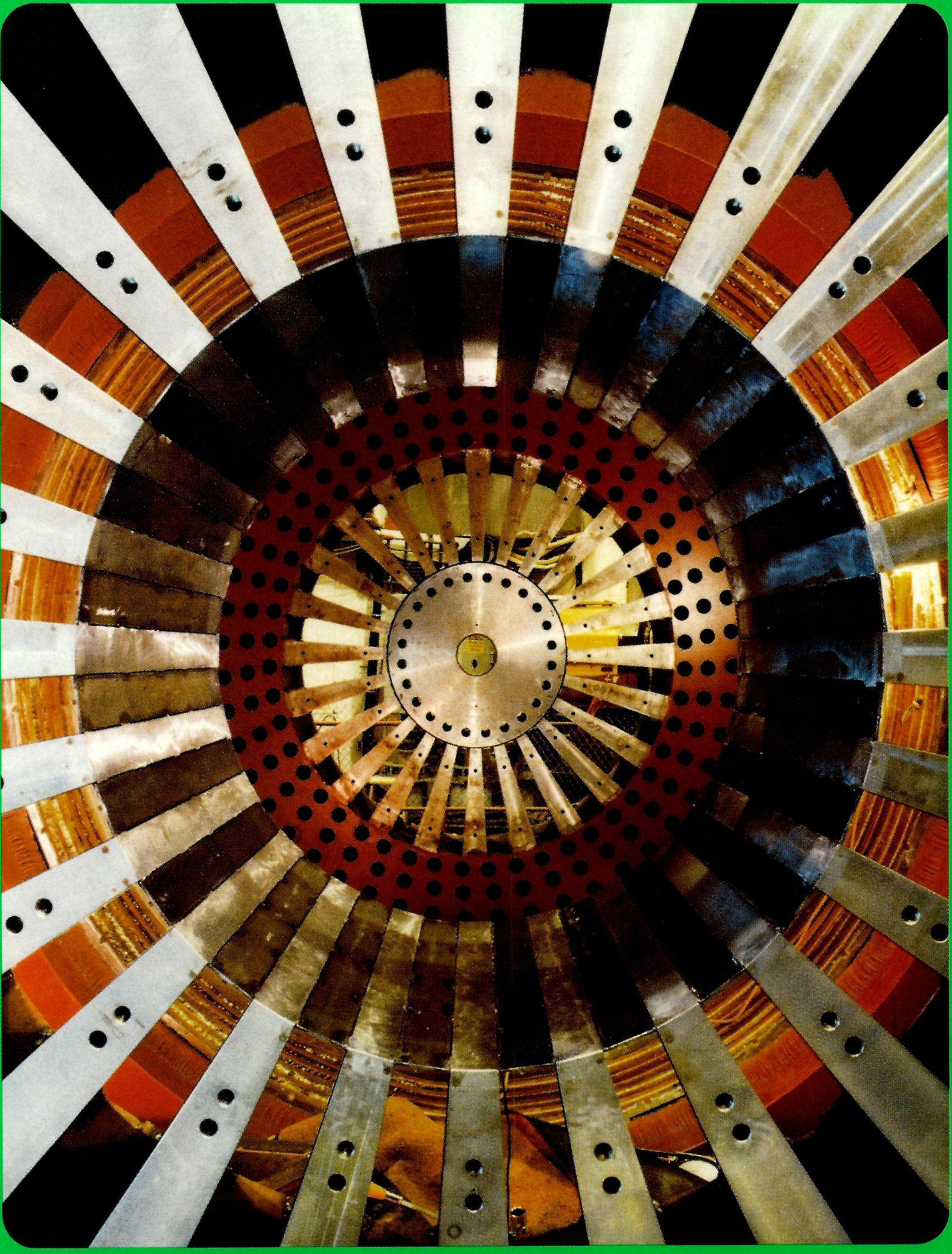
CERN COURIER

International Journal of High Energy Physics



VOLUME 27 **8** OCTOBER 1987

Put Physics in Your Trigger

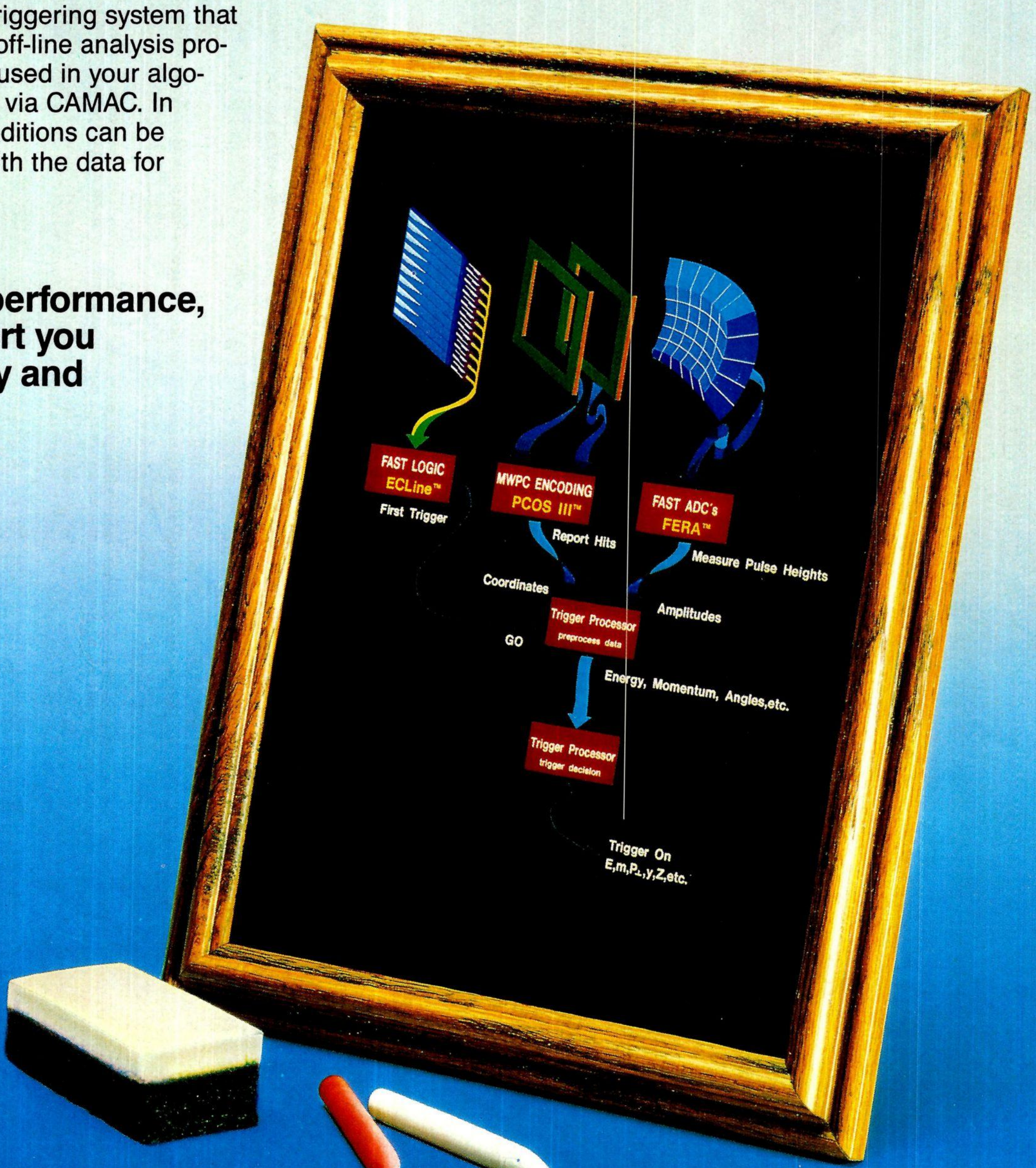
Raw data from scintillator counters and hodoscopes, silicon strip detectors, wire chambers and calorimeters reflect the geometry of the apparatus . . . not the physics under study. Now, you can select rare physics phenomena and reject background by using LeCroy ECLine Trigger Processors in your next trigger design. Imagine determining *total energy, missing energy, rapidity, momentum transfer, and multiplicity* directly from the raw data and increasing the sensitivity of your experiment!

Functions like memory mapping, arithmetic operations, sequencing, pipelined data flow and programmable logic can be combined in a