (rather like the SPCP).

The development of the low energy end of these schemes is going ahead successfully. High current sources have been operated at all three Laboratories with good currents and good emittance. An ingenious idea of Al Maschke, which goes under the name of MEQALAC for 'multiple beam electrostatic quadrupole focusing linear accelerator', will probably find applications in other areas besides the heavy ion fusion work.

At low particle velocities drift tubes in r.f. linacs have to be shorter and of smaller bore; using electrostatic quadrupoles bore sizes can be made orders of magnitude smaller and the costs are less. A formula can be worked out specifying the maximum current which can exist in a linac at one time. MEQALAC skirts around this by having many 'beamlets' passing through many independent electrostatically focused channels. Bringing together these beamlets, after passing them through a pepper-pot type structure, achieves high output current at low energies. With further development, MEQALACs could be replacing all Cockcroft-Waltons in some years time.

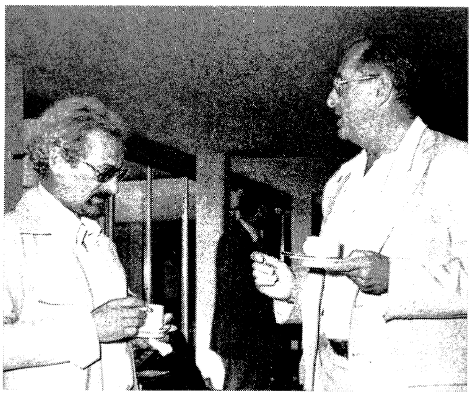
Brookhaven has operated a nine beamlet structure with xenon ions and a four parallel beam proton linac will soon be operated to test the ideas further. A xenon beam from a duoplasmatron source has been accelerated through a Wideroe linac. Argonne has had xenon ions at 1 MV using a dynamitron. Acceleration through a 9 MeV Wideroe linac is the next step to be followed later by a second Wideroe and a large aperture synchrotron to take the ions to 10 GeV. This complex is known as the Beam Development Facility and was described by Ron Martin. At Berkeley the emphasis is on induction linac technology. Xenon and cesium (1.2 A achieved) sources have been operated and a 2 MeV three drift tube structure is yielding beams of the expected quality. It is intended to build 80 m of induction linac structure.

Energy panel

It is logical to move from the topic of potential applications of accelera-

4.

5.



6.

tors in energy production to the subject of a panel discussion introduced at an International Conference for the first time — 'Minimizing energy consumption of accelerator and storage ring facilities'. The panel was chaired by Mark Barton with H. Gerke, Gregg Loew, Dick Lundy and Wolfgang Schnell as panel members.

There are two approaches to the energy consumption question. On the one hand high energy physics Laboratories consume less than one part in ten thousand of the world total electrical energy consumption. If we believe that our research, both culturally and practically, is the most important of the 20th Century, this figure is a long way from appearing an excessive drain on energy resources. On the other-hand, we can never talk glibly about energy requirements of hundreds of megawatts when there are large energy needs elsewhere in the world. We have to be a responsible and socially acceptable part of society which means that it must be seen that we do all that is reasonable to reduce our demands.

Apart from this social responsibility it was obvious in the discussion that we have a vital self interest in minimizing the megawatts simply because they cost money. When Laboratory budgets take a quantum jump downwards it is not easy to switch off people, equipment investments, etc... but it is easy to switch off the power to the machines. Quite small fluctuations in budgets can make disastrous inroads into the research programme.

It seems obvious that all the big new facilities now proposed need to look at the possibilities of using waste heat, microwave power, synchrotron radiation etc... to help other people with heating, drying, cooking, sterilizing etc... This is being done for example with the LEP project. It is certainly not an easy problem, however, because of the intermittent nature of machine operation and the varying operating conditions.

Efforts to improve equipment efficiencies, the introduction of storage devices, the use of superconductivity, the use of pulsed rather than d.c. units etc... are under way. An interesting debate developed on superconducting systems as to whether these would necessarily be power savers. The fact that they need to be cooled continuously regardless of whether the accelerator or storage ring is operating may result, in some cases, in an integrated power consumption which is not dissimilar from conventional systems. Experience will show.

Some attempt may emerge to formalize the communication between Laboratories of information on energy-saving exercises. It is an important thought that the sort of expertise lodged in accelerator Laboratories could emerge with vital ideas for the community at large on energy problems.

Visions of the future

The Conference closed, again following an established tradition, with a look into the distant future. Lee Teng, showing that seven decades in energy had been mastered in fifty years of accelerator construction, extended the scale into the next century (with a 20 TeV proton synchrotron and 350 GeV electron-positron linear colliders). Ugo Amaldi then chaired a panel consisting of Vitali Kaftanov, Burt Richter, Carlo Rubbia, Lee Teng, Bjorn Wiik and Bill Willis which looked at 'Accelerators for the future physics'.

Ugo Amaldi reviewed the present highly successful theoretical picture of matter and forces and drew out the remaining outstanding questions which emerge from it — existence of intermediate bosons, top quark, Higgs particles, further quartets, proton decay, neutrino mass... Burt Richter said that no experimentalist should pay too much attention to the 'received message' of the prevailing very tidy theories. There are peas under the mattress which prevent us being totally comfortable. There are too many particles around, what is the answer to the question of neutrino mixing, etc... He cautioned, however, that very soon, because of the need for ever higher energy devices, we are going to need lots more dollars or new accelerator concepts 'or we quit'.

Carlo Rubbia concentrated on the cosmic ray evidence (Tien Shan and Centauro events) that at higher energies we are going to run into phenomena with no existing explanation. Bjorn Wiik emphasized that substructure beyond quarks is likely and we still have to explain the origin of mass, to find magnetic monopoles and to incorporate gravity into an overall scheme.

Vitali Kaftanov pleaded for continued construction of higher energy fixed target machines to cater for the production and use of many types of particle beam, particularly neutrino and muon beams. Bill Willis concentrated on long-range order amongst hadron constituents for which no 'standard wisdom' exists. We need to create and study pion fluids, the possibility of quark matter, glueballs (blobs of gluons),...

Leon Lederman came in with a nice summarizing intervention, 'Ugo says that at higher energies there is a desert; Burt says there is no desert. Carlo says there is no desert and I can prove it; Bjorn says maybe there is a desert but the sand is not fundamental. Vitali says desert schmesert, there is a lot to do. But Bill Willis is more interesting because he reminds us of history. When physicists discovered the proton and the electron in some order, they gave rise to a new subject called atomic physics which changed the world. Later on physicists found clusters of protons and neutrons in a small space and they gave rise to a subject called nuclear physics which changed the world. Now Bill Willis is pointing out that the desert is full of lizards and cactus plants and all kinds of rich ecology because one can take the new particles and look at their complexities giving rise to a subject which we will call something like 'Complex particle physics' and that is also going to change the world. Some people, probably now in high school, will go on to study physics from thereon. We have a beautiful picture of a future which will guarantee full employment to all.'

Despite the great advances in our understanding of the nature of matter in recent years, there is no sign of lack of interest in the physics of the future and no sign of lack of ability of the accelerator builders to make that physics possible.

Madison Physics Conference

If there was no unexpected major development which emerged as the highlight of the 20th International Conference on High Energy Physics, held at the University of Wisconsin at Madison from 17 to 23 July, there was still something of interest for everybody. Despite the parallel sessions of the first three days being held on campus, the University appeared to cope easily with the impact of 1200 visiting physicists and their needs. With its relaxed Berkeley-style atmosphere and a pleasant site overlooking Lake Mendota, the campus and its attractions provided a welcome balance to the intensity of the physics sessions.

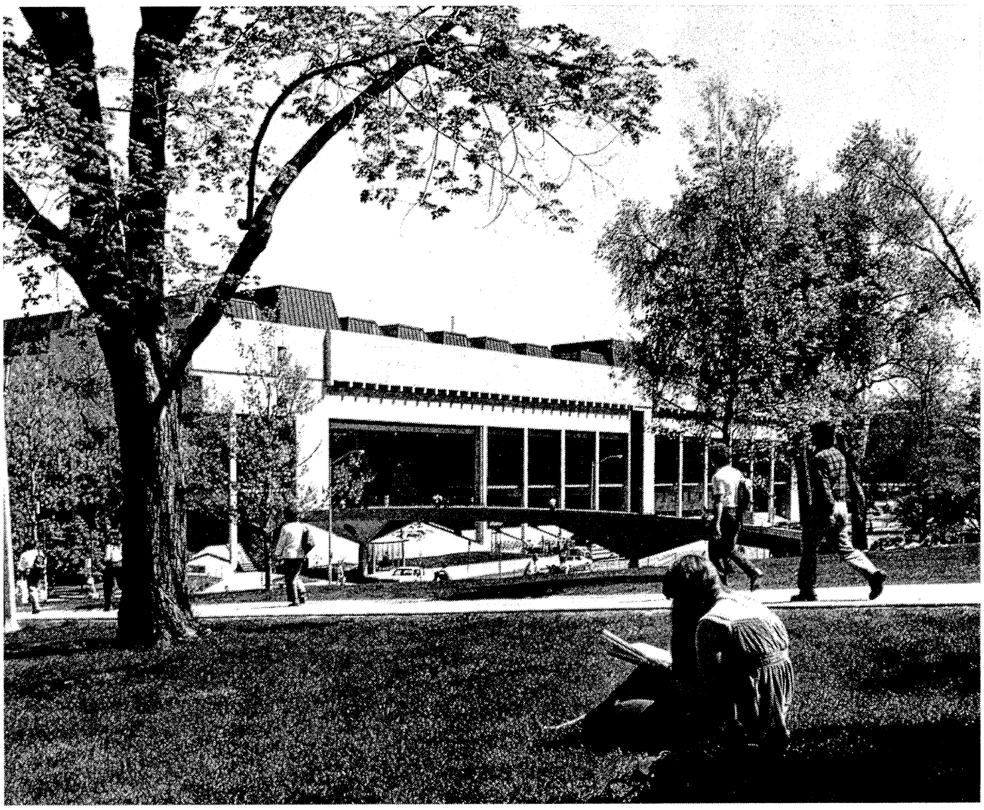
The Madison Meeting was the first in the 'Rochester' series to be organized as an open conference, with a minimum of official invitations being issued. With four streams of parallel sessions, it was inevitable that initially there would be conflicts of interest, and many attendees found themselves frequently commuting between different parallel sessions. At some stages, even the same experiment was being discussed simultaneously in different places.

Despite its size, the conference was impeccably organized. When something did not run according to plan, there were back-up arrangements which made it look as though nothing had gone wrong. Even the usual trauma of registration was made almost trivial thanks to a computer system.

One disappointment was that L. Okun, scheduled to give the keynote speech at the end of the conference, was unable to attend. Over 800 of the delegates to the Conference signed a statement, addressed to A.P. Alexandrov, President of the Soviet Academy of Sciences, which said they were 'deeply disturbed' by this, and the signatures were eventually delivered to the Soviet Embassy.

With a wealth of experimental data to report, reviewers at the conference frequently found it difficult in the relatively short time alloted to cover all the ground. With the electroweak theory now almost history, the accent is very much these days on the analysis of hadronic phenomena. Although quantum chromodynamics (QCD), the emerging theory of quark forces, *The Humanities Building, University of Wisconsin-Madison, scene of most of the parallel sessions at the recent International Conference on High Energy Physics.*

(Photo University News Service)



has a predictive power which seems to grow daily, much of the experimental data has still to be quantitatively, if not qualitatively, explained, and there was a plethora of parametrizations presented at the conference.

According to Chris Llewellyn-Smith, who gave the review talk on QCD, the list of processes and effects suitable for treatment by QCD has grown considerably and the calculational techniques are being continually improved. However from an experimental point of view, the effects which provide a window on inter-quark forces tend to be rare, or subtle, or both. Examples are production of specific particles (direct leptons, single photons or inclusive hadrons), event topology in deep inelastic scattering, and high energy electron-positron interactions.

To attack these measurements, QCD has grown into a major international industry, and Llewellyn-Smith, following the custom of the experimentalists, showed a densely-packed transparency listing the people involved in the effort. (Who knew that Mickey Mouse was involved?)

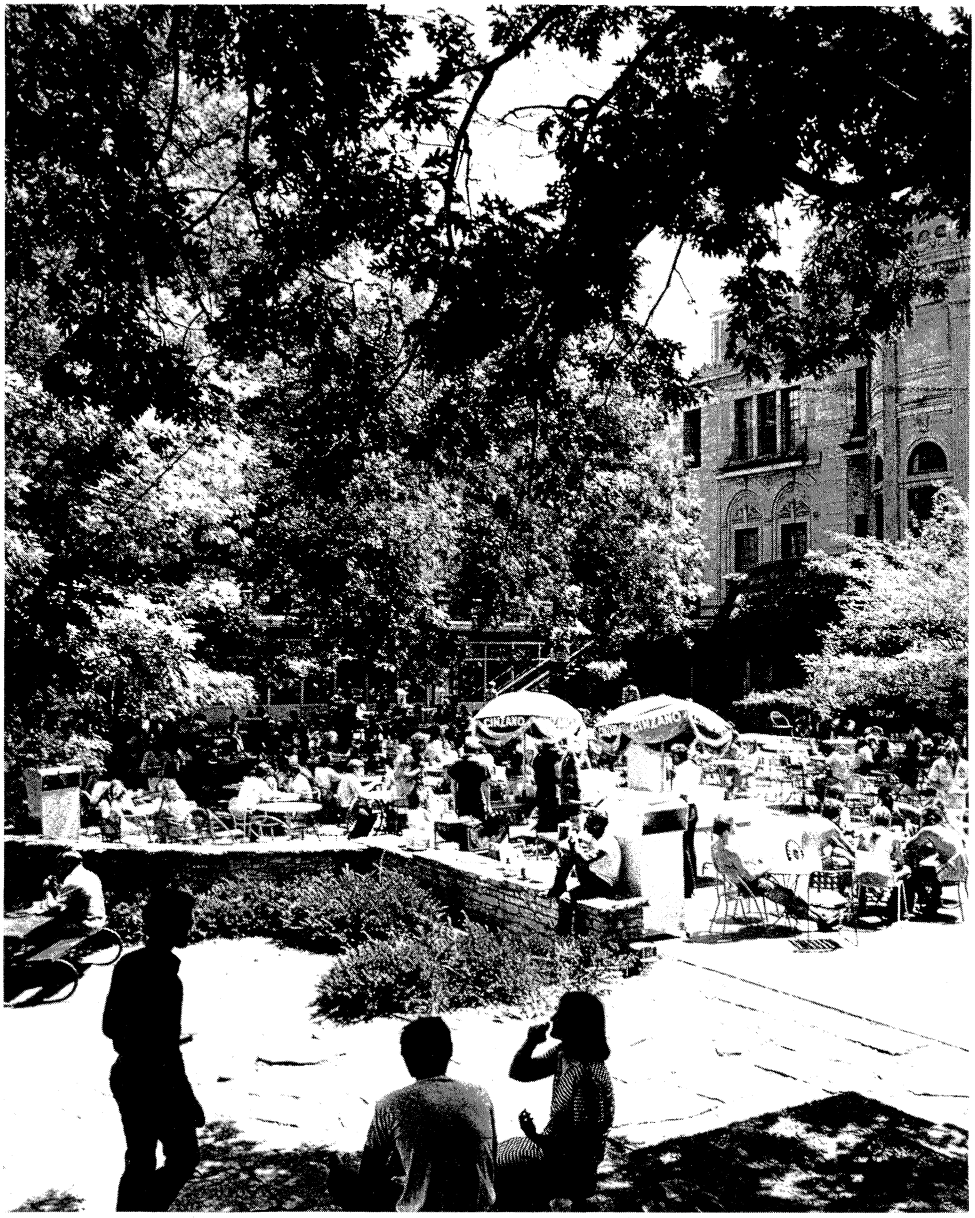
One newcomer effect at the conference was the study of two-photon physics (interactions between two virtual photons emanating from colliding particles), and William Frazer of San Diego summarized much of the present situation in physics in his introduction to the two-photon session. 'The smaller the event rate, the better we can calculate it', he said, and 'while some time ago we knew practically nothing about everything, now we know almost everything about practically nothing!'

While QCD and QCD-related effects proliferated, some hardy annuals of physics remained. There are still new 'old' (i.e. non-charm) particles turning up. The lifetime of charmed particles still provides a talking point, not so much because of disagreement between measurements, but because it is becoming clear that different particles have different lifetimes.

Elsewhere, question marks loomed even larger still over baryonium — the proposed narrow baryon-antibaryon bound states. Now no narrow baryonium candidate appears to have withstood confirmation, and the joke is that baryonium is being replaced by buryonium!

There was a large attendance at some of the early sessions on more ambitious theoretical ventures such as supersymmetry and grand unification, topics which contrast sharply with workaday parametrizations of experimental data. Valuable material for theoreticians came from H. Sobel's talk on the recent neutrino experiment by an Irvine group at a reactor. This still reports an unexpected value for the 'ratio of ratios' — the relative proportion of neutral and charged current events is not what is given by theory. This could be interpreted as evidence for the existence of neutrinos with mass, and different masses at that, giving rise to neutrino oscillations (see July/August issue, page 189).

However evidence for neutrino oscillations from high energy neutrino experiments at accelerators was less optimistic, and in his rapporteur talk on low energy weak interactions, George Trilling of Berkeley attributed the reactor effect to statistics and put forward the view that there is no 'compelling' evidence for neutrino oscillations. In particular, a run with the narrow-band neutrino beam at CERN shows nothing special. There was no news at the conference from the Moscow experiment on the beta decay of



Relaxing at Madison

(Photo University News Service)

tritium, which has also provided evidence for neutrino masses.

A minor controversy surrounded preliminary results from the NA5 Bari/Cracow/Liverpool/Munich/Nijmegen collaboration studying high energy pion and proton interactions at the CERN SPS. This experiment analyses high transverse momentum reactions using a calorimeter which surrounds the streamer chamber vertex detector.

Rather than intercepting clearly defined jets of high transverse momentum particles, this experiment so far picks up what appears to be a mainly uniform distribution of particles. Although there are some signs of increasing 'planarity' with increasing transverse momentum, the behaviour is better described by a statistical model. These distributions of final particles also seem to contain relatively large numbers of charged particles — about 27 if the total transverse momentum threshold is 10 GeV.

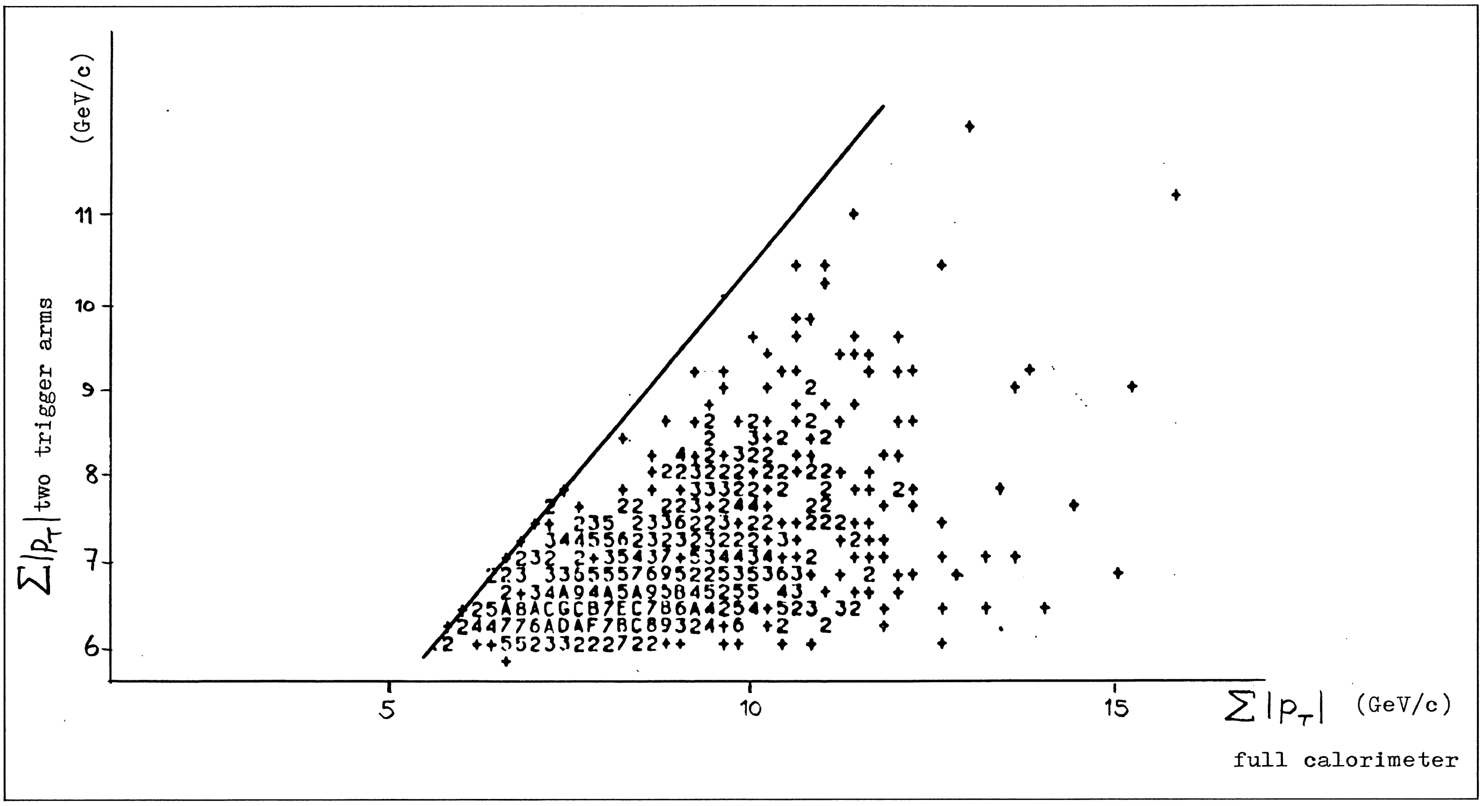
This result provoked some highly polarized comments, as according to some, here was evidence against jets! In his rapporteur talk on deep inelastic processes, Jacques Lefrançois of Orsay took a more conservative line and proposed that jet physics might be difficult at the energies covered by the NA5 experiment.

One thing which has appeared on the scene since last year is the so-called K-factor required in the analysis of lepton pair production by the 'Drell-Yan' mechanism — the electromagnetic interactions of quark pairs. A number of different experiments now find that the magnitude of their experimentally-observed dimuon levels is about 2.5 times larger than that predicted by the model, although the general shape of the spectrum seems satisfactory. This renormalization effect has some theoretical (QCD) basis, although some people thought that putting K as a constant with no kinematical dependence could be an oversimplification.

Another dimuon development is the appearance on the scene of signals from muon pairs containing two particles of like sign, and for which there is no accepted explanation. According to Michael Shaevitz, reporting results from the Caltech/Fermilab / Rochester / Rockefeller high energy neutrino experiment, if his like sign dimuon signal is extrapolated, then the production of like and unlike sign muon pairs will become comparable at Tevatron energies!

While just a short time ago it was a novelty, single photon production in hadron collisions has now been measured in a number of different experiments. It is interpreted as a

This preliminary data from the NA5 Bari / Cracow / Liverpool / Munich / Nijmegen collaboration was a talking point at the Madison Conference. The vertical axis shows the energy picked up in two mutually opposite trigger arms, while the horizontal axis shows the energy deposited in the full calorimeter surrounding the interaction region. The scatter plot shows that at SPS energies, there is as yet little evidence for clearly defined jets of final particles emerging in mutually opposite directions. The distance from the solid line indicates the energy which eludes the two trigger arms.



QCD Compton effect in which a gluon scatters off a quark, producing a photon instead of another gluon, and looks like providing another playground for QCD.

The B-meson (containing a beauty quark) candidate reported last year by the WA11 experiment at CERN has now been washed away in a mass of new data, however new evidence for B-particles (although still indirect) comes from the new CESR electron-positron storage ring at Cornell. Ed Thorndike of Rochester showed how data from the CLEO detector near the fourth upsilon (see June issue, page 151), indicates lots of leptonic activity in the total energy region 10.3–10.6 GeV — just where the B-meson would be expected. Another B hint is that the ratio of kaons to pions in this region increases fourfold, suggesting that the dominant decay is through charm states. The CUSB detector also sees lots of electrons in this region and the probable branching ratios for a B-meson going to a hadron plus electron plus neutrino is similar from both detectors.

Elsewhere in the electron-positron area, the high energy scene is dominated for the moment by PETRA. Results were presented up to 36.5 GeV collision energy, with no signs of any top quark effects. A search for further heavy leptons has so far revealed nothing below 17 GeV. At lower energies, SPEAR continues to be a prolific source of information on the charmonium sector. Another interesting speculation is that the E(1420), seen in the photon decays of psions, might be a long-awaited example of a 'glueball' — a state made up of gluons, but no quarks.

Information on charm production and lifetimes came from a wide range of different detectors. Now the charged charmed meson lifetimes look to be several times, if not an order of magnitude, longer than that of the neutral charmed meson. This keeps theoreticians busy. There were also reports from Fermilab of the observation of the F-meson (carrying charm and strangeness) decays in emulsion, giving a lifetime intermediate between that of the charged and neutral D-mesons. The F-meson was also reported from a photoproduction experiment at CERN using the Omega spectrometer. However the F still eludes the detectors at SPEAR.

Some new data was presented from the Stanford cryogenic experiment which measures the residual electric charge on heat-treated niobium spheres. More fractional charges (always in multiples of one third of the electronic charge) now have been seen, with one sphere displaying nine fractional changes of its electric charge in 14 measurements! On the other hand G. Morpurgo, who has devoted about 15 years to a search for fractional electric charges in matter, had no quark-like charges to report. An effect which Morpurgo alleges could be responsible for the Stanford results was dismissed by the US group. A cosmic ray experiment, reported by P. Yock of Auckland, provided three candidate quark events.

Lucien Montanet's summary talk on 'old' hadrons was far from being old material. Montanet took in the controversial area of baryonium, where in his view the present lack of evidence for narrow resonances is far from being the last word on the subject. Although baryonium for the moment seems to be sinking fast, dibaryons are very much alive. Akihiko Yokosawa of Argonne gave his customary talk on the evidence for dibaryons from the experiments at Argonne with polarized beams and targets. This data has now yielded three good dibaryons and five more candidates (see page 252). Other dibaryon states carrying strangeness were also reported at the conference.

The weak interaction sector now seems to be on such firm ground that electron, muon and neutrino beams are used more as a tool for probing hadron structure. Muon-derived data received a boost from the European Muon Collaboration and the NA4 (Bologna/CERN/Dubna/Munich/Saclay) groups at CERN. Together with electron data from SLAC and neutrino results from CERN and Fermilab, there is now a wealth of information on hadron structure details and QCD parameters from a wide range of experiments. The data is moreover in broad agreement, although there are still some differences to be reconciled.

Although many predictions still seem to be a bit woolly, QCD in general seems to be in good shape for a theory still so young. However a word of warning came from Fermilab Director Leon Lederman during an evening session on the future of high energy physics. Like a lot of people, Lederman was anxious to know when QCD predictions would reach a precision level of within five per cent, but among some of the most severe problems afflicting particle physics today, he listed 'overconfidence of theorists' in a prominent position.

Brookhaven looks back... and forward

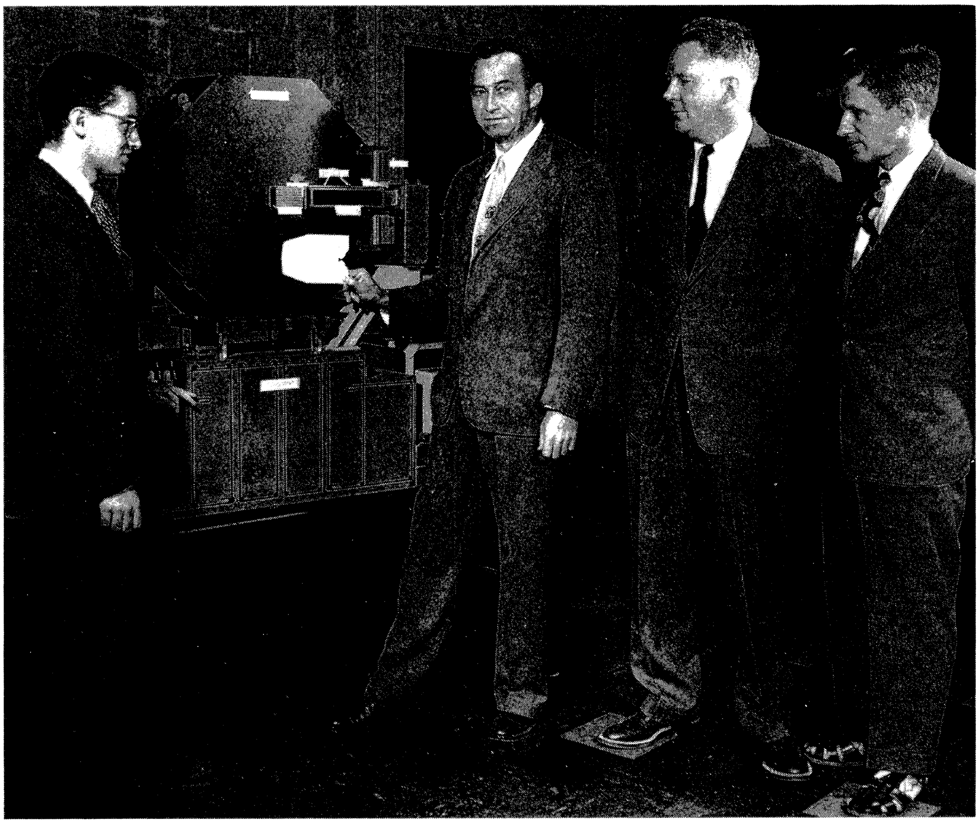
On 22 May, Brookhaven National Laboratory celebrated the 20th anniversary of the bringing into operation of the Alternating Gradient Synchrotron. The AGS circulated its first beam on 26 March 1960 and reached 30 GeV on 29 July. The machine has subsequently reached a beam intensity of 10^{13} protons per pulse, a thousand times greater than originally anticipated. It has been one of the most productive of accelerators for physics, counting among its discoveries the muon neutrino, charge-parity violation, the omega minus, the J/psi, the charmed baryon and numerous other particles and resonances. Today the AGS still sustains a vigorous programme of high energy physics research, serving many university users with a rich variety of beams and facilities. In the future it will also operate as injector for the ISABELLE proton-proton storage rings.

The anniversary celebration was held in conjunction with the annual meeting of the AGS users' organization, HEDG (High Energy Discussion Group). A large audience heard John Blewett and Ernest Courant (Brookhaven), and Kjell Johnsen (CERN) recall the early days of designing and building the machine.

It was an exciting time, beginning with the invention of strong focusing of synchrotron beams by using alternating magnetic field gradients. This major breakthrough allowed much higher energies to be reached for a given cost ($ 30 M for the AGS). It is interesting to note that the 1952 summer study leading to this invention was triggered in part by the expected visit to Brookhaven of a European group planning a Cosmotron-like machine for the nascent CERN Laboratory. The visiting group immediately decided to adopt the new alternating gradient principle for the CERN proton synchrotron. The friendly and open collaboration between the two Laboratories which prevailed throughout the construction of the PS and the AGS was especially emphasized by Kjell Johnsen, who is presently serving as Deputy Director of the ISABELLE project.

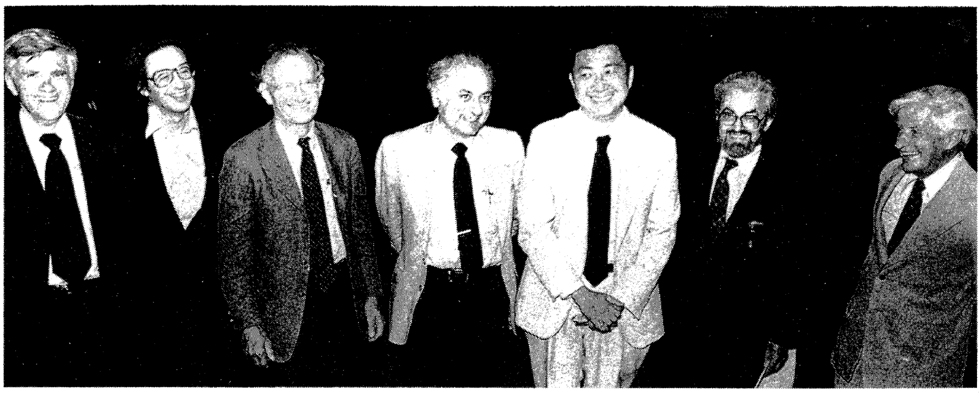
Other speakers reminisced about some of the great physics discoveries made at the AGS. Melvin Schwartz (Stanford University) talked about finding the muon neutrino and reflected on a 'residual

Pioneers of the AGS Brookhaven Alternating Gradient Synchrotron alongside an early scale-model which showed the great reduction in AGS magnet aperture compared to that of the Brookhaven Cosmotron thanks to the invention of the alternating gradient focusing system. From left to right are Ernest Courant, Stanley Livingston, Hartland Snyder and John Blewett.



Below: Speakers at the 20th Anniversary Celebration in May to mark the first operation of the AGS. From left to right are Kjell Johnsen, Nicholas Samios, Val Fitch, Melvin Schwartz, Samual Ting, Ernest Courant and John Blewett.

(Photos Brookhaven)



level of junk' events which were probably neutral currents! Val Fitch (Princeton University) described the discovery of CP violation, an experiment approved on the basis of a two-page proposal with no detailed background calculations. Nick Samios (Brookhaven) read an excerpt from the six-page letter from Leland Haworth (former Director of BNL) to the Atomic Energy Commission which justified the AGS construction project, and recalled the twenty year, 40 million picture bubble chamber programme which included two pictures of particular interest: the first omega minus and the first charmed baryon. Sam Ting (MIT) talked about the experiments leading to the famous J/psi particle which helped usher in the new age of high energy physics with charm, beauty and other gracious qualities.

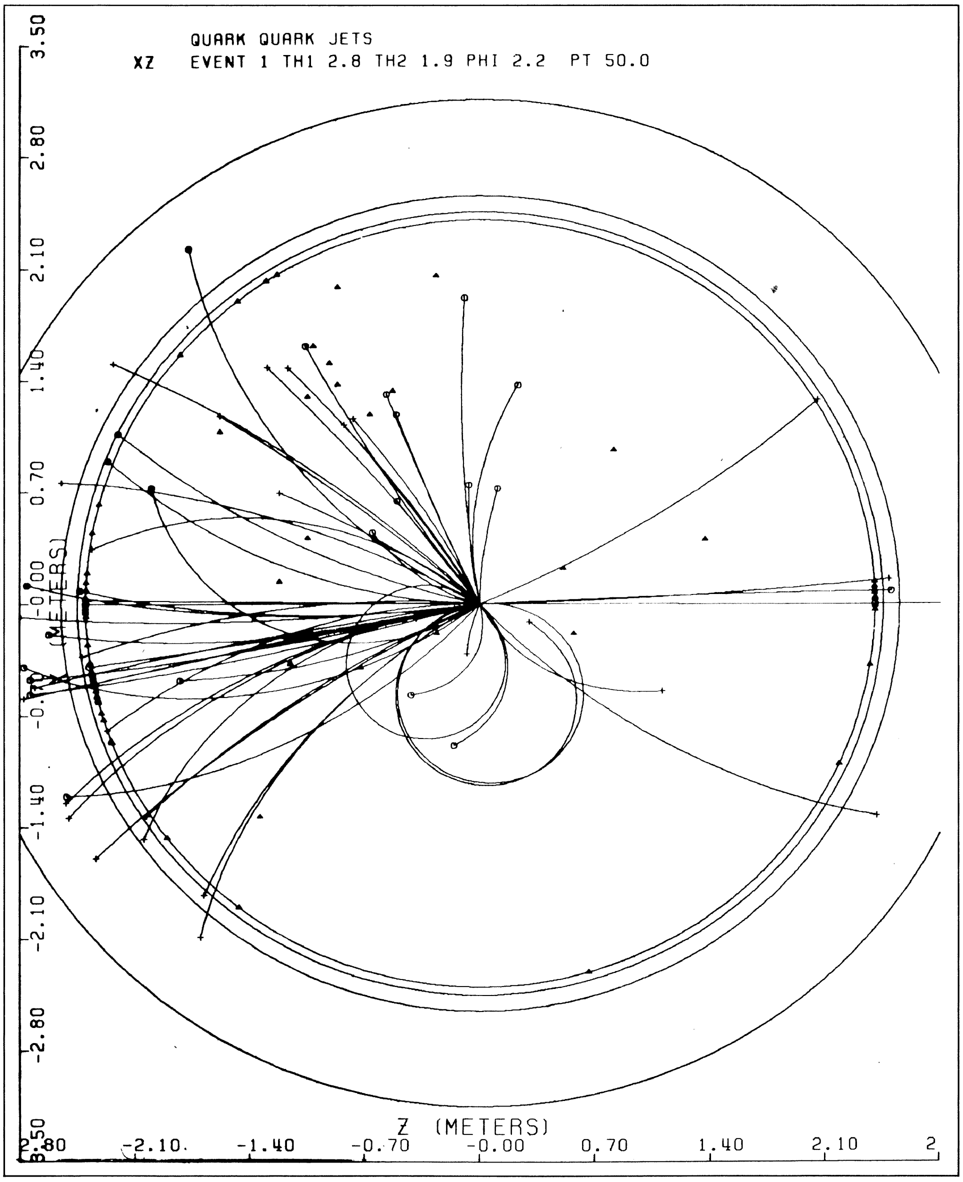
The celebration was concluded with a reception and banquet, highlighted by after-dinner speeches from Maurice Goldhaber, former Brookhaven National Laboratory Director, and C.N. Yang of SUNY Stony Brook.

Looking forward

While the AGS proton synchrotron looks back over 20 years of highly successful and productive operation, Brookhaven is in the enviable position of being the scene of the construction of the major new USA high energy physics facility and has other physics projects under way.

The ISABELLE 400 GeV proton-proton storage rings are now in a fairly advanced stage of construction with the first experimental halls taking shape. However, problems remain with the machine's superconducting magnets. The National Synchrotron Light Source, scheduled to come into operation next year, will be another addition to Brookhaven's considerable range of research tools. At the same time, the venerable AGS, with an impressive list of physics milestones to its credit, has a vigorous ongoing programme. AGS themes include exploitation of intense separated beams, with refined measurements looking for subtle effects, and detailed investigations in special areas. At AGS energies, investigations of specific final states have reduced background to contend with, so low energy is sometimes an advantage, rather than a disadvantage!

The progress on ISABELLE was covered by Harold Hahn at the international accelerator conference at CERN (see page 231). For experiments, the big selling point is ISABELLE's high design luminosity



A theoretician's view of how interactions will look at the ISABELLE proton-proton collider now under construction at Brookhaven. It is the work of ISAJET, an event generator written by Frank Paige and S.D. Protopopescu.

(in the 10^{32} range). However such a high event rate creates its own instrumentation problems, and these are already being tackled.

ISABELLE will have six intersection regions, sited at the two, four, six, eight, ten and twelve o'clock positions on the ring. The six and four o'clock halls are under construction, and work for the two o'clock hall is scheduled to begin shortly.

While formal proposals for ISABELLE experiments are not expected until next year, the general form of the experimental areas has been drawn up after a dialogue with potential users. Hywel White heads ISABELLE's Experimental Areas Division.

ISABELLE's Detector Division, under Bill Willis, has commissioned research and development projects to look into the special requirements of handling the machine's luminosity and extracting new physics from high background rates. However at wider angles, event rates will drop off and present less of a problem.

The instrumentation R & D areas already picked out include calorimeter design to measure hadron jets with good energy resolution, extending drift chamber techniques to cover wire lengths measured in metres and providing good space resolution, and particle identification.

Globally, the idea is to have the big, flexible detectors needed to exploit ISABELLE's interactions ready as early as possible rather than gradually building up detecting power as time goes on. In this way it is hoped that interesting and unexpected phenomena will not lie unobserved during the early years of machine operation.

At the AGS, there is an attractive programme looking at, for example, the deep symmetries of kaon physics (see June issue, page 156).

Other AGS experiments will look into special investigations on, for example, exotic and special states — exotic atoms, multiquark systems, baryonium, hypernuclei etc. In addition, the AGS has to face up to its new role of the proton source for ISABELLE.

A major new project is afoot in the neutrino beamline, where a Brown/Brookhaven/University of Pennsylvania/Japanese collaboration is building a detector containing 150 tons of liquid scintillator, interspersed with drift tubes. This major new addition to Brookhaven's neutrino physics effort will, for example, study the scattering of muon-type neutrinos on electrons. This could shed new light on possible neutrino oscillations. The work has benefitted by funding resulting from the recent US/Japanese high energy physics agreement.

Despite a reduction in running hours brought about by budget restrictions (28 weeks per year rather than 36 or 38), the range of floor experiments supported by the AGS at any time has been extended by the provision of a new bigger switchyard with four beams provided in the same space which previously provided three (see July/August issue, page 198). A new curved beamline will cater for more new experiments, including polarized proton physics.

On a completely different front, the National Synchrotron Light Source (NSLS) brings some of the flavour of big science to small science. Providing a continuously-tunable source of electromagnetic radiation, the NSLS will cater for experiments on the study of solid surfaces, X-ray crystallography, X-ray scattering (usefully complementing the neutron scattering work done using the Brookhaven reactor), *Hywel White, head of the experimental areas division of ISABELLE, at the wide-angle experimental hall under construction at the '6 o'clock' intersection region.*

(Photo Brookhaven)

X-ray lithography, microscopy, etc.

As well as the Laboratory developing instrumentation packages for NSLS users, the aim is obviously to allow users to install their own instruments. In return for free photons, these user-developed units will be expected to be available for 25 per cent of their running time for other users. These new instruments will make what were once physics 'effects' into useful new measuring techniques. Commercial and proprietary users are also keen to get NSLS time.

Brookhaven's particle physics community faces the future with confidence. Their impressive track record of achievements looks as though it is far from being a closed book.

PEP, and more besides...

With the PEP electron-positron storage ring now operational and first physics events being logged, there is a lot of excitement in the air at SLAC.

One big selling point of PEP is its relatively high design luminosity (maximum 10^{32} per cm^2 per s). Collision energies extend from 8 to 36 GeV, and could go on to 40 GeV with the installation of some additional r.f. power. Still higher collision energies could be attained by colliding an 18 GeV positron beam in PEP with an electron beam from the linac, boosted to about 50 GeV by the continuing energy development programme (SLED II).

While many people think that bound states of top quarks and their antiquarks (toponium) are out of reach of PEP and PETRA, this has yet to be proved. But even if toponium is beyond PEP's reach, lighter states containing just one top quark could be picked up.

Other physics aims include the study of hadron jet structure, which is still in its infancy, and possible new heavy leptons. The delicate interference effects between weak and electromagnetic interactions should be detectable, while two-photon physics (interactions between the virtual photons produced from an electron and a positron) is another area of growing interest.

PEP has six beam intersection regions (numbered evenly from 2 to 12), and as the machine started up, five detectors were ready to take data — Mark II and DELCO (both with SPEAR experience behind them), the MAC magnetic calorimeter, a free quark search and a scan for magnetic monopoles. (We managed to get some details of the experimental programme confused in the July/August issue; these paragraphs give the correct situation).

Mark II, a Berkeley/SLAC collaboration, was moved last year from the west pit at SPEAR, where it had done sterling work, to PEP's interaction region 12. One of the first PEP detectors to take data, Mark II plans to look closely at hadron production over the PEP energy range.

The MAC calorimeter (termed 'Big Mac' by some) is a Colorado / Northeastern / SLAC / Utah / Wisconsin collaboration installed in PEP interaction region 4. It is well-suited to measure hadron production rates and to look for leptons. Although it was ready for the first PEP beams, some of the outer drift chambers surrounding the central calorimeter have still to be installed.

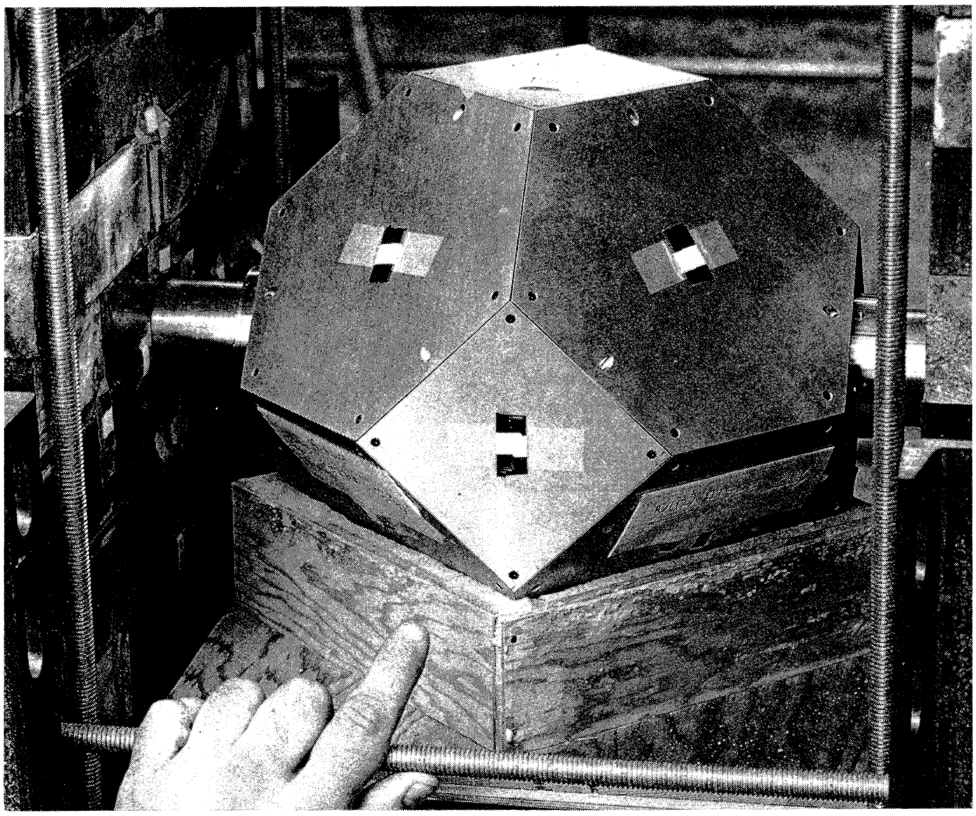
Also already taking data is a quark search by a Berkeley / Frascati / Hawaii / Northwestern / Stanford group. The apparatus is designed to measure electric charge to within ±0.04, and so should easily pick up any fractionally-charged particles around. It uses intersection 6, but will be replaced eventually by the High Resolution Spectrometer using the big superconducting magnet from the old 12 foot Argonne bubble chamber.

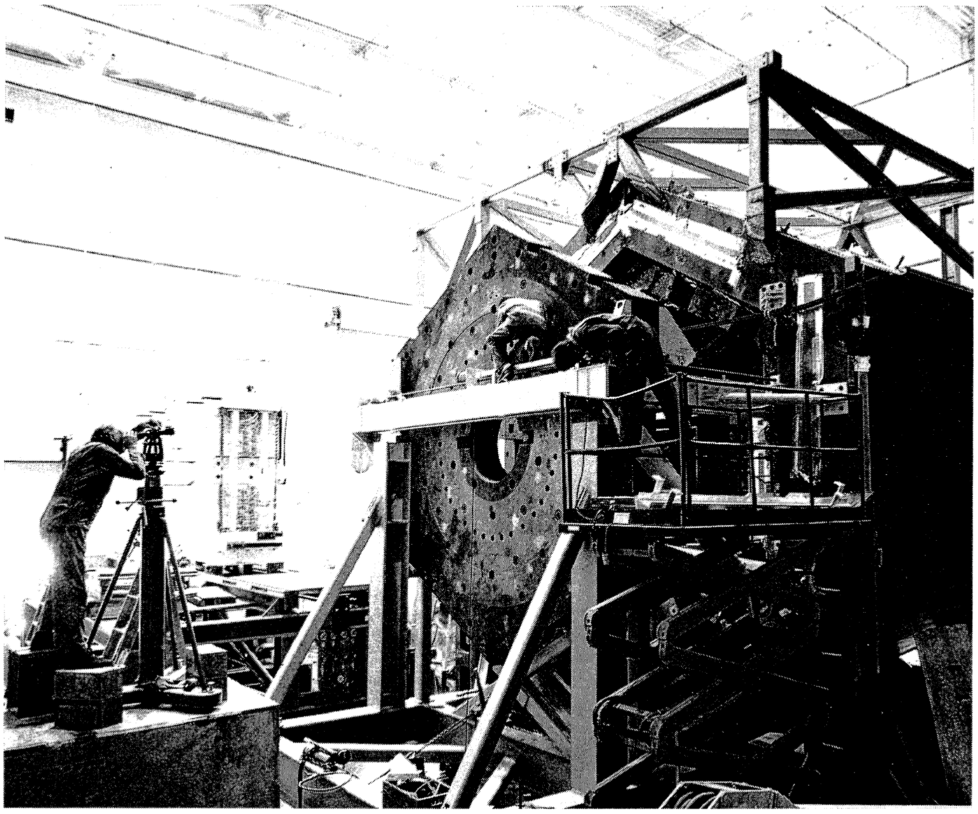
At intersection 10 is a Berkeley/SLAC monopole search using a specially constructed thin section of the PEP vacuum chamber. Highly ionizing tracks would show up after etching the plastic material of the detector after long exposure.

Like Mark II, DELCO (Caltech/SLAC/Stanford) has SPEAR operating experience behind it, but has been upgraded for PEP, where high multiplicities are expected. DELCO

One of the first experiments to take data at PEP was this small detector built by a Berkeley / SLAC group to look for signs of magnetic monopoles.

(Photo Joe Faust)

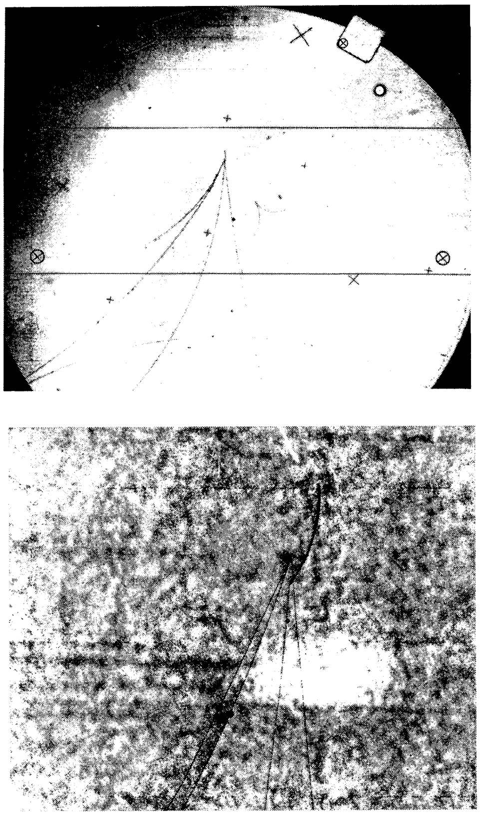




Pole base being fitted during the assembly of the apparatus for the Time Projection Chamber (TPC) experiment at PEP. In the background can be seen part of the apparatus of the Amsterdam / Davis / Santa Barbara / San Diego experiment to study two-photon interactions and which will eventually straddle TPC at PEP's intersection 2.

(Photo Joe Faust)

A new development with the hybrid detector at SLAC, where the one metre bubble chamber has been equipped with a high resolution camera capable of seeing bubbles just 50 microns in diameter. Seen here is an interaction in the chamber and an enlargement of the vertex.



already has achieved much at SPEAR and looks for more physics honours at PEP. It was replaced at SPEAR in 1978 by the Crystal Ball, and next year Crystal Ball will once more follow in DELCO's footsteps and move to PEP. Whether the Crystal Ball will replace DELCO at intersection 8, or whether the two detectors will alternate is still not decided.

Detectors lined up for PEP include the High Resolution Spectrometer (Argonne / Berkeley / Indiana / Michigan / Purdue / SLAC). The big superconducting magnet, trucked overland from Argonne amid a blaze of publicity, has been slightly modified and is now to provide a horizontal magnetic field instead of a vertical one. Inside the magnet will be drift chambers and a barrel shower counter.

The Time Projection Chamber (TPC) of the Berkeley/Johns Hopkins/Riverside/Tokyo/UCLA/Yale collaboration will occupy the central part of intersection 2. A special detector to look at two photon reactions is being built by an Amsterdam / Davis / Santa Barbara / San Diego group and will straddle TPC.

The small SPEAR ring is now almost lost in the SLAC landscape, but has produced a volume of physics information out of all proportion to its size. SPEAR is far from being made redundant by PEP. Besides operating as the Stanford Synchrotron Radiation Laboratory, SPEAR still has the Crystal Ball in operation in the east pit. In addition a new Mark III detector is being built by a Caltech/Illinois/Santa Cruz/ SLAC/Washington collaboration to occupy the west pit vacated by Mark II. The Crystal Ball has just completed a new scan of the total hadron cross-section. Both these detectors want to look for the F meson reported by DESY, but which has so far escaped detection at SLAC.

At the linac itself, beam energies of up to 33 GeV have been attained as a result of the SLED I energy improvement programme. In addition, prototype equipment to allow a further energy boost (SLED II) is being installed as part of the accelerator development programme.

End Station A, scene of many illustrious experiments including the first measurement of the interference between weak and electromagnetic interactions, is now only used for test beams.

The LASS large-angle spectrometer operates in End Station B, and the hybrid bubble chamber is now in End Station C so as to be able to exploit the new monochromatic back-scattered photon beam.

An interesting new development with the hybrid detector is a high-resolution camera capable of seeing 50 micron diameter bubbles in the one-metre chamber. First pictures have been taken and the collaboration hopes soon to have some results on charm photoproduction.

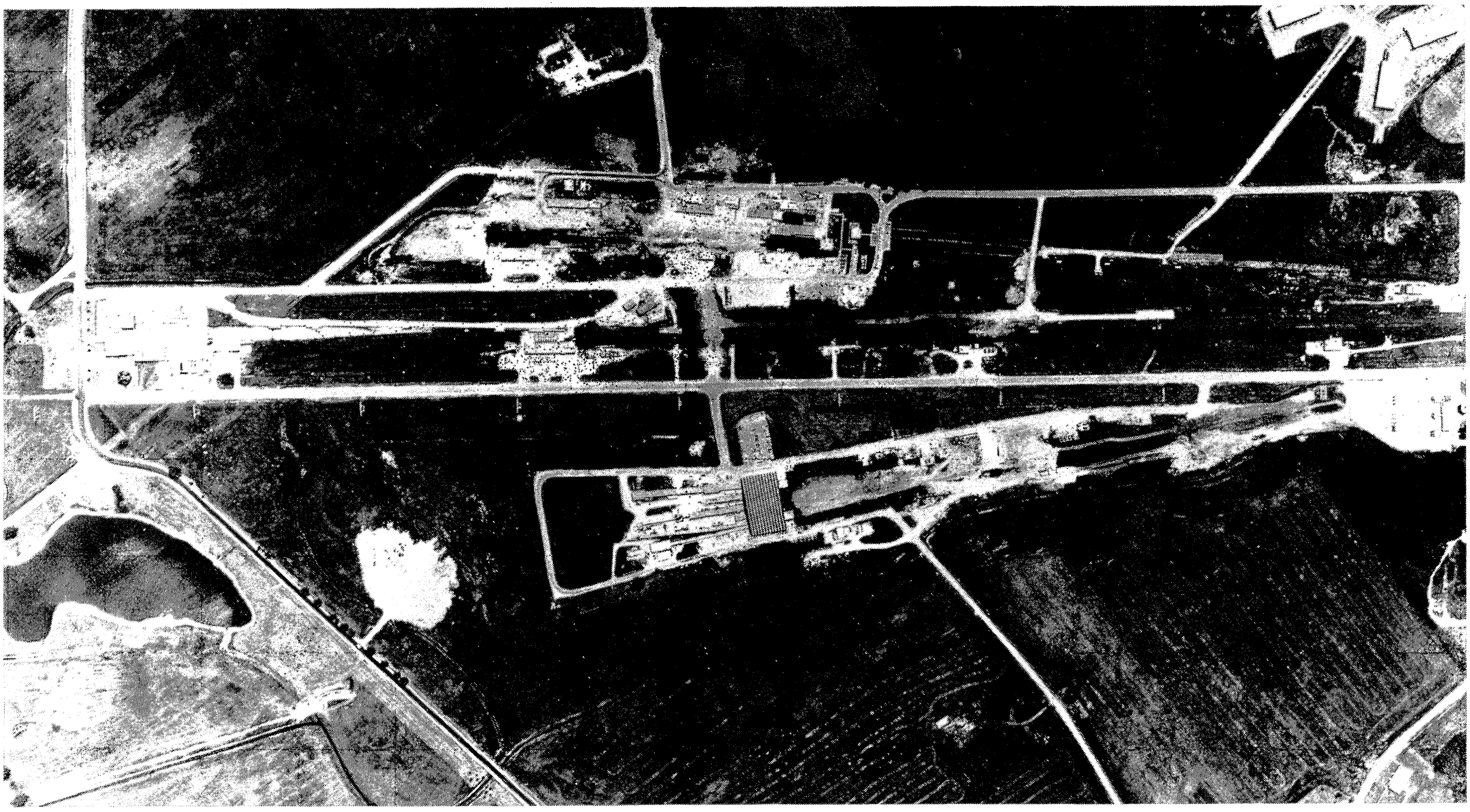
As a result of the recent US/ Japanese agreement on collaboration in high energy physics, the hybrid bubble chamber and LASS at the linac, and the TPC detector at PEP, will benefit from Japanese funding.

One cloud on the horizon is US funding. SLAC is perhaps fortunate that, unlike the proton Laboratories, it can absorb cuts in operational budgets by feeding its electron-positron rings at low linac pulse rates (60 per s instead of a possible 360 per s). However this disturbs those fixed target experiments (like LASS) which prefer to log events at a high rate. Other operational problems are posed by regional power restrictions (brownouts). However despite these problems, the SLAC physics programme, retains its traditional high quality.

Preparing for 1000 GeV physics at Fermilab

Aerial view of the experimental areas at Fermilab, which receive beam from the main ring, away to the right. The three areas are the Meson Laboratory (bottom), Neutrino (centre and centre left) and Proton (top), although these days these labels are far from accurate descriptions of the physics carried out.

(Photo Fermilab)



While work continues to equip the Fermilab ring with superconducting magnets, attention is also turning to the task of adapting the beamlines and experimental areas for the physics programme which will exploit the availability of 1000 GeV protons.

With the PEP and CESR storage rings in operation at SLAC and Cornell, and the ISABELLE collider under construction at Brookhaven, Fermilab provides US physicists with their major outlet for fixed target physics. But Fermilab also plans to have its collider, with 1 TeV proton and antiproton beams probably coming together in two experimental areas (although plans for only one detector are presently taking shape).

Despite the appeal of a collider project whose centre of mass energy will outstrip anything made by man, Fermilab Director Leon Lederman sees the Tevatron fixed target programme as his initial primary objective. He advocates that Fermilab, as a national Laboratory, should cater for a wide range of experiments and a broad user base. For the Tevatron, he envisages a programme of smaller, faster experiments using multi-purpose spectrometers.

Russ Huson, Head of the Accelerator Division, aims to convert the bulk of the existing three-way split to the experimental areas for 1000 GeV operation before the Tevatron itself comes on. One initial, and crucial, task is to install a string of 20 superconducting magnets in the 'left bend' which serves the Meson Laboratory. (The three experimental areas at Fermilab are labelled the Meson, Neutrino and Proton Laboratories, although these are not necessarily accurate descriptions of the respective physics experiments they house.)

The superconducting magnets for the right bend, serving the Proton Laboratory, are scheduled for a few years' time. Although the beamlines serving the Neutrino Laboratory will contain only conventional magnets, a lot of modifications have to be carried out, including the installation of ten thousand tons of steel shielding from the old Argonne ZGS.

In the Meson Laboratory, the M6 cryogenic hadron beamline is in operation, and according to Research Division Head John Peoples, means that Fermilab has 'crossed the Rubicon' in the large scale application of superconductivity.

M6 contains east and west branches. The west branch contains the MPS multiparticle spectrometer, which after its initial applications now operates as an open user facility. Using MPS and a large calorimeter, a Caltech / Fermilab / Illinois /

Indiana / Maryland / Rutgers collaboration is soon to embark on a study of jet structure. Another scheduled MPS experiment is by an Arizona / Fermilab / Florida State / Notre Dame / Tufts / Vanderbilt / Virginia collaboration looking for resonances decaying into two pairs of charged particles.

In the M6 east branch, an experiment studying elastic scattering at large momentum transfer is making way for another jet study, this one using the sophisticated calorimeter of an Argonne / Fermilab / Lehigh / Pennsylvania / Rice / Wisconsin group.

In the M1 beamline, previously the scene of hadronic charm production, construction is under way for an additional building downstream of the existing hall. This will house a new experiment to look for signs of new particles in final states (e.g. dimuons) as far out as the kinematics allow. The collaboration includes participants from Europe and Japan as well as the US and will use two big magnets from steel salvaged from the old Nevis cyclotron.

First data has been taken in the M2 line for a beam dump experiment by a Michigan / Ohio State / Wisconsin group using a neutrino detector containing 150 tons of shower counters. Meanwhile another major beam dump run is scheduled for the neutrino area, using the 15 foot bubble chamber.

Neutral particles are provided by the M3 line, where an experiment by a Chicago / Stanford / Wisconsin group has just finished looking at the properties of exotic atoms with muons bound to pions. Its place is being taken by a similarly composed collaboration aiming at precision measurements of charge-parity violation in neutral kaon decays. Right underneath M3 is the M4 enriched negative kaon beam.

As well as catching neutrinos, the Neutrino Laboratory also houses studies with secondary hadron beams serving the hybrid detection system composed of the 30 inch bubble chamber and the CRISIS electronic instrumentation downstream. Muon beam studies have also been carried out, but future muon users will be catered for by a new beam providing particles of up to 800 GeV. This would require an experimental area some 600 metres further downstream than anything which exists so far. The Chicago cyclotron magnet, now largely rebuilt, could be moved from its present home in the neutrino area for these new muon experiments.

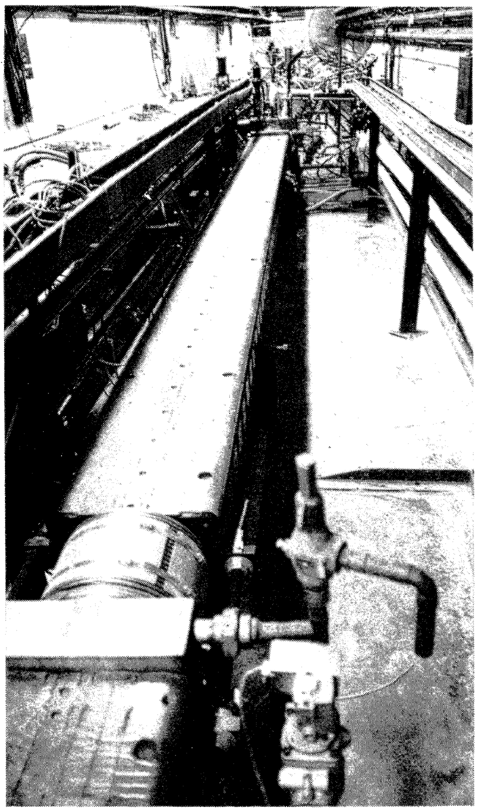
Neutrino experiments proper at Tevatron energies are expected using the Caltech / Fermilab / Rockefeller / Rochester detector containing 1200 tons of iron, and using the 15 foot bubble chamber. Downstream of the big bubble chamber, a new experiment by a Fermilab / Michigan / MIT / N. Illinois group will soon come into operation. Upstream of some toroids from the old Fermilab / Harvard / Pennsylvania / Wisconsin (HPWF) apparatus, this experiment has a 500 ton detector using flash chambers with magnetostrictive readout. It is well-suited to measure neutral current interactions and neutrino-electron collisions.

The US / Japan / Canada collaboration using an emulsion target and downstream spectrometer in the neutrino beam has already reported a difference between the lifetimes of charged and neutral charmed particles. It is now improving its apparatus for further measurements. Another emulsion experiment uses an emulsion stack placed inside the 15 foot bubble chamber.

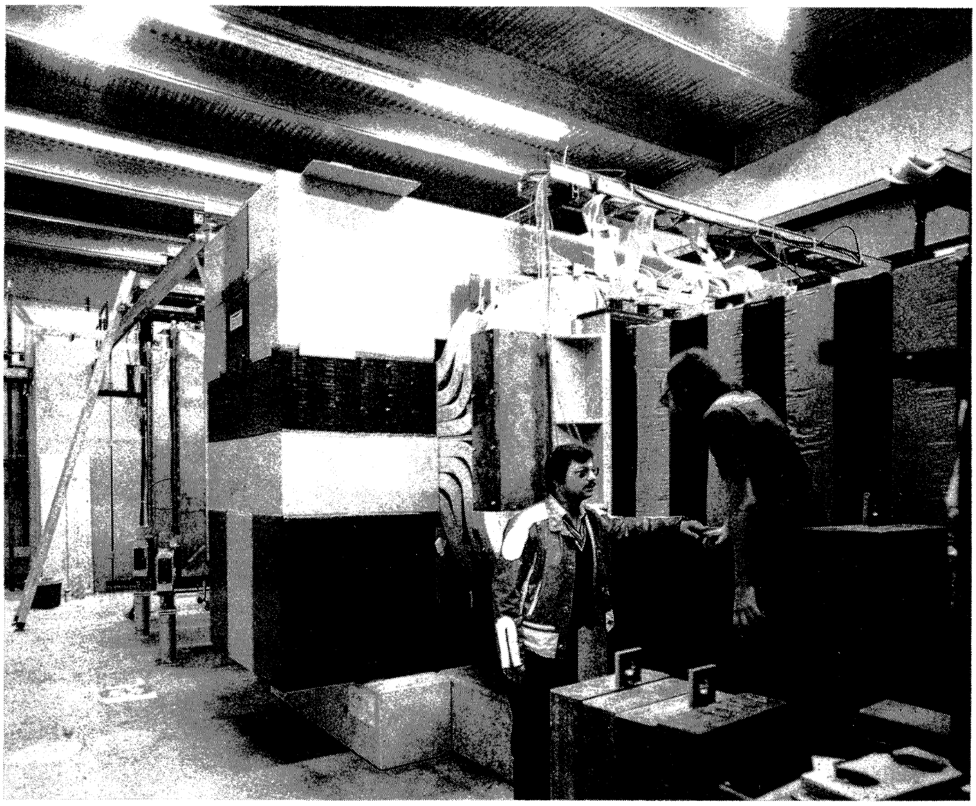
Another possibility is the installation in the Fermilab neutrino beam of the detector from CERN used by the CERN / Dortmund / Heidelberg / Saclay team led by Jack Steinberger. No dates have been fixed, and one immediate problem would be to find a home for this huge detector, which would be difficult to accommodate in the existing halls.

The Proton Laboratory is now entirely devoted to experiments with secondary beams of hadrons and photons. A big effort here has gone into the construction of a major new spectrometer for use in a tagged photon beam by a number of different experiments. There is a separate broad band neutral beam for either photoproduction studies or for charm (or charm-associated) production. These various neutral beams make up the now enlarged proton east area.

In the central proton area, the experiment which discovered the upsilon in 1977 has been removed


The M6 superconducting beamline in Fermilab's Meson Laboratory. The successful operation of this beamline marked a significant milestone in Fermilab's superconducting programme.

(Photo Fermilab)



Apparatus for a Tevatron-compatible experiment at Fermilab which will soon produce data on dilepton production at high energies. By an Athens / China / Fermilab / McGill / Michigan collaboration, it uses an unseparated beam of antilambdas to provide, among other things, antiprotons.

(Photo Fermilab)

and replaced by a Fermilab / Iowa State / Yale group using a charged hyperon beam. The Fermilab / Yale experiment using a streamer chamber to study rare decays is scheduled to move here from the Meson Laboratory.

Proton West is a new high intensity area and is the scene of two experiments looking at dimuon production. One is the Chicago / Princeton group using a spectrometer made from the old Cosmotron magnet hoping to see detailed effects in the dimuon spectrum, while the other is an Athens / Fermilab / McGill / Michigan collaboration, with Chinese assistance. This is a major project, and will use pions and antiprotons coming from the decay of lambda antiparticles. As well as looking at the continuum production of muon pairs by quark electromagnetics, this experiment will also be able to scan for possible new heavy states. It should complement the data obtained by the NA3 group at CERN.

Preparing for the time when the Tevatron runs as a proton-antiproton collider, a big detector is being designed to monitor the 2 TeV centre-of-mass collisions. The final form of this detector is not yet decided, but basically it will have a 1.5 T superconducting solenoid with finely-segmented shower counters and calorimetry outside. The detector will surround the Tevatron beam pipe, but will also have to contend with the 500 GeV ring. Unless a bypass is constructed, this ring will have to pass through the detector.

Preparing a physics programme for a wide user base while having to endure fiscally enforced machine shutdowns poses obvious problems. However, the reduced power requirements of the Energy Saver offers the promise of some 48 weeks of running per year for the same energy bill as some 32 weeks per year with the conventional magnet ring.

Fairly soon, Fermilab will be the scene of the highest particle energies in the world, both for fixed target and for colliding beam experiments. This will make the Laboratory a real world focus for physics research and could open the door to new and significant discoveries.

Helium transfer line tested

The first segment of the helium transfer line, that will eventually run around the Fermilab Main Ring on top of the berm, has been completed and successfully tested. The line is an important ingredient in the construction of the Energy Saver/ Doubler.

It was a major accomplishment for the Energy Saver Cryogenics Group. The transfer line is 900 feet long (the second longest helium transfer line in the world, second only to the one in the Proton Area at Fermilab) and runs from the refrigerator in the A1 service building to the refrigerator in the A2 service building.

It covers 1/25 of the distance around the Main Ring. When completed, the full transfer line will be supplied from the Central Helium Liquefier Facility, which recently came on line as the world's largest producer of liquid helium. The refrigerator in the A1 service building is operating at this time as a miniature CHLF making liquid helium. The helium then moves through the transfer line as supercritical helium (liquid helium under high pressure) to the A2 refrigerator that is operating as a normal satellite refrigerator.

The transfer line is coaxial and carries more than one fluid. The

Around the Laboratories

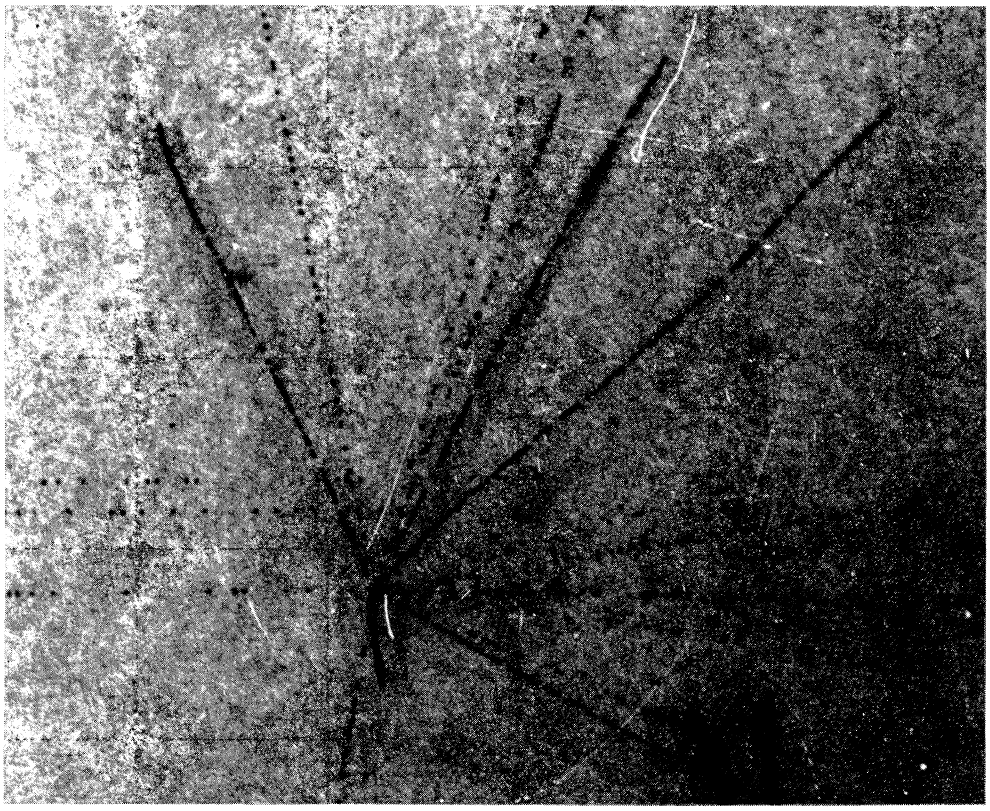
supercritical helium is carried in a stainless steel pipe, 1.77 inches in diameter, surrounded by a vacuum. Next comes a supercooled liquid nitrogen shield at minus 315°F and several more vacuum spaces. The total outside diameter of the tube is more than six inches.

The temperature of the helium is minus 450°F. During the test, droplets took twelve hours to move from the A1 building to the A2 building. A droplet of helium warmed up by 20°F and a droplet of nitrogen by 10°F in passage.

The next steps are to extend the line to the A3 building, then to the nearby Central Helium Liquefier Facility, and back to the A4 building. The system has been designed so that despite any failure in the line (when a segment around the ring is 'lost') the system will continue to operate unaffected.

At present, three refrigerators are running and two compressors are operational. The A1 refrigerator cooled the string of 25 superconducting magnets in the A1 tunnel that were used in an early test of the superconducting system. The A2 refrigerator is being used to cool a string of forty superconducting magnets in the A2 tunnel. These magnets and their associated cryogenic system are now undergoing tests. The B1 refrigerator provides the liquid helium that cools the string of twenty magnets in the B12 test facility.

Particle tracks recorded in an argon bubble chamber for the first time at the CERN SPS. The use of this bubble chamber liquid has some very interesting advantages.



CERN
Successful tests of argon chamber

Bubble chambers refuse to die. This detection technique, which has poured out such a colossal amount of beautiful physics data over the past few decades, looked like being superseded by the improving abilities of electronic detectors with their additional advantages of selectivity and rapid data taking rates. But bubble chambers are bouncing back in hybrid systems and rapid cycling versions. There are new developments in associated techniques such as holography (see June issue, page 154) and recently there was a successful demonstration at CERN of the use of argon as the chamber liquid. Argon has several interesting properties which might be exploited over the next few years.

The idea of using argon had been proposed several times in the past but it is believed that the recent tests in a pion beam at the SPS are the first ever to show that particle tracks can be obtained in argon. Similar results were also achieved in nitrogen and in argon-nitrogen mixtures. The bubble chamber specialists involved were G. Harigel, G. Linser and F. Schenk.

The use of argon could allow more information to be drawn from the interaction region (rather than from outside the bubble chamber with surrounding electronics as in the usual hybrid systems). For example, introducing wires into the chamber volume for charge collection would give calorimeter type information. Immediate data on the energy content of hadron or electromagnetic showers could thus be obtained as well as the visual information from the bubble chamber picture. (This is now being tried at CERN.) There is also the possibility of measuring the relativistic rate of rise of ionization and thus identifying high momentum particles with the help of bubble counting.

Liquid argon is an appropriate scintillator material and the fast signal of the scintillation light when events occur could be picked up by external photomultipliers to trigger the taking of a photograph. Argon has the advantages of being cheap, of being an inert gas and of being cooled to the necessary temperature conditions (around 130 K) by liquid nitrogen. A much smaller volume swing is required than with the usual heavy liquids in order to become sensitive for track formation. The expansion system can thus be rather similar to the types used in hydrogen bubble chambers.

Pictures were obtained at CERN with pure argon using a 2.7 l test chamber. The track quality was excellent and control of chamber conditions was easy. The results with argon/nitrogen mixtures showed that it would be possible to adapt chamber properties to particular requirements concerning radiation lengths as is already done with hydrogen/neon mixtures. If the tests continue to be successful, then much larger argon bubble chambers could soon appear on the scene.

ARGONNE
Results on dibaryon states

One of the more interesting experimental results to come out of the last days of the polarized beam programme at the Argonne Zero Gradient Synchrotron was the large energy dependence in proton-proton total cross-section difference in pure longitudinal spin states (see October issue 1977, page 330,and October 1978 issue, page 347) measured by the Argonne polarized target group. Together with data on the cross-section in transverse spin states (from Michigan / Argonne / St. Louis and Rice / Houston groups) and measurements of polarization and spin correlations in elastic scattering (by several experimental groups), this has led to interpretations regarding dibaryon resonances. This interpretation has been supported by some proton-proton phase-shift analyses and other kinds of evidence, both experimental and theoretical.

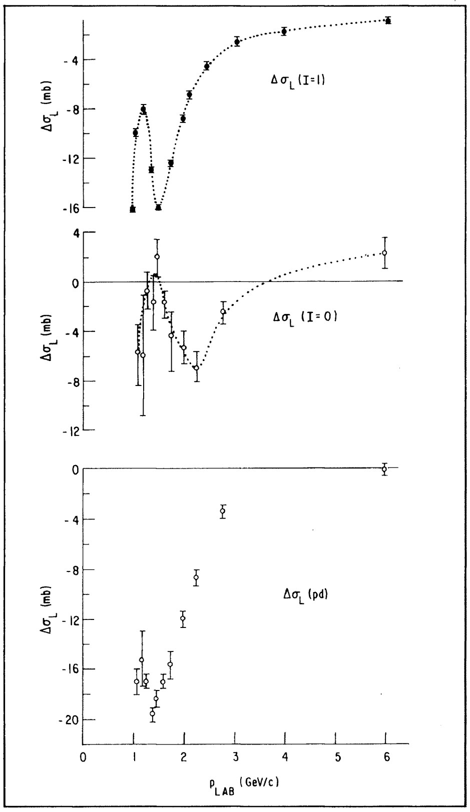
The existence of isospin one dibaryons suggests the existence of similar isospin zero states and indeed some MIT 'bag-model' calculations predict many such states. The measurement of the total cross-section difference in pure spin states for proton-neutron interactions gives information on both isospin one and isospin zero states. The isospin zero channel is free of nucleon-lambda production so that the interpretation of the results is simplified.

During 1978 and 1979, the polarized target group at the ZGS measured the total cross-section difference in longitudinal spin states for proton-deuteron interactions with a polarized beam and polarized deuteron target. This appears to be the most viable way at present to obtain the information on proton-neutron interactions since polarized neutron beams of the required intensity and energy are not easily produced.

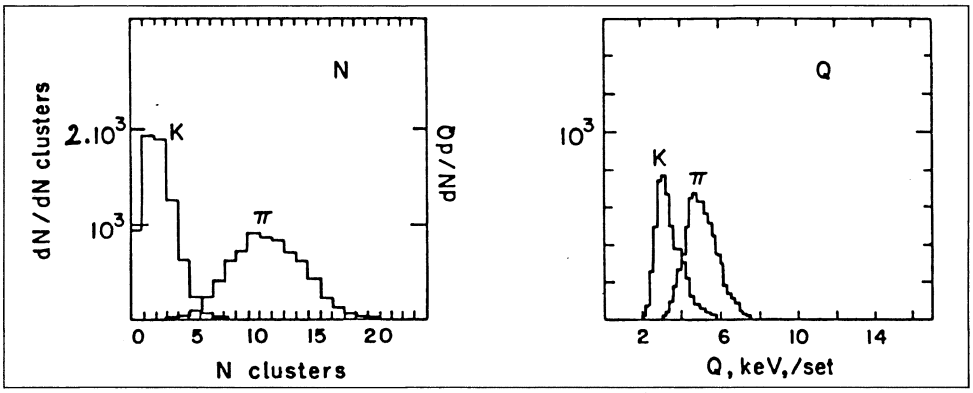
Final analysis is almost complete and preliminary results are available. There are complications in extracting the proton-neutron data from the deuteron target results (including spin-dependent Glauber corrections, the significant real parts of the amplitudes, Coulomb nuclear interference, Fermi motion, the deuteron D wave, as well as the rapid energy dependence of various amplitudes). The cross-section difference in the proton-deuteron results show a smooth energy dependence compared to the proton-proton results. The structure for isospin zero is essentially a reflection of the structure in the proton-proton results. The Argonne group was able to recheck their measurement during the proton-deuteron runs because their target contained both protons and deuterons which could be selectively depolarized.

Data taken by a Rice group just before the shutdown of the ZGS on proton-deuteron interactions in transverse spin states will help to determine the spin singlet amplitudes but many different types of data will be needed to pursue all the questions raised by this part of the spin physics programme of the ZGS.

Total cross-section differences in pure spin states extracted from experiments with polarized beams and polarized targets at the Argonne Zero Gradient Synchrotron.



Improvement in kaon-pion separation using a new technique with transition radiation detectors, from an experiment by a CERN/Moscow group. Rather than measuring total ionization charge (right), the new method (left) concentrates instead on the detection of clusters of intense ionization.



CERN/MOSCOW Transition radiation detector developments

A charged particle moving a medium of varying density generates a changing electron polarization in the medium, which gives rise to electromagnetic radiation, called transition radiation (TR). It is closely related to the more familiar Cherenkov radiation which peaks in the ultra-violet region of the spectrum, while TR is observed in the X-ray region, for photon energies in the keV range. The rate of photon production increases in proportion to the photon energy, for a given threshold, and a TR detector can be a thousand times shorter than a Cherenkov threshold detector.

For a long time technical problems prevented the practical application of this phenomenon. These included the problem of developing a radiator with low-atomic number (in order to avoid photon absorption in the X-ray region), and with the correct microscopic structure to ensure efficient radiation. Also, the photons are radiated at very small angles to the particle track, leading to difficulties in separating signals coming from the photons from those due to ionization.

The first use of TR for high energy physics took place at the CERN ISR five years ago, in an experiment on electron pair production, which used radiators fabricated from thin lithium foil.

A CERN/Moscow collaboration has recently completed an experiment to explore improved methods of TR detection, in a continuation of earlier work together with Aachen and Brookhaven. In this work, the signal due to the ionization of the track is effectively suppressed by concentrating on the detection of the clusters of intense ionization produced by the photons. (The ionization due to the track has only occasional clusters of this type due to delta-rays.)

A drift of the ionization electrons along the track direction is used effectively to divide the chamber into several layers. The number of such clusters is then counted, using a threshold of about 4 keV. This avoids the fluctuations in ionization energy, characteristic of the Landau distribution, which limit the accuracy of the standard method since it integrates the total ionization signal.

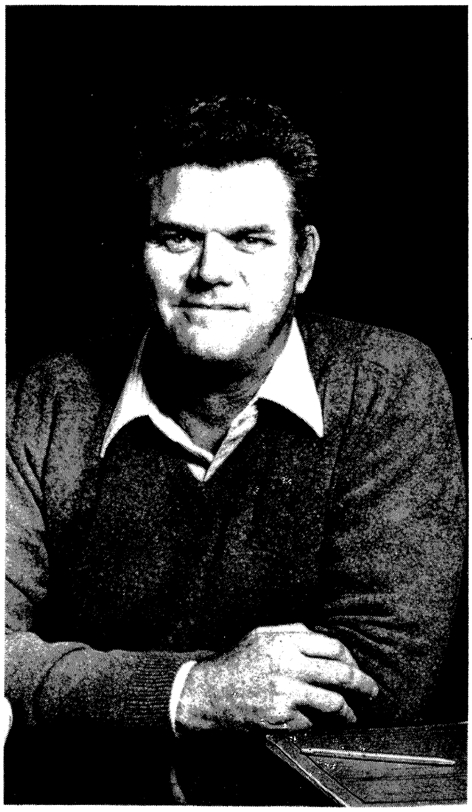
A compact set of twelve chambers and carbon film radiators has been run in hadron and electron beams at the SPS. With the new method where the number of clusters is counted, there is a significant improvement in electron-pion and kaon-pion separation, compared with the old method where the total ionization charge is measured. The electronics is also simpler and the requirements on chamber gain tolerances are much relaxed.

Performance is also considerably improved with respect to previous TR detectors. Electrons can be separated with a pion rejection of a thousand in less than 70 cm, and separation for 140 GeV kaons and pions can be achieved in only 132 cm.

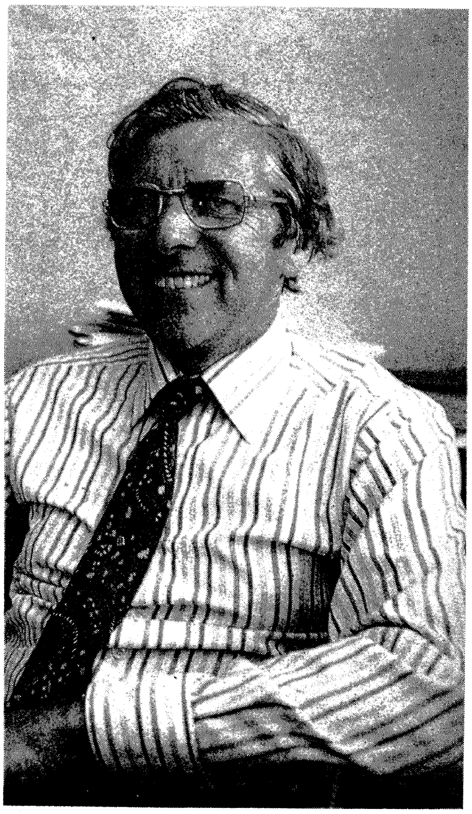
With this method of detection, the principal limit to the performance is just the statistics on the number of photons radiated. Further development of the radiators can be expected to double the number of photons produced, leading to further substantial improvements.

People and things

Dick Taylor



Godfrey Saxon



On people

Richard Taylor of Stanford University has been awarded the degree of Doctor Honoris Causa at the Université de Paris-Sud, Orsay. The award was in recognition of his work which gave some of the first evidence for the existence of structure inside hadrons, his recent demonstration of parity violation in the interference between neutral current and electromagnetic processes, and his important role from 1958 to 1961 in the bringing into operation of the linear accelerator at Orsay.

This year sees the 75th birthday of the distinguished Swiss physicist Ernest C.G. Stueckelberg von Breidenbach. After studies at Basle and Munich, Stueckelberg has held staff positions at Princeton, Zurich, Geneva and Lausanne. His physics activities cover a wide field, including molecular theory and relativistic thermodynamics. However he is perhaps best known for his contributions to quantized field theory. His discovery in 1953 of the renormalization group has widespread implications in both field theory and solid state theory. His research in relativistic quantum electrodynamics, with the integral determination of the S-matrix (1948) and the representation of its elements in graphical form (Feynman diagrams) earned him universal acclaim. In more recent years, he has turned to once more to thermodynamics, and has written a work 'Phenomenological Galilean Thermokinetics'.

Abdus Salam has been given the degree of Doctor Honoris Causa by the University of Istanbul for 'his contributions to physics, his great ability to use physics as an efficient tool of peace and comprehension between nations and his contribution to the development of physics in Turkey by his continuous interest and by providing material and moral support for Turkish physicists.'

The John G. Rutherglen prize for 1980 goes to Stephen John Wimpenny of Sheffield University. The Prize is given to a postgraduate student in experimental physics from one of the universities traditionally associated with research at the NINA electron synchrotron at Daresbury.

Godfrey Saxon of Daresbury Laboratory has been awarded the OBE (Officer of the Order of the British Empire) in the recent Queen's Birthday Honours List. He has been active in the field of electron accelerators since 1949 when work started on the design of the first linac for X-ray therapy. He joined Daresbury in 1964 and later assumed responsibility for accelerator physics investigations on NINA where for the last three years of NINA's life he was responsible for the accelerator's operation and development. He is now closely associated with the 2 GeV storage ring for synchrotron radiation experiments and has particular responsibility for the future development of this machine.

On 21 June in Florence, Antonino Zichichi was awarded the 'Lorenzo il Magnifico' European Prize for Science by the International Medici Academy. The prize aims to draw attention to the example of outstanding personalities in science, art and literature who have honoured Europe and promoted European ideals. Among the many scientific achievements of Professor Zichichi, particular mention was made of lepton-antilepton pair pro-

Vladimir Shekhter

duction in hadronic interactions, such as led to the award of the 1976 Nobel Prize to Sam Ting, of pioneering work towards the heavy lepton through the study of electron-muon final states in electron-positron annihilation, and of the series of searches for quarks. His contribution to the promotion of European collaboration in physics was highly appreciated. During the same ceremony, President of the European Parliament Simone Veil was also awarded the 'Lorenzo il Magnifico' Prize in acknowledgement of her work for European ideals.

Appointments at CERN Council

At the CERN Council meeting in June, Director General designate Herwig Schopper announced his first two nominations for the CERN Directorate as from January 1981. Giorgio Brianti will become Technical Director with responsibility for the accelerator divisions and Site and Buildings Division. Emilio Picasso will become the eventual LEP Project Leader. Three other Directorate Members will be nominated soon — two for the research programmes and one for administration. The appointment of Erwin Gabathuler as Head of Experimental Physics Division has been extended for one year from January 1981. Abdus Salam and L. Okun have been elected new members of the CERN Scientific Policy Committee. Council also paid tribute to S.A. Wouthuysen, who was attending a session of the Council for the last time as delegate from the Netherlands, a post he has held for many years.

Vladimir Shekhter

High energy theorist Vladimir Shekhter from Leningrad Nuclear Physics Institute died on 8 July after a merciless illness. Recognized mainly for his work on the quark structure of hadrons and multiparticle production, he recently became Head of the LNPI Theoretical Laboratory. His untimely death comes as a deep shock for his friends and for the physics community which knew him.

LEP project at CERN Council

At the 66th Session of the CERN Council on 27 June the project to construct a large electron-positron storage ring, known as LEP, as Europe's next major facility for high energy physics research was formally presented for the first time. The Council agreed that, particularly in the context of the use of the existing CERN proton accelerators (the PS and SPS) in the injection scheme for LEP, the new project can be considered as an extension of the existing CERN facilities. This simplifies authorization procedures in a number of the Member States. It was also agreed that the form of the project now under discussion is that known as 'Phase 1', involving the construction of an electron-positron linac, an accumulator ring, the use of the PS and SPS in the injection system, the construction of the 10 km diameter LEP main ring, equipped so as to reach (initially) an energy of 50 GeV per beam, and the equipping (initially) of four experimental halls for colliding beam physics. The total cost of Phase 1 is estimated at 900 million Swiss francs and it is hoped to finance construction from within existing CERN budget levels over a period of eight years, though first colliding beams could be achieved sooner.

HERA meeting in Munich

A meeting, organized jointly by DESY and the Max-Planck Institute in Munich, will be held in Munich on 24–25 October for those interested in the construction and later use of the proposed HERA electron-proton colliding ring. The main purpose of the meeting is to present the status of the technical studies and to discuss how a collaboration between DESY and interested institutions can be organized. Those wishing to participate in the meeting should contact P. von Handel at DESY not later than 1 October.

USA-China collaboration extended

On 19 June papers were signed at Fermilab extending the collaboration in high energy physics between the USA and China which first took formal form early in 1979. Some 200 physicists from the Peoples' Republic of China have been working at the USA Laboratories (Argonne, Berkeley, Brookhaven, Fermilab and Stanford) in recent years in order to develop rapidly the expertise in accelerator technology which they need to construct the 50 GeV proton synchrotron which is to be built near Peking. The details of the extended collaboration will be worked out by the US-PRC Joint Committee in High Energy Physics.

Signing of the agreement to extend collaboration in high energy physics between the USA and China. James Leiss, Associate Director for High Energy and Nuclear Physics, from the USA Department of Energy and Zhang Wen-Yu, Director of the Institute for High Energy Physics in Beijing sign the document at Fermilab assisted by Bill Wallenmeyer and Qian Hao. In the second row are W. Hartsough (Berkeley), R. Rau (Brookhaven), W. Panofsky (Stanford), T. Fields (Argonne), L. Lederman (Fermilab), Zhao Dong-wan, Vice-Minister of the state scientific and technological commission of the PRC and Ji Cheng, Zhu Hong-yuan, Xie Jia-lin, Zhang Hon-ying, and Xiao Jian (Beijing).
(Photo Fermilab)

Symposium on History of the Particle Physics

At the end of May, a second International Symposium on the History of Particle Physics was held at Fermilab. The first (in 1977 at Minnesota) had covered nuclear physics through to the 1930s and the Fermilab meeting moved on from there with Paul Dirac on 'The origin of quantum field theory', Gilberto Bernardini on 'The intriguing history of the mu meson', Viki Weisskopf on 'Growing up with field theory (the development of quantum electrodynamics in half a century): personal recollections', Carl Anderson on 'Unravelling the particle content of cosmic rays including the discovery of the positron and the muon', Satio Hayakawa on 'Development of meson physics in Japan', Robert Gerber on 'Elementary particle physics in the 30's, a view from Berkeley', Bruno Rossi on 'The decay of mesotrons, 1939–1943, experimental particle physics in the days of innocence', Willis Lamb on 'Fine structure of hydrogen and some other atoms', Julian Schwinger on 'Renormalization theory of quantum electrodynamics – an individual view' and Robert Marshak on 'Particle physics in rapid transition'. Charles Weiner, a professor of the history of science and technology also gave 'A historian's view of the perils of doing contemporary history'.

To mark the International Symposium on the History of Particle Physics, a small exhibition was mounted at Fermilab of memorabilia spanning eighty years of the search for the fundamental structure of matter. Items on display included a four-inch cyclotron built by Lawrence and Livingston in the 1930s, the forerunner of today's giant (and tomorrow's even bigger) accelerators. Other exhibits reflected the dramatic development in instrumentation which has occurred since the early days. In particular, a number of intricate mechanical devices for harmonic and pulse-height analysis displayed well the ingenuity which was used before modern electronics and computer technology made their impact. A more up-to-date item was the interactive video terminal on-line to Fermilab computers which showed in full colour the Feynman diagrams describing different kinds of electromagnetic interactions.

MARIA in Alberta

The Government of the Canadian province of Alberta has given interim funding for the conceptual design of an accelerator complex which will consist primarily of a heavy ion synchrotron giving ions up to A = 40 and 600 MeV/amu. The project has the acronym 'MARIA' — Medical Accelerator Research Institute, Alberta. Situated close to existing hospitals, the centre would have extensive treatment and radiographic facilities. In addition, there would be an experimental area for fundamental research in physical and biological science. The facility would be shared by a broad range of users covering radiography, nuclear medicine, microsurgery, radiopharmacy, biomedical engineering and physics. Two injectors are anticipated, one of which would normally be used for isotope production. It is anticipated that construction could begin next year and heavy ion beams would be available in about five years.

The MARIA project will be holding a number of workshops in the autumn to define the best approach for such a facility. A Workshop on

Left to right, Robert Marshak, Paul Dirac, and Willis Lamb chat informally with a group of Fermilab theorists during the recent symposium on the History of Particle Physics held at Fermilab.

(Photo Fermilab)

Radiation Oncology Beams will be held on 9–10 October, and one on Accelerator Systems and Ion Sources from 20–24 October. Anyone interested in attending these meetings should contact the appropriate organizing committee, MARIA Project, University of Alberta, Edmonton, Alberta, T6G2E1, Canada.

Cryogenic Workshop at Fermilab

On 16, 17 June a Cryogenic Workshop was held at Fermilab to focus on helium refrigeration systems for superconducting high energy accelerators. Over 90 people, including representatives from the industrial sector and Europe (G. Horlitz from DESY and P. Genevey from Saclay), together with sizeable groups from Brookhaven, Berkeley, Stanford and Fermilab, attended the two-day meeting. Coordinators from other energy programmes which use superconducting technology and, therefore, similar cryogenic equipment also attended.

One major accomplishment was the exchange of previously uncirculated informal technical papers. Bill Hassenzahl of Berkeley acted as editor of the Workshop report, which includes summaries of all the papers presented and in particular includes summaries from the working groups on Compressors and oil removal, Expansion devices, Instrumentation, Computer control and computer simulation, and Cryogenic systems. Further information is available from members of the organizing committee; Bill Fowler at Fermilab, Don Brown at Brookhaven, Bill Hassenzahl at Berkeley and Dave Sutter at the Department of Energy.

DARESBURY
NINA magnets on offer

A few years ago, when the 5 GeV electron synchrotron NINA at the Daresbury Laboratory was in its final years of operation, the magnets of NINA seemed to be built into every new accelerator proposal then emerging in Europe. Now, with the machine closed down, the magnets remain available and Daresbury would like to see them in action again if anyone could make good use of them.

There are forty magnets (plus two spares). They are of the combined function type (twenty F and twenty D) made of eleven blocks of laminations with wedge-shaped gaps between the blocks. There are four coils on each magnet, 32 turns on an F and 40 turns on a D type.

For further information contact D.J. Thompson, Daresbury Laboratory, Warrington WA4 4AD, UK.

Meanwhile both major new projects at the Laboratory are on the brink of operation. We hope to have news on the Nuclear Structure Facility (the 30 MeV tandem Van de Graaff) and the Synchrotron Radiation Source (the 2 GeV electron storage ring) in the near future.

The NINA magnets

Radius of curvature	20.77 m
Peak flux	0.9 T
Field index in F magnet	– 46.169
Field index in D magnet	47.169
Magnetic length and physical length	3.2625 m
Field gradient in F magnet	2.22% per cm
Field gradient in D magnet	2.28% per cm
Magnet gap at orbit centre (F)	61 mm
Magnet gap at orbit centre (D)	76.2 mm
F magnet horizontal aperture	130 m
D magnet horizontal aperture	89.9 mm
Excitation frequency (nominal)	50 cps
Peak current at 0.643 T	1362 A
Approximate weight of magnet	10 tonnes

Charm at the ISR

In reporting the new charmed baryon candidate seen in an experiment using the BEBC bubble chamber (July/August issue, pages 194–5) our summary of previous charmed baryon developments omitted to recall the work done in this area by a number of experiments at the CERN ISR. This was reported in the September 1979 issue, page 247.

Britain at CERN 1980

From 23–26 September, British trade associations and the British Consulate General in Geneva are organizing an exhibition of British instrumentation and electronics at CERN. It will be mounted in the Administration building and will be open daily.

Come to Britain at CERN '80

The Group of Associations of Manufacturers of British Instrumentation, Control and Automation

in co-operation with

The British Overseas Trade Board

and

The British Consulate General in Geneva

Invite you to an exhibition featuring twenty-one British Manufacturers of instruments, and electronics in the:

CERN Administration Building
September 23-26
Daily 10.00-17.00 hours (Friday 12.00 noon)

University of British Columbia/TRIUMF

Research Fellowship in Muon Spin Rotation (μSR)

Applications are invited for a Research Scientist working in the μSR Group at TRIUMF (Tri-University Meson Facility in Vancouver, Canada). Applicants must possess a Ph. D. in chemistry or physics and preferably should have a minimum of 2 years post-doctoral experience; prior experience in μSR or a technically related field is desirable but not essential.

The successful candidate will be expected to spend about 50% of his (or her) time coordinating the operation of a multi-user μSR experimental program at TRIUMF, and about 50% of his time on research in collaboration with one or more of the μSR groups. Experience with any or all of the following is highly desirable since they form the basic responsibilities of the position: PDP11 computers (present system is 96K operating under RSX 11-M), fast electronics and data acquisition (ns time resolution, MBD, Camac), liquid He cryostats, gas handling systems, magnet technology (mG to kG fields), beam line components and vacuum technology.

Starting salary will be in the range $20,000 – $25,000/ annum, depending upon age and experience. Initial appointment will be for a term of up to three years, commencing October 1, 1980. Interested parties should send a resume outlining experience and research interests, list of publications, etc., and have 3 letters of recommendation sent to:

Professor Jesse H. Brewer,
Department of Physics,
University of British Columbia
Vancouver, B.C. V6T 1W5
Canada

or

Professor Donald G. Fleming,
Department of Chemistry,
University of British Columbia,
Vancouver, B.C. V6T 1Y6
Canada

The closing date for application is September 15, 1980.

SEN

ELECTRONIQUE Genève
Instrumentation scientifique

recherche

un ingénieur de vente

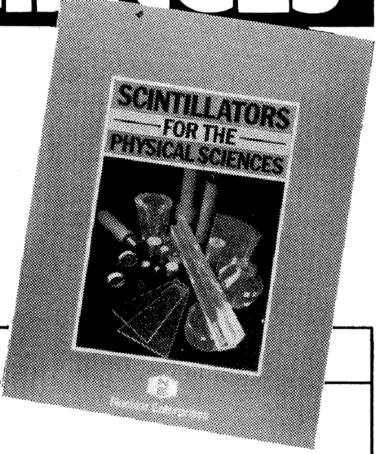
nous demandons:
- une formation ingénieur EPF ou équivalent.
- plusieurs années d'expérience en systèmes CAMAC.
- une expérience en électronique rapide si possible.
- anglais courant, allemand souhaité.
- une grande puissance de travail et le goût du travail bien fait.

nous offrons:
- un travail sur des matériels à la pointe de la technique.
- une ambiance stimulante dans une équipe sympathique.
- les démarches pour l'obtention d'un permis C si souhaité.

Veuillez soumettre vos offres à:
SEN ELECTRONIQUE
31, avenue E.-Pictet, 1211 Genève 13, Suisse

SCINTILLATORS

FOR THE PHYSICAL SCIENCES


SCINTILLATORS
FOR THE
PHYSICAL SCIENCES

With over twenty-five years as world leader in the manufacture and supply of Scintillators, Nuclear Enterprises has a range of plastic and liquid scintillators unrivalled in efficiency, size, transparency and speed. Scintillator "know-how" unsurpassed, and supported by a unique collection of published papers and reference service, is at the disposal of customers.

Items from the Company's range of particular interest to researchers in the Physical Sciences are listed in the Table of Physical Constants above. For full details request Brochure No. 126P.

TABLE OF PHYSICAL CONSTANTS

	Scintillator	Type	Light Output (% Anthracene)	Decay Constant, Main Component ns	Wavelength of Maximum Emission nm	Content of Loading Element (% by wt.)	Principal Applications
PLASTIC	NE 102A	Plastic	65	2·4	423	····	γ, α, β, fast n
	NE 104	Plastic	68	1·9	406	····	ultra-fast counting
	NE 104B	Plastic	59	3·0	406	····	with BBQ light guides
	NE 105	Plastic	46	····	423	····	dosimetry
	NE 110	Plastic	60	3·3	434	····	γ, α, β, fast n, etc.
	NE 111A	Plastic	55	1·6	370	····	ultra-fast timing
	NE 114	Plastic	50	4·0	434	····	as for NE 110
	NE 160	Plastic	59	2·3	423	····	use at high temperatures
	Pilot U	Plastic	67	1·36	391	····	ultra fast timing
	Pilot 425	Plastic	····	····	425	····	Cherenkov detector
LIQUID	NE 213	Liquid	78	3·7	425	····	fast n (P.S.D.)
	NE 216	Liquid	78	3·5	425	····	α, β (internal counting)
	NE 220	Liquid	65	3·8	425	O 29%	Internal counting, dosimetry
	NE 221	Gel	55	4	425	····	α, β (internal counting)
	NE 224	Liquid	80	2·6	425	····	γ, fast n
	NE 226	Liquid	20	3·3	430	····	γ, insensitive to n
	NE 228	Liquid	45	····	385	····	n
	NE 230	Deuterated liquid	60	3·0	425	D 14·2%	(D/C) special applications
	NE 232	Deuterated liquid	60	4	430	D 24·5%	(D/C) special applications
	NE 233	Liquid	74	3·7	425	····	α, β (internal counting)
	NE235	Liquid	40	4	420	····	large tanks
	NE 250	Liquid	50	4	425	O 32%	internal counting, dosimetry
LOADED LIQUID	NE 311 & 311A	B loaded liquid	65	3·8	425	B 5%	n, β
	NE 313	Gd loaded liquid	62	4·0	425	Gd 0·5%	n
	NE 316	Sn loaded liquid	35	4·0	425	Sn 10%	γ, X-rays
	NE 323	Gd loaded liquid	60	3·8	425	Gd 0·5%	n
NEUTRON) (ZnS-type) and GLASS	NE 422 & 426	^{6}Li-ZnS(Ag)	300	200	450	Li 5%	slow n
	NE 451	ZnS(Ag)-plastic	300	200	450	····	fast n
	NE 901, 902, 903	Glass	28	20 & 60	395	Li 2·3%	n, β
	NE 904, 905, 906	Glass	25	20 & 58	395	Li 6·6%	n
	NE 907, 908	Glass	20	18 & 62	399	Li 7·5%	n
	NE 912, 913	Glass	25	18 & 55	397	Li 7·7%	n, β (low background)

Note:

BA1 CELLS: All Nuclear Enterprises liquid scintillators are available encapsulated in glass cells of appropriate composition. "Bubblefree" aluminium cells are produced with white reflector and glass windows. Standard sizes with internal diameters 50 to 125mm and internal lengths 50, 75, 125 and 150mm. Special non-standard sizes on request.

FLOW CELLS: A wide range of flow cells for continuous monitoring of liquids and gases is available. The cells have good counting efficiencies for ^{14}C, ^{3}H and other isotopes.

NUCLEAR ENTERPRISES

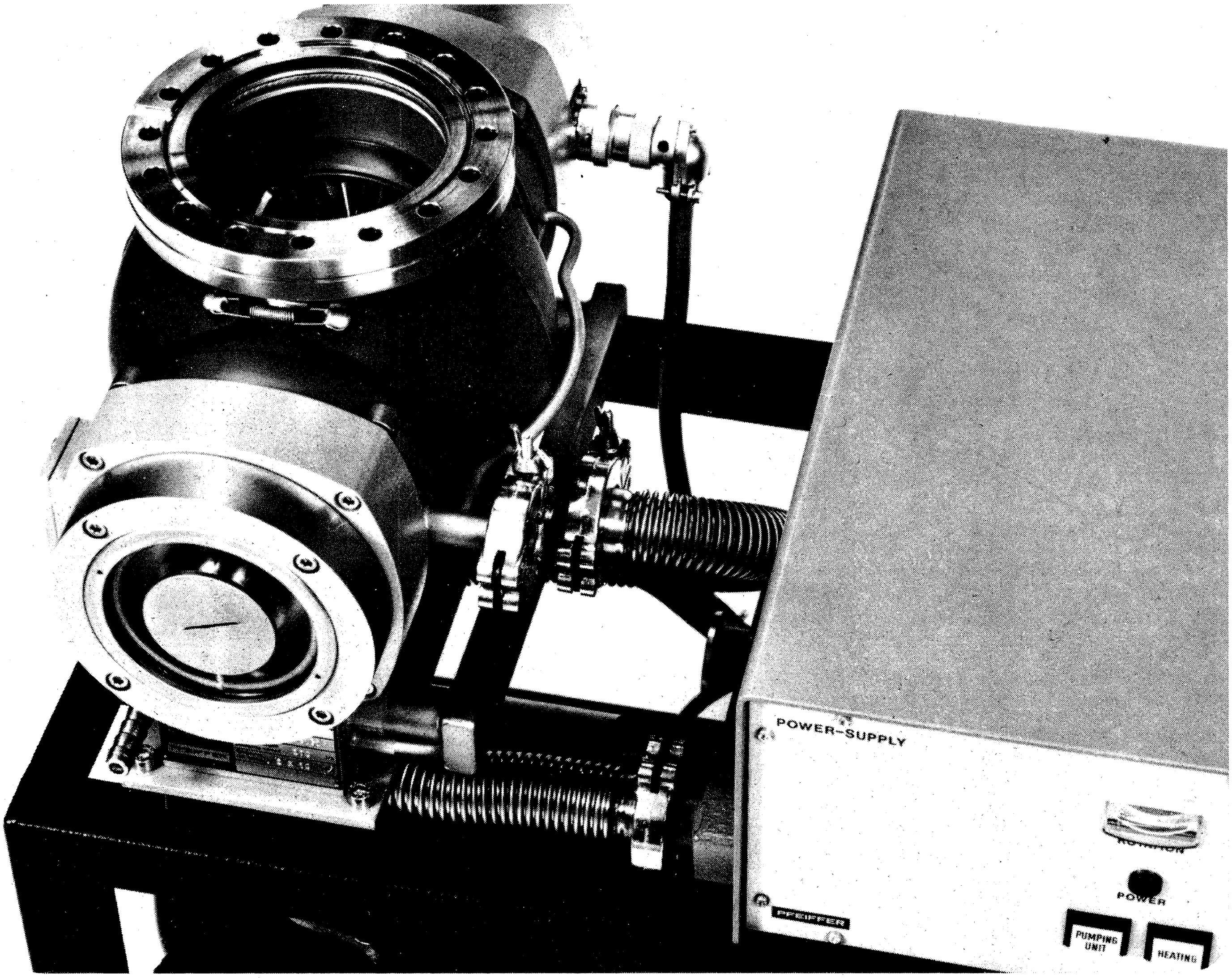
25 Chemin François-Lehmann, 1218 Grand-Sacconex, Genève, Switzerland.
Tel. (022) 98-16-61.

Nuclear Enterprises Ltd
Sighthill, Edinburgh EH11 4EY, Scotland
Tel: 031-443 4060. Telex: 72333
Cables: Nuclear Edinburgh.

Nuclear Enterprises GmbH
Schwanthalerstrasse 74, 8 München 2
Germany. Telephone 53-62-23
Telex 529938.

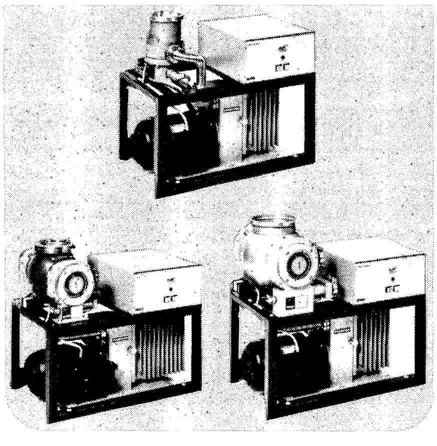
1979

The 11 Series
with the PFEIFFER TURBO*



In addition to individual pumps, fully-automatic turbo-molecular pumping units which are ready to connect have been available from the very beginning.

The new 11 series comes in three sizes, with volume flow rates of 110, 270 and 510 l/sec. for N_2. All pumping units have the same basic design and consist of a frame, a 12 m^3/h backing pump, an electronic drive system and a control unit. The PFEIFFER-TURBO will be fitted to suit the desired volume flow rate. These extremely compact pumping units are designed to run on single-phase current (AC) and can therefore be operated with no trouble at all. In comparison to traditional high-vacuum pumping units, 11 series pumps are smaller in size, lighter in weight and lower in price.

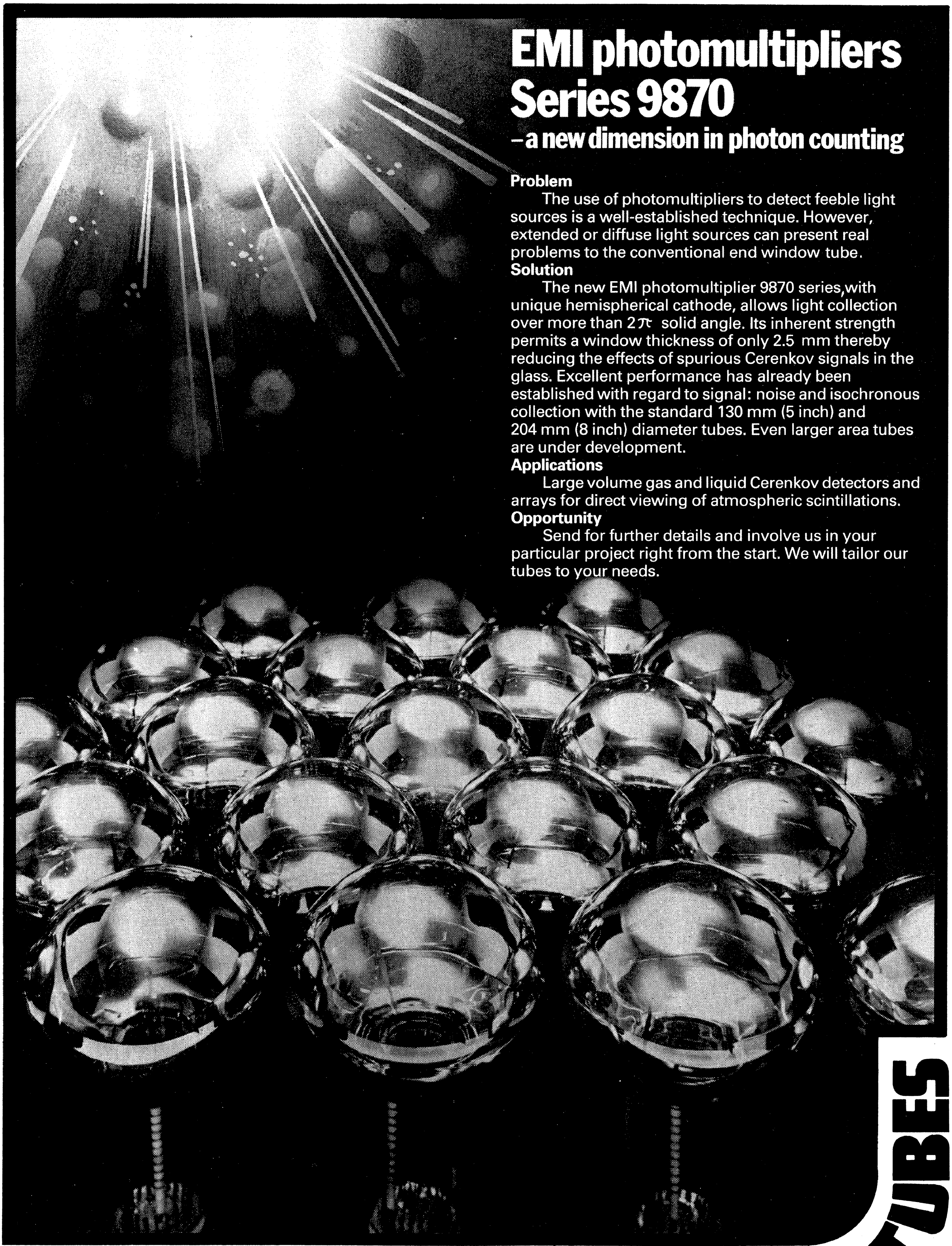


* The PFEIFFER TURBO is a turbomolecular pump which creates hydrocarbon-free high and ultra-high vacuum at a constant volume flow rate for all gases betwee 10^{-2} and 10^{-9} mbar.

BALZERS

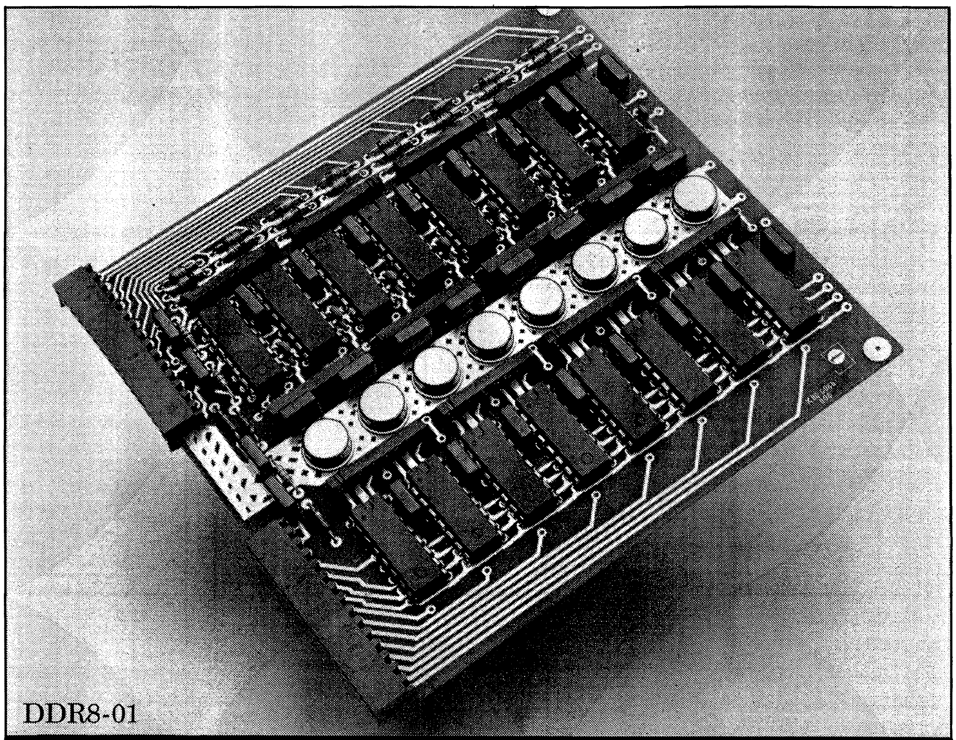
ARTHUR PFEIFFER
Vakuumtechnik Wetzlar GmbH
Postfach 1280
D-6334 Asslar

PM 800 043 PE DN 7247

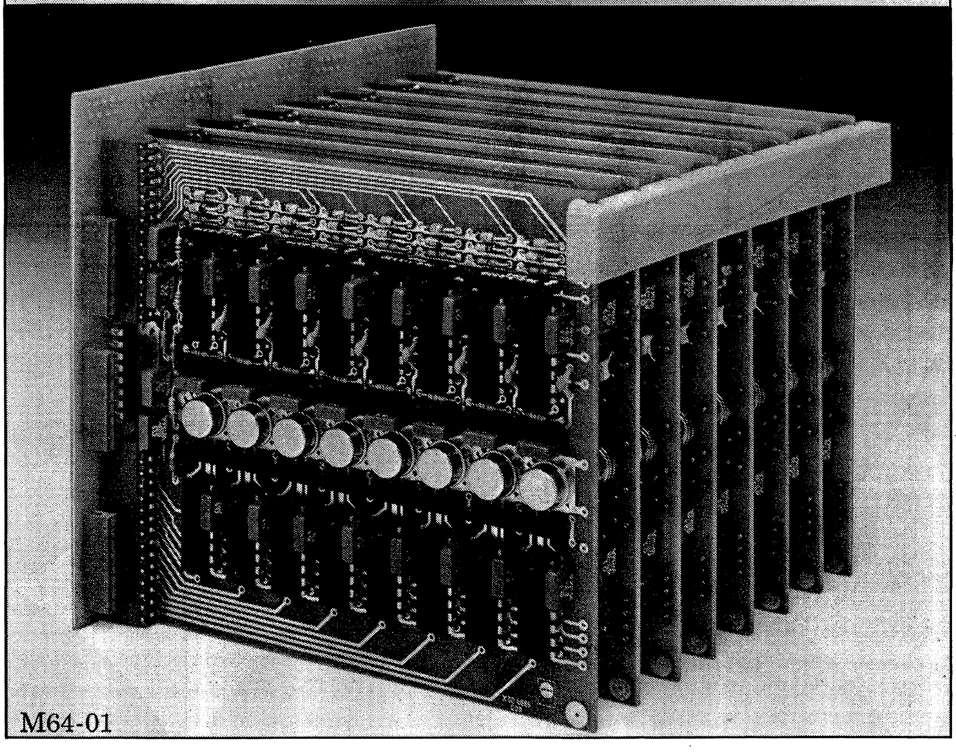



AIRCO
Superconductors

Chamber Read-out Electronics from Plessey



DDR8-01



M64-01

Important new developments from Plessey Controls offer a number of outstanding features...

- *** Genuine multi-pulse resolution**
- *** Very high speed read-out capability**
- *** High reliability at low cost —by virtue of full monolithic integration**
- *** Compact construction—full discriminator/delay/read-out functions 'on chamber'**
- *** Low power consumption—250mW per channel from single 5.2V rail**

The increasing use of multi-wire proportional chambers in particle physics has stimulated attention to the read-out electronics—in particular, the technique used to provide the necessary delay. Of the two methods currently in use—the very bulky cable delay and the monostable delay—the latter offers 'on chamber' compactness but lacks the capability of the cable delay to resolve multiple pulses during the delay period. In the Plessey system, however, the use of a surface acoustic wave delay line in conjunction with an expressly designed monolithic integrated circuit has achieved an advanced, no-compromise solution.

Systems can be fabricated in many ways. Illustrated are:

DDR8-01: a card containing 8 complete channels of full discriminator/delay/read-out circuitry

M64-01: the 64-channel module formed by building eight DDR-80 cards on to one control card, thus providing high component density for 'on chamber' mounting

Also available are discriminator only cards, RM^H compatible delay and read-out modules, NIM or ECL standard multiple delay modules, and other special configurations.

These developments will be demonstrated at the 'Britain at CERN' Exhibition from 23-26 September 1980. Visit us on Stand No. 10 and see for yourself the increased perspective offered to the whole field of chamber read-out electronics.

PLESSEY
CONTROLS

Plessey Controls Limited, Sopers Lane, Poole,
Dorset, United Kingdom BH17 7ER.
Tel: Poole (02013) 5161. Telex 41272.

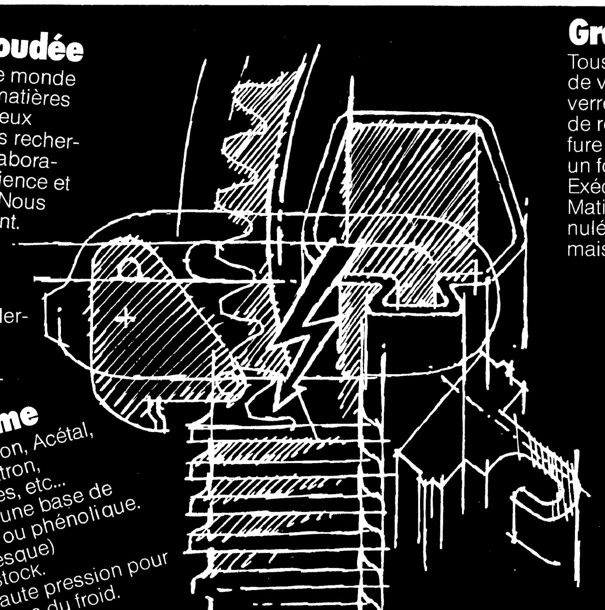
0600 2 0333

La matière plastique... c'est notre affaire

En avance d'une coudée
Grâce à nos relations dans le monde entier dans le domaine des matières plastiques, nous sommes mieux informés. Vous profitez de nos recherches et développements en laboratoire ainsi que de notre expérience et de celle de nos fournisseurs. Nous vous conseillons objectivement.

Nous produisons...
des pièces de haute précision selon les procédés les plus modernes depuis plus de vingt ans. Nous avons les connaissances requises pour travailler correctement les matières plastiques.

Un vaste programme
Plastomères comme Nylatron, Acétal, PTFE, Kel-F, Polyester, Novatron, Nylon coulé, matières frittées, etc... **Duromères** renforcés sur une base de résine polyester, époxyde ou phénolique. Comme semi-produit (presque) tout immédiatement du stock. **NYLAFLOW**-Tuyaux à haute pression pour l'hydraulique et la technique du froid.



Granulés renforcés
Tous les plastomères renforcés de fibres de verre, de fibres de carbone, billes de verre, verre mélangé ou d'autres matières de remplissage. Lubrifiés au graphite, bisulfure de molybdène, PTFE ou silicone pour un fonctionnement exempt d'entretien. Exécution ininflammable (UL 94 V.O.). Matières expansables sous forme de granulés, et ceci non seulement pour dix tonnes, mais aussi pour les petites quantités.

Nos exclusivités
Résistance à haute température (vérifié UL) THERMOCOMP à base de polymères polysulfonés, polyéthers sulfonés, sulfures de polyphénylène, Tefzel, Hytrel et polyamides, ou CEVOLIT G-200 en plaques.
Haute résistance aux radiations! Torlon 4203 (jusqu'à 10^9 rad) ou Polypenco Q-200.5.
Résistance aux étincelles rampantes: CEVOLIT-UTR vérifié NEMA.
Résistance à la flamme: (avec certificat UL-94 V.O.) CEVOLIT-UTS (GF-UP) et beaucoup de granulés injectés.
Magnétisable: MAGNACOMP en granulés.

CELLPACK

Partenaire pour les matières plastiques CELLPACK SA, Dépt produits industriels, 5610 Wohlen, Tél. 057/6 22 44, Télex 52 699

When you're hot and under pressure feed through with Ferranti

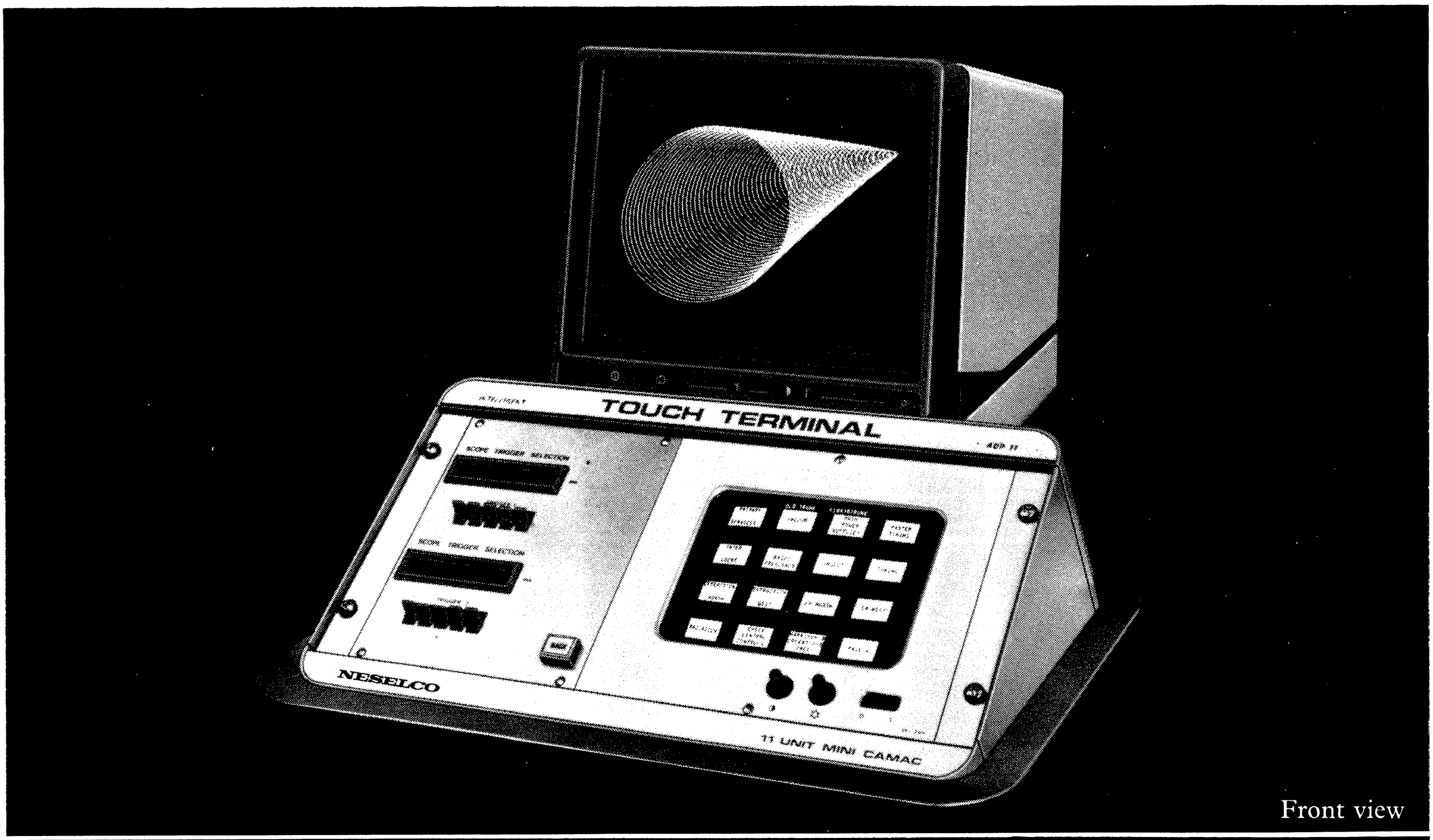
Ferranti supply ceramic to metal seals for all kinds of situations where a leak tight insulated connection is needed into high pressure or high vacuum systems, especially where high temperature is involved.

We have been making ceramic to metal seals for many years for use in the nuclear power, aircraft and communication industries, and for lots of other special applications.

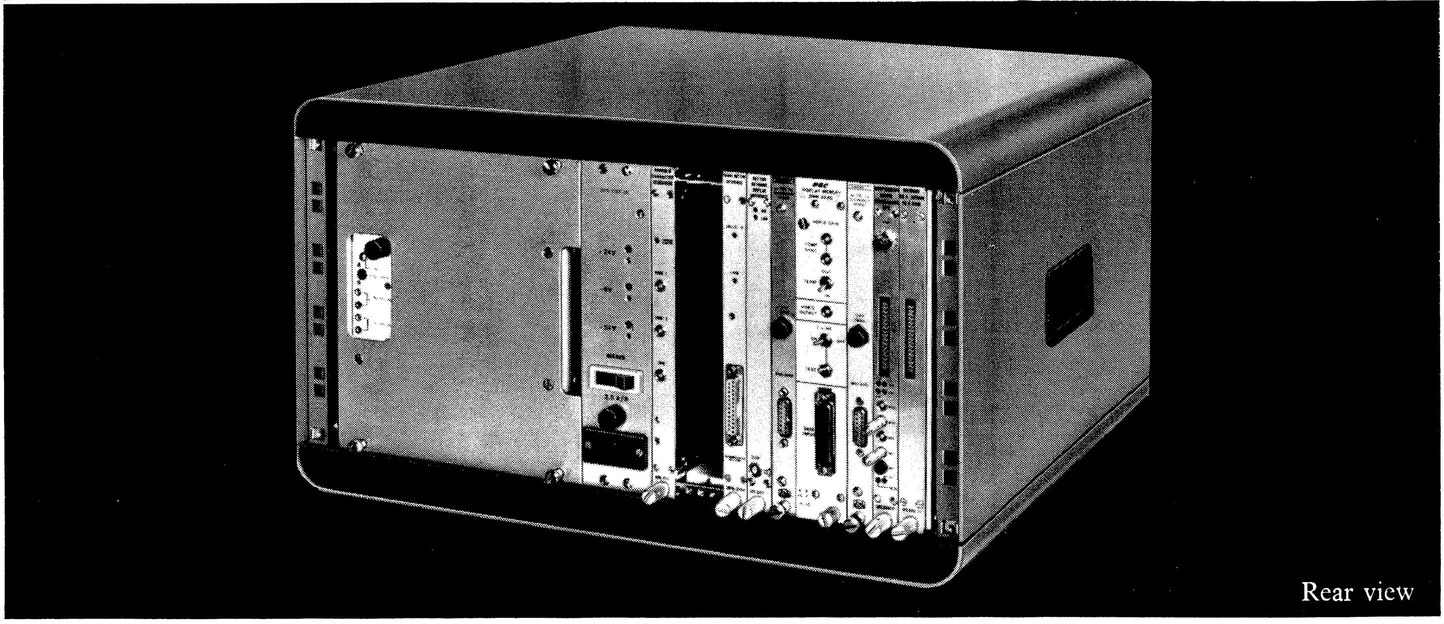
For further information and literature, contact
Ferranti Electronics Limited, Fields New Road, Chadderton, Oldham,
Lancs. OL9 8NP
Tel: 061-624 0515 Ext. 215 & 249
Telex: 668038

FERRANTI
Ceramic to metal seals


XP2020
XP2020



Front view



Rear view

If it's a question of cryogenics...

the answer is here.

No one can offer the research community a wider range of reliable, useful cold sources.

HELI–TRAN® systems provide simple-to-operate cooling in the 2–300K range.

DISPLEX® cryocoolers offer unsurpassed versatility and reliability in continuous closed-cycle cooling from 10–300K.

HELIPLEX™ refrigerators can replace use of liquid helium for around-the-clock cooling down to 3.7K.

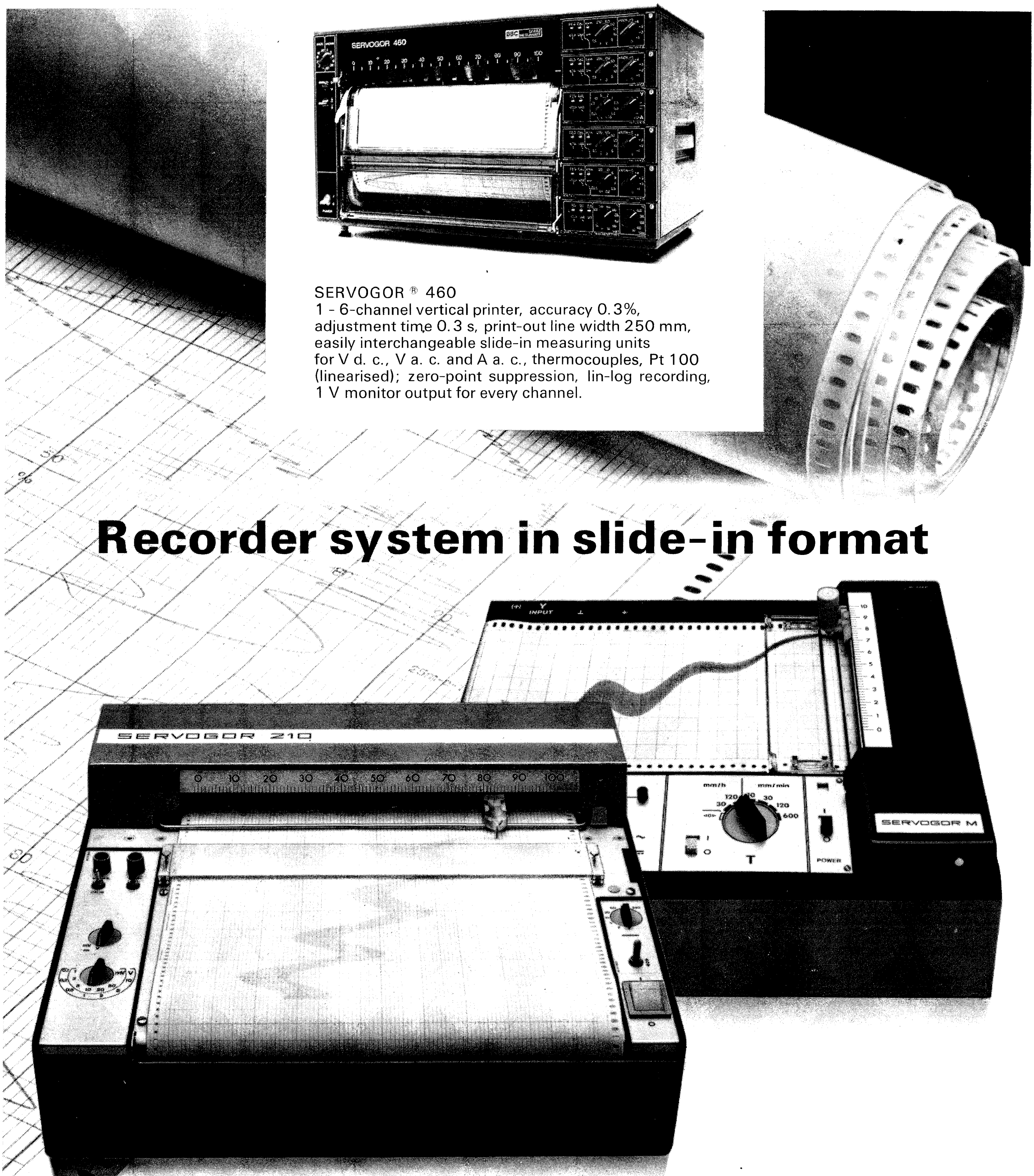
Add to this the most complete selection of temperature controllers and indicators, radiation shields, vacuum shrouds, sample holders, and other equipment vital to ESR, NMR, Mössbauer effect, x-ray diffraction, and other low-temperature research.

More than 1000 laboratories worldwide use our reliable cryogenic equipment. Send today for our latest catalog: Laboratory Cryogenic Systems.

Air Products

APD CRYOGENICS

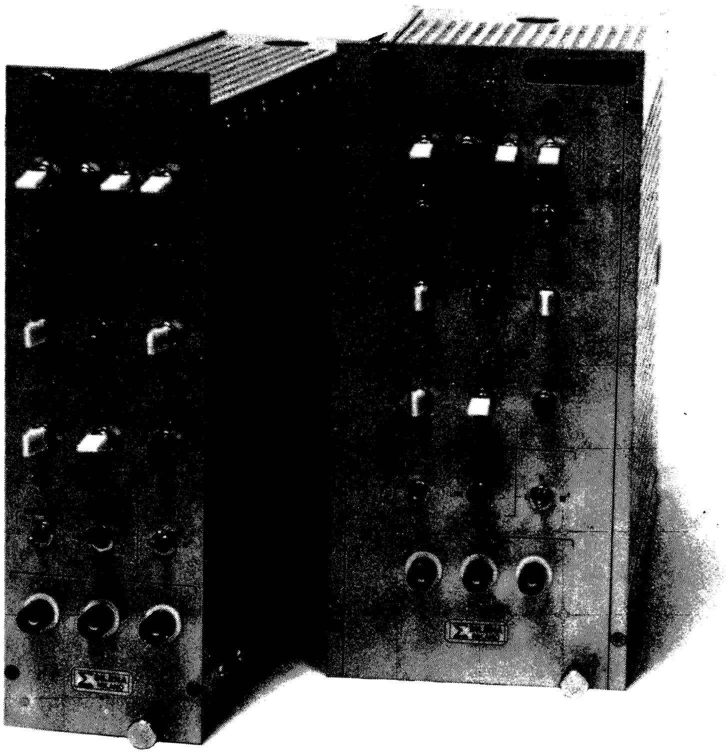
1919 Vultee Street, Allentown, PA 18103 (215) 398-8419 Telex: 84-7416


SERVOGOR 460
BBC
SERVOGOR 210
INPUT
mm/h
mm/min
T
POWER
SERVOGOR M

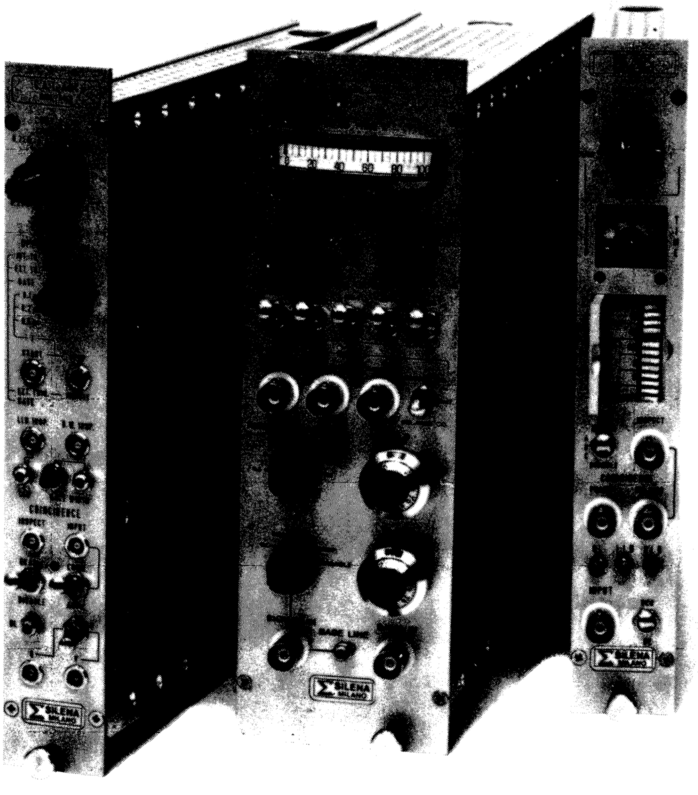

Tubes électroniques
pour l'énergie nucléaire:
de l'électron unique
aux
MEGAWATTS
QUALITÉ

SILENA

The world's fastest Wilkinson type ADC. The most compact 4096 channels NIM MCA. The most versatile Charge, Amplitude and Time Converter.



1024, 2048, 4096 channels NIM MCA's
10^6 - 1 counts per channel
X-axis expansion
Roll
Character generator
Selection of any number of ROI's
Spectra overlap
ROI integration with or without background subtraction
Wide range of interfaces for I/O peripheral devices and computers
Internal timing
Automatic cycles



2048 channels Charge, Amplitude and Time converter
0,125 picocoulombs/channel;
50 picoseconds/channel

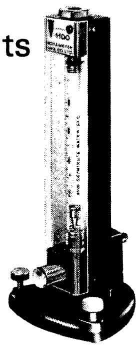
8192 channels ADC, **400 MHz CLOCK RATE**
0,3% differential non linearity
0,025% integral non linearity

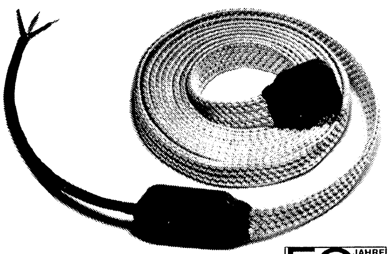
8192 channels ADC, 100 MHz clock rate

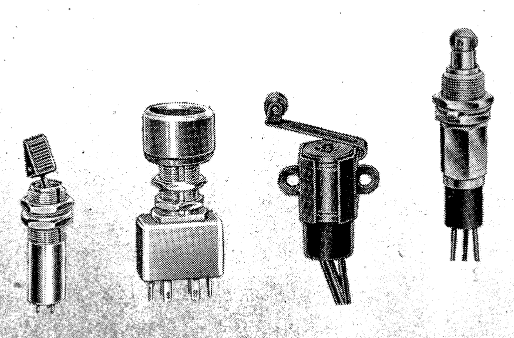
SILENA

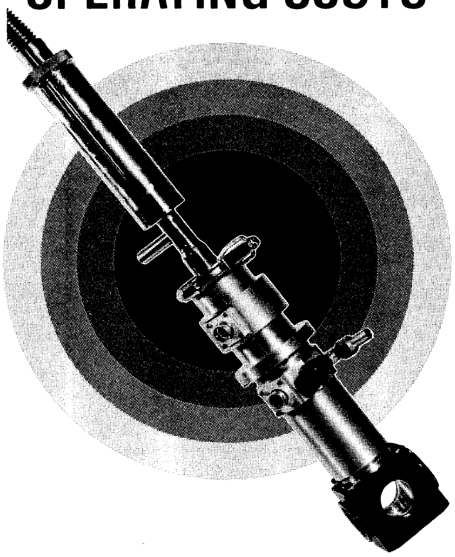
SILENA S.p.A.
SOCIETÀ PER L'ELETTRONICA AVANZATA
20133 Milano
uffici: Via Negroli, 10/A
laboratorio: Via Negroli, 6
Tel. (02) 7490565 - 713871

Sales agents in Benelux, Canada, France, Germany and Great Britain.


type 1100



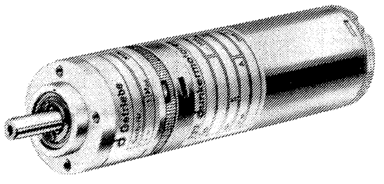




ANTEL

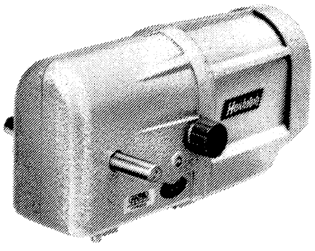
Représentation générale
pour la Suisse

dunkermotoren



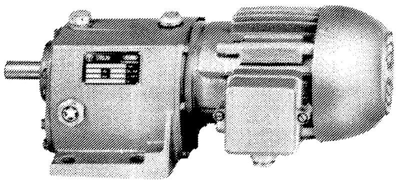
Réducteurs à engrenages, à vis sans fin et planétaires. Couples jusqu'à 2400 Ncm
Moteurs triphasés, monophasés, synchrones et à courant continu jusqu'à 80 watt
Partiellement **du stock**

Heidolph



Variateurs de vitesse mécanique. Couples nominales de 2,5 Ncm à 4000 Ncm. Gamme de vitesses de 0,003 min^{-1} à 2000 min^{-1}.
Gamme de réglage 1:10.
Partiellement **du stock**

Strojna



Réducteurs à engrenages ou à vis sans fin avec pied ou flasque équipés de moteurs triphasés I.E.C., puissances de 0,18–4 kW, possibilités de réduction i = 6,26 à 99,75.
Partiellement **du stock**

ANTEL
Antriebselemente AG
CH-8055 Zürich
Birmensdorferstrasse 470
Tel. 01 353850 Telex 54506 tzco

DESMARQUEST
CERAMIQUES TECHNIQUES

DESMARQUEST has been specializing in high-performance sintered oxide ceramics since 1804. Examples of the wide range of fields in which we work are: nuclear physics, aerospace, electronics, mechanical engineering and medicine.
The processes and equipment used in the manufacture of these components involve advanced technology, to ensure compliance with the most stringent quality requirements. Our quality assurance service, equipped with the most up-to-date instruments, supervises every stage of production.
Backed by our experience and highly efficient processes we are able to manufacture **METAL-CERAMIC** components which fully meet your requirements.

DESIGN AND MANUFACTURE
TO YOUR DRAWINGS
AND SPECIFICATIONS

DIVISION

DESMARQUEST
CERAMIQUES TECHNIQUES

CEC

Zone Industrielle N° 1
27025 EVREUX CEDEX

Tél. : (32) 39.15.95
Télex 180573 F DESCERA

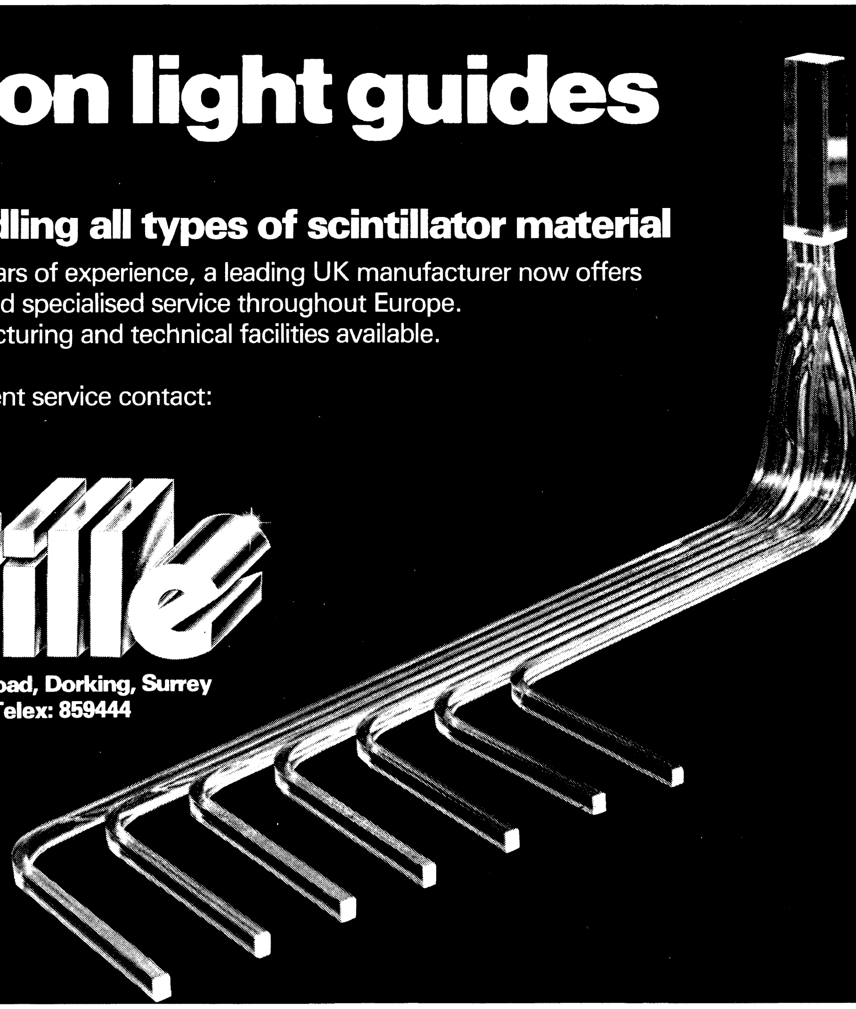
precision light guides

Expertise in handling all types of scintillator material

Backed by many years of experience, a leading UK manufacturer now offers their highly sophisticated and specialised service throughout Europe.

Full design, manufacturing and technical facilities available.

For a fast and efficient service contact:



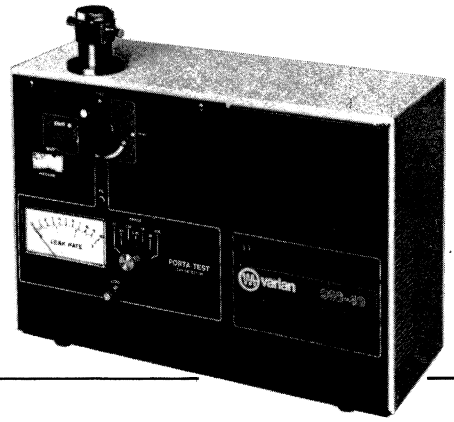
Carville

Carville Limited, Station Road, Dorking, Surrey
Tel: (0306) 81681 Telex: 859444

VARIAN presents the new 936-40 Porta-test^tm. The only helium mass spectrometer leak detector not requiring liquid nitrogen...

...and weighing less than 30 kg

The VARIAN 936-40 Porta-test is the smallest and handiest helium mass spectrometer leak detector ever devised, with a sensitivity up to 10^{-10} atm cc/sec. Thanks to the VARIAN Contra-Flow^tm principle, the 936-40 works without liquid nitrogen, even in the most critical working conditions. And, it is able to detect gross leaks in the range of 1 atm cc/sec without requiring a throttle valve.



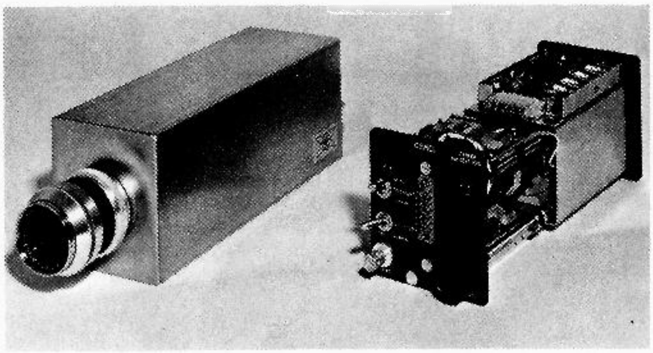
The 936-40 is compact (50 x 35 x 21 cm) and lightweight (less than 30 kilograms). This means easy leak detection, even in inaccessible areas. And, with its handy size, it is simple to transport.

The 936-40 Porta-test from VARIAN.
Made in Italy

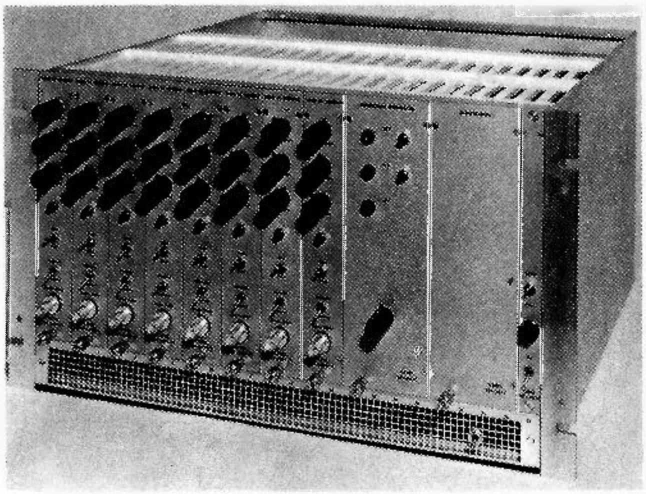
Varian spa
Via Varian 54
10040 Leini (Torino)
Tel. 011/9968086

varian

KOLMAR



CAMERA HEAD



CAMERA CRATE

INFORMATIONS ABOUT OUR CAMERA

NAME ____________________

TITLE ____________________

COMPANY ____________________

ADDRESS ____________________

CITY ____________________

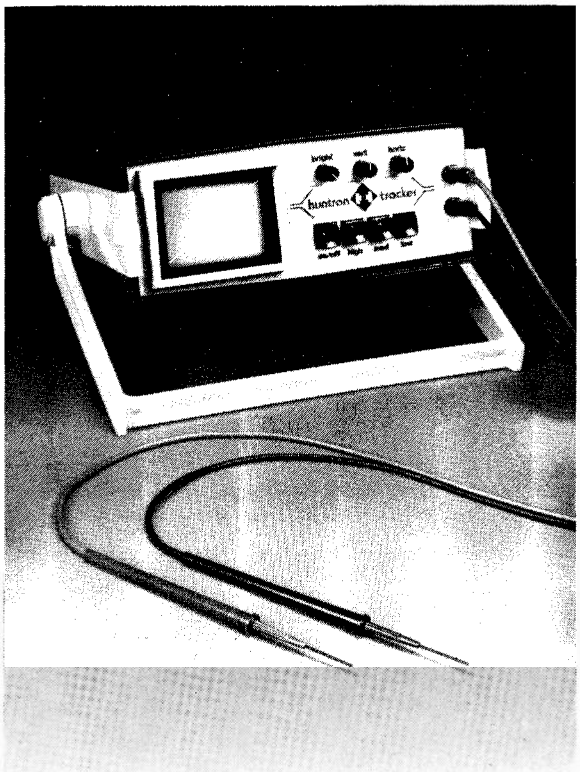
COUNTRY ____________________

RADIATION RESISTANT VIDEO CAMERA

REF. CERN (CH), SACLAY (FR), ORSAY (FR)

CONSTRUCTIONS
ÉLECTRONIQUES ET MÉCANIQUES
DU LÉMAN – C.E.M.E.L.
Rue Léone de Joinville
01170 GEX FRANCE
Tél. (50) 41 50 07

Huntron-tracker – L'appareil de test idéal pour le laboratoire et le service après-vente

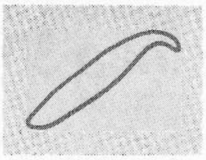


Prix 2250 francs, Icha non compris

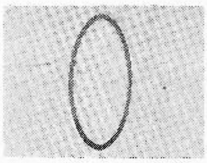
Le «dépanneur» Huntron essaie les composants dans le circuit:

- diodes Zener
- redresseur
- transistor
- condensateur
- ICs, CMOS ICs, etc.

Exemple avec condensateur:



condensateur défectueux



condensateur bon

Il n'est plus nécessaire de dessouder les composants, 50 % d'économie de temps!

Démonstration ou documentation:

Knürr ag

Mécanique
pour
l'électronique

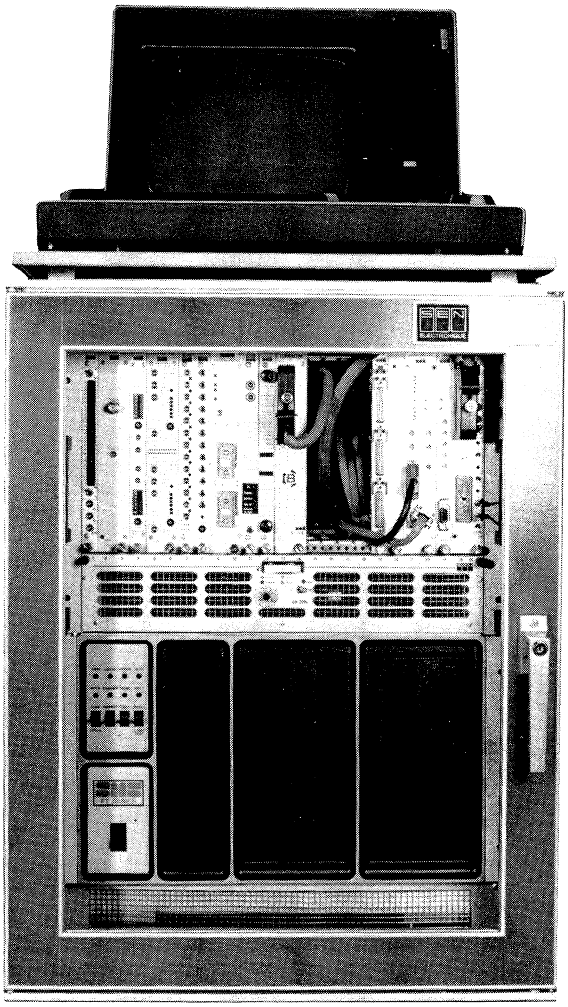
Industriestrasse 47, Postfach
8152 Glattbrugg/Zürich
Telefon 01/810 14 43/44
Telex: 59 706 knuag ch

Conseil pour la Suisse
romande: R. Curchod
rue du Sablon 25, 1110 Morges
Tél. 021/71 37 51

CAMAC

The 16 bit CAMAC Computer Systems

from SEN ELECTRONIQUE



feature:

★ **either completely stand-alone systems**
with STACC 2107 Stand Alone CAMAC Computer
or

★ **smart front-end processors and spy systems**
with ACC 2099/ACC 2103 and CC 2089 A2 or SCC 2115 L2 Controllers. The cycles are interleaved with the parallel or serial CAMAC branch cycles. This feature allows extended front-end processing facilities and real-time debugging without any modification to the existing software.
As many ACC 2099 can be connected as required for multiprocessing programming.

in both cases

★ **16 bit TMS 9900 microcomputer**

★ **up to 23 CAMAC slots free for user's modules**

★ **many interfaces available:**
RS 232 C, floppy disc, etc...

★ **high-level powerful NODAL interpreter**
EPROM resident or disc resident with automatic bootstrap and disc-file support.

★ **more user's space for application programs**
than in most mini-computer controlled CAMAC systems.

★ **and a very competitive price.**

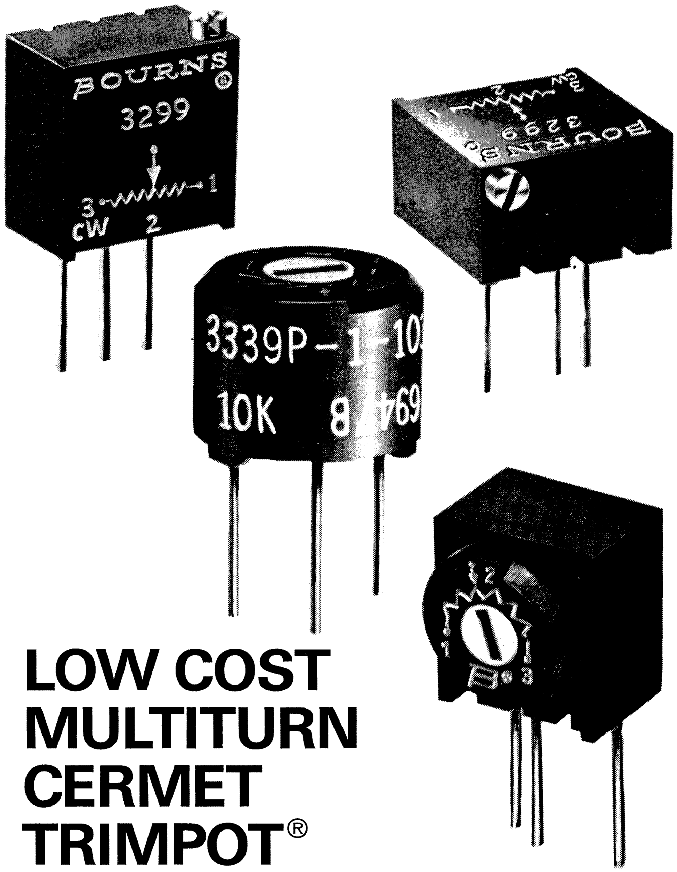
STACC Systems consist of:

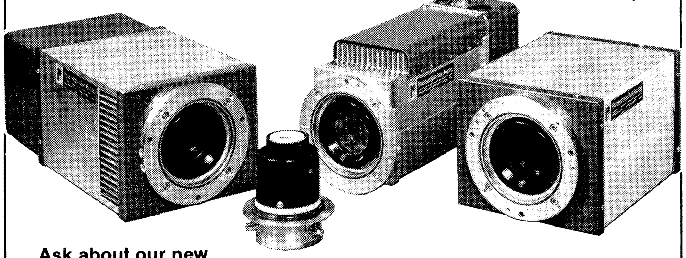
— 1 CPC 2057S full-width well proven silent CAMAC Crate
— 1 CC 2089 A2 A2 Crate Controller or 1 SCC 2115L2 L2 Crate Controller
and
— 1 CC 2099/2103 Auxiliary Crate Controller with 16K-16 bit RAM, up to 8K EPROM, TTY and RS 232C interfaces
or
— 1 STACC 2107 Stand-Alone CAMAC Computer with 16K-16 bit RAM, up to 12K EPROM, TTY and RS232C interfaces
— 1 dual drive 2.4 M byte intelligent floppy disc controller.
options include:
— RP 2114 dual byte universal EPROM programmer
— CI 2092 triple high speed buffered RS 232C interface
— HPIB interface
— etc...

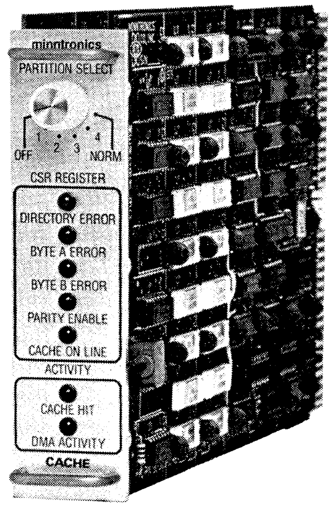
France: **ORTEC Sarl;** 7, rue des Solets; Tel. (1) 6872571 - Tlx 202553F, F-94 RUNGIS – **Germany:** **SEN ELEKTRONIK GmbH;** Brandstücken 11; Tel. 041 802046 - Tlx 2163705d, D-2000 HAMBURG 53 – **DIDAS Digital System;** Radspielstrasse 8; Tel. 089 916710 - Tlx 529167d - D-8000 MÜNCHEN 81 – **Switzerland:**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

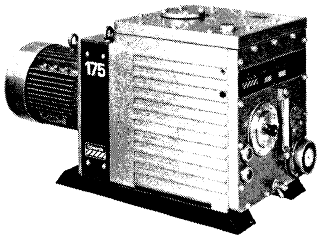
Headquarters:
SEN ELECTRONIQUE S.A.; Avenue Ernest-Pictet 31; Tel. (022) 442940 - Tlx 23359ch - CH-1211 GENÈVE 13.

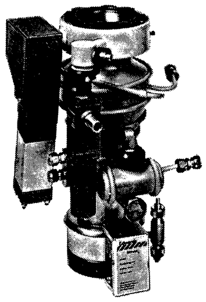
SEN
ELECTRONIQUE

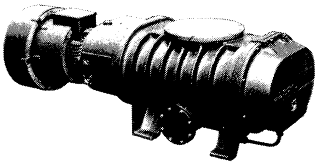

BOURNS
3299
3 CW 2 1
3339P-1-10
10K B
BOURNS 3299

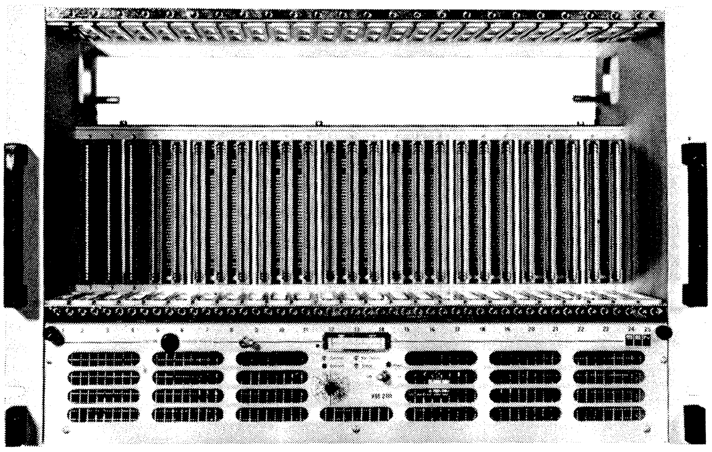



minntronics
PARTITION SELECT
OFF 1 2 3 4 NORM
CSR REGISTER
DIRECTORY ERROR
BYTE A ERROR
BYTE B ERROR
PARITY ENABLE
CACHE ON LINE
ACTIVITY
CACHE HIT
DMA ACTIVITY
CACHE



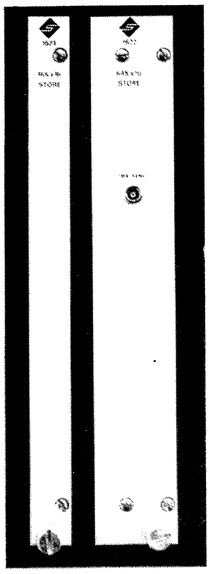






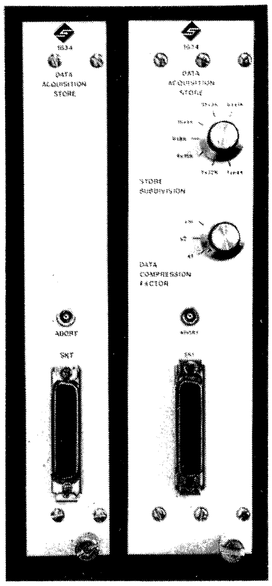

B HiVE
BERTAN High Voltage Enclosure
15 +7500
OVERLOAD GLOBAL
OVERLOAD LOCAL
INTERLOCK
TYPE
VOLTS
mA
SET
TRUE
AC
F1
EXT PWR
115V
HIGH VOLTAGE
OFF
ENABLE
REMOTE
LOCAL
OFF
ON
BERTAN ASSOCIATES, INC., SYOSSET, NEW YORK, U.S.A.

Sension Scientific



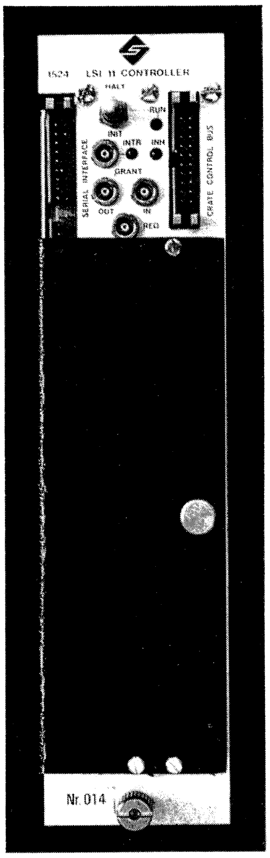
CAMAC stores
Type 1624–27

- 16K/32K x 16-bit in single width.
- 48K/64K x 16-bit in double width.
- Large fast-access in-crate store.
- 4 independent access channels.
- Auto-incrementing address pointers.
- DMI facility with overflow management..
- Microprogrammed control.
- Data is parity-checked on output from store.
- DMA sync facility.



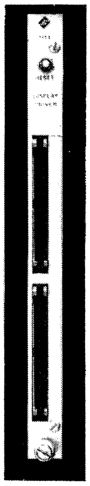
Data acquisition stores
Type 1631–34

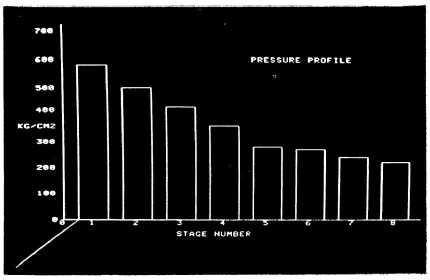
- Large fast-access in-crate store with front panel access. 16K, 32K, 48K or 64K x 16 bit.
- Independent read and write store pointers.
- Can always respond to transfers at maximum Camac rate.
- Memory increment or memory add (DMM) facility with overflows handled by 64 x 16 FIFO (optional).
- Data is parity checked on output from store (optional).
- Double width. Treble when optional hardware data compressor is fitted.



LSI – 11/2
Auxiliary controller
Type 1524

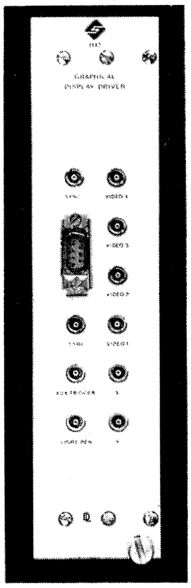
- Includes digital equipment LSI - 11/2 with its powerful, fast instruction set and byte or word addressing.
- Contains up to 32K words of MOS memory.
- Integral teletype interface and 'Q' bus extension.
- Can run the DEC range of standard software, CATY, etc.
- Can be configured as a crate or auxiliary controller by the user.

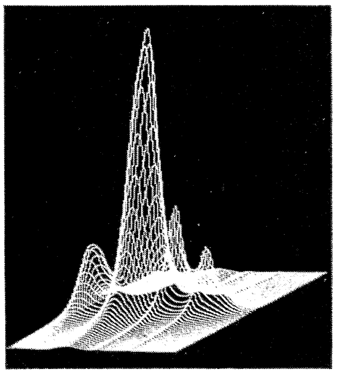




Display driver
Type 1114

- 512 x 384 field.
- Firmware vector generation.
- 4010/VT52 replacement.
- Internal Z80 microprocessor and 32K bytes of RAM.
- V 24 (RS232) interface via Sension 1134 module or direct to 1524 crate controller.

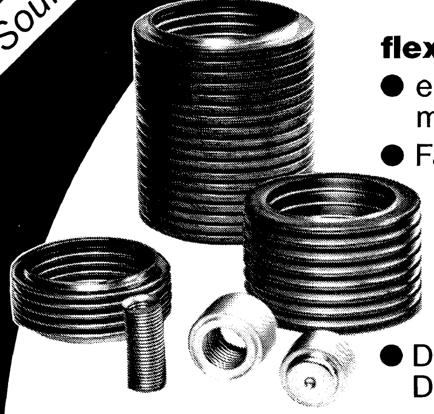


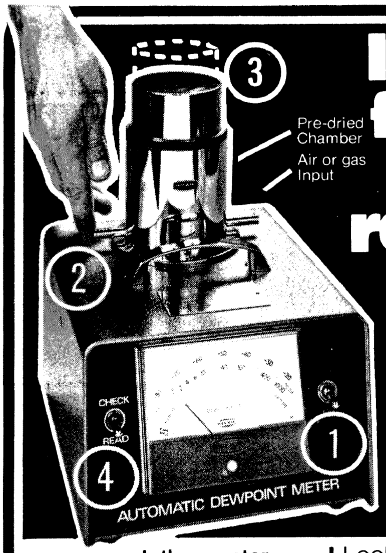


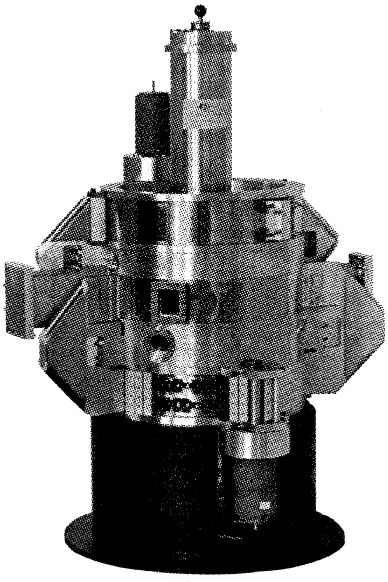
Graphics driver
Type 1112

- Powerful histogram and spectrum display modes.
- Full alphanumeric capability.
- Vector generating.
- High speed, high precision.
- 4096 x 4096 field.
- Integral picture store.
- Light pen input.

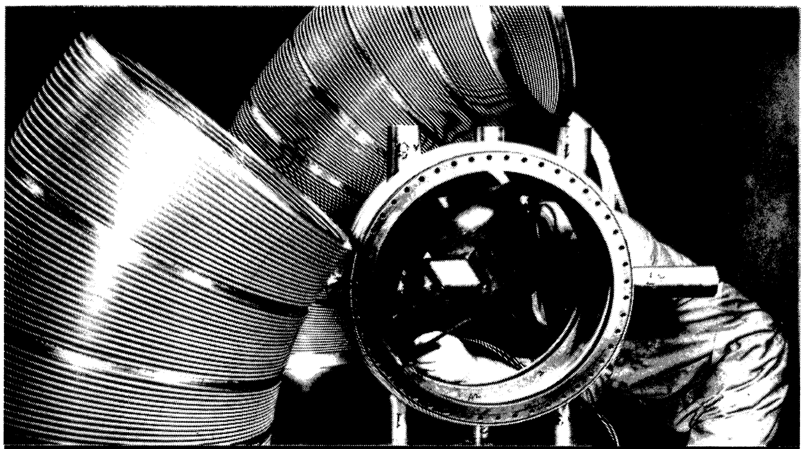
Sension Scientific Limited
Denton Drive Industrial Estate, Northwich, Cheshire CW9 7LU, England.
Telephone: Northwich (0606) 44321 Telex: 666468



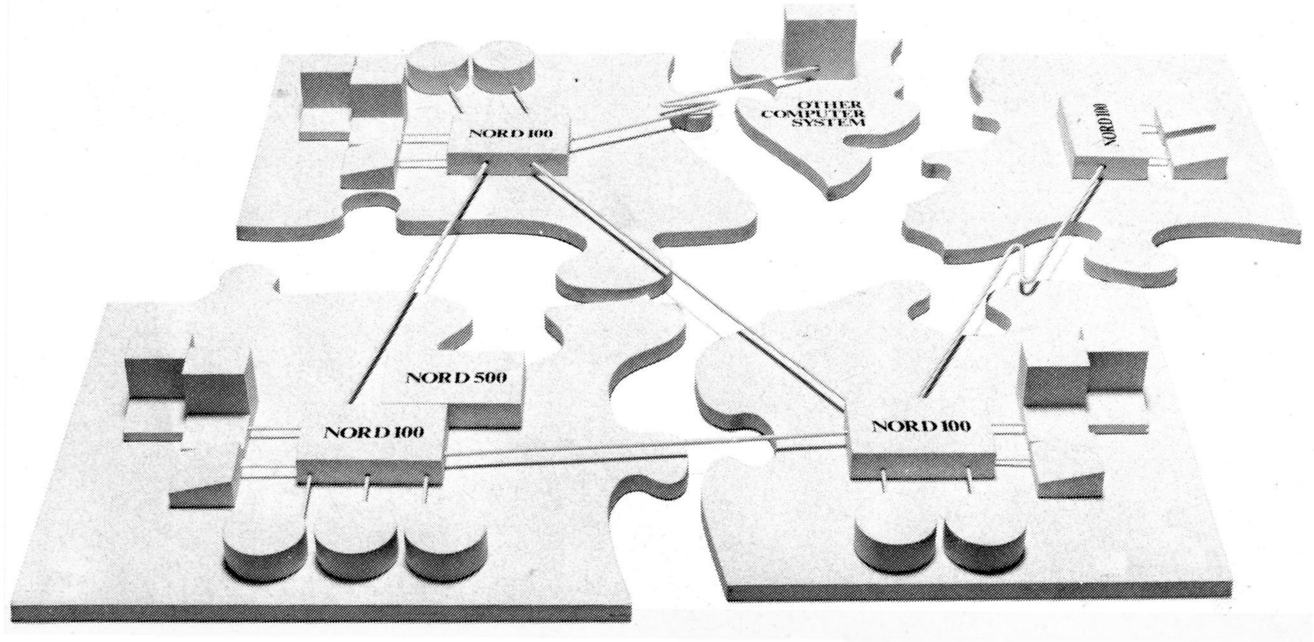

3
Pre-dried Chamber
Air or gas Input
2
CHECK
READ
1
4
AUTOMATIC DEWPOINT METER




borer
BUFFERED ADC
N
LAM
BUFFER
FULL
¾
½
¼
EMPTY
ANLG. IN
CONV
CONTROL
SCAN·1
OUT
EXT.START
IN



NORD



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.

La possibilité de connecter plusieurs systèmes locaux indépendamment de leur emplacement permet la communication entre systèmes et la création de puissants réseaux d'ordinateurs.

Les systèmes NORD sont entièrement modulaires. Chaque matériel ou logiciel peut être développé et adapté aux besoins qui évoluent sans que des unités couteuses deviennent superflues. Nos systèmes s'étendent du mini-ordinateur 16 bits aux complexe d'ordinateurs 32 bits avec une capacité de mémoire virtuelle de 4,3 G-octets pour les données comme pour les instructions.

Nos dépliants d'information sur le NORD 100, NORD 500, et sur le traitement décentralisé des données en relèvent les possibilités et les avantages.

Les ordinateurs NORD – élément fondamental d'un traitement efficace des données.

Norsk Data sarl, » Le Brévent », Avenue de Jura, 01210
Ferney-Voltaire

Oui, je veux en savoir plus sur le système Nord de traitement « élargi » des données.

Nom____________________

Entreprise____________________

Adresse____________________

Téléphone____________________

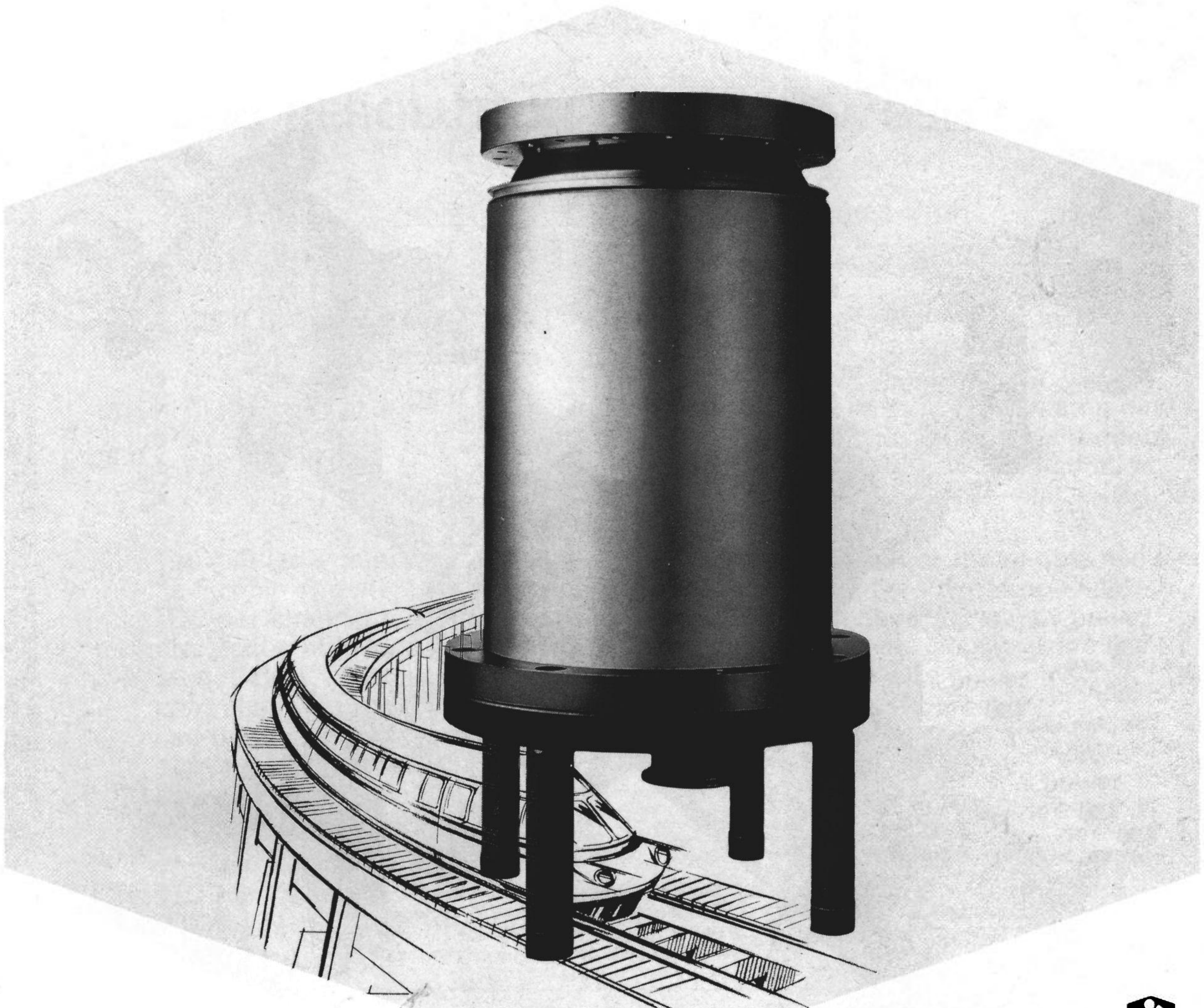
IPR 015

ND

Norsk Data

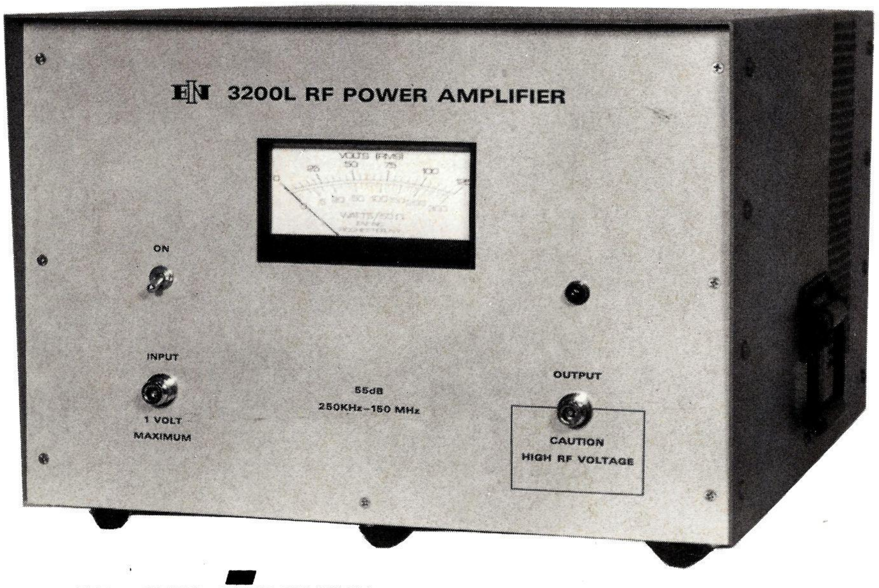
Siège : « Le Brévent », Avenue du Jura, 01210 Ferney-Voltaire
Tél. : (50) 40 85 76
Paris : 120 Bureaux de la Colline, 92213 Saint-Cloud
Tél. : (1) 602 33 66

NORD – Une alternative à étudier




PROVEN!
ENGLISH ELECTRIC VALVE CO LTD
MADE IN ENGLAND
CX1171B
7434
II/D1-29


LeCroy
4291A
32 DRIFT
CHAMBER TDC


ENI 3200L RF POWER AMPLIFIER
ON
INPUT
1 VOLT
MAXIMUM
55dB
250KHz–150 MHz
OUTPUT
CAUTION
HIGH RF VOLTAGE

August 5, 1978

JANUARY 1980
EIMAC
8973 PROVIDES
OVER ONE MEGAWATT
CW POWER OUTPUT
AT 78MHz WITH
14dB STAGE
GAIN

EIMAC 8973 tetrodes helped bring fusion power a step closer at Princeton.

Project PLT—a significant achievement

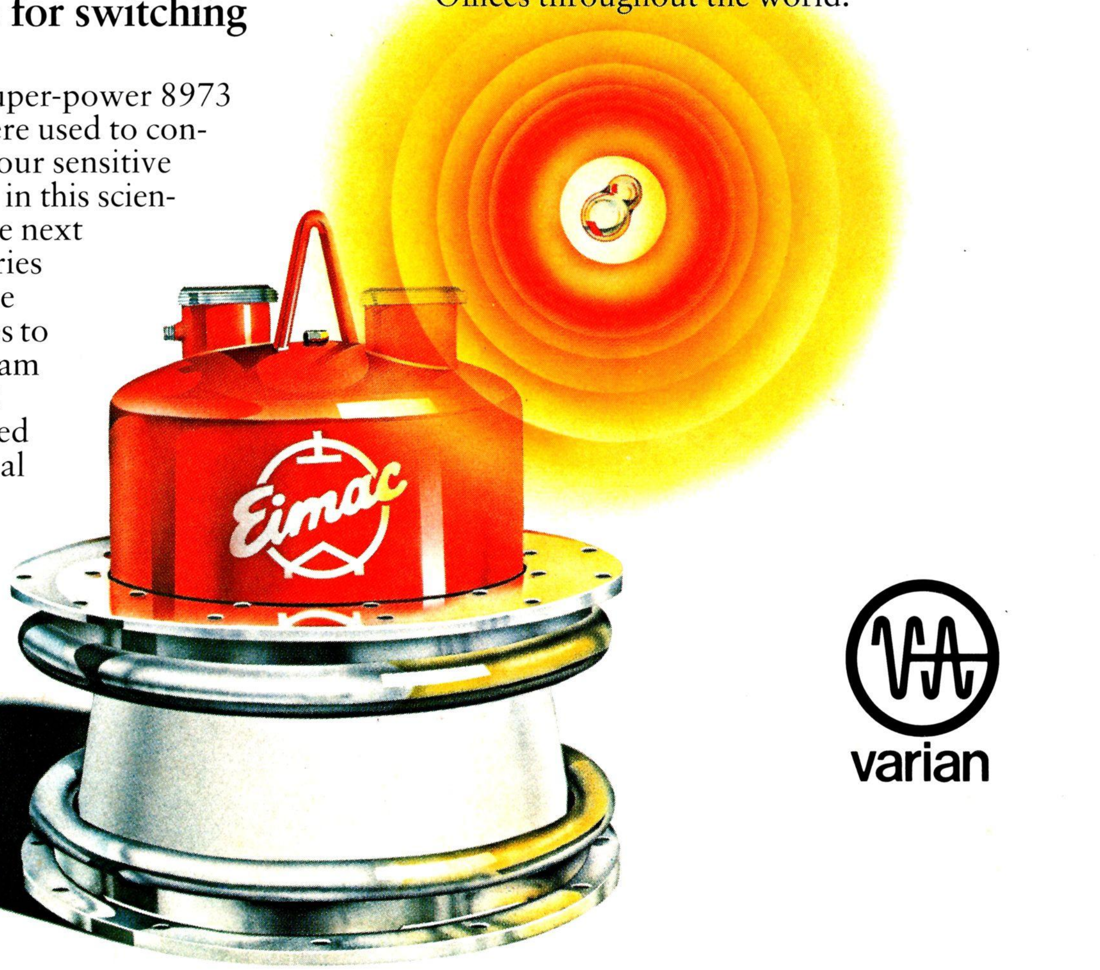
On August 5, 1978 scientists at Princeton University Plasma Physics Laboratory succeeded in heating a form of hydrogen to more than 60 million degrees Celsius and produced the highest temperature ever achieved in a TOKAMAK device—four times the temperature of the interior of the sun, thus bringing fusion power a step closer for mankind.

EIMAC tetrodes for switching and regulating.

Four EIMAC super-power 8973 (X-2170) tetrodes were used to control and protect the four sensitive neutral beam sources in this scientific achievement. The next experiment in this series (PDX) will also utilize EIMAC 8973 tetrodes to control the neutral beam sources. The EIMAC 8973 is also being used at Oak Ridge National Laboratory, another major research facility involved in the Department of Energy's program to develop practical fusion power. The 8973 is a regular production tube designed for high power switching and control by EIMAC division of Varian.

For information

Contact Varian, EIMAC Division, 301 Industrial Way, San Carlos, California 94070. Telephone (415) 592-1221. Or any of the more than 30 Varian Electron Device Group Sales Offices throughout the world.



varian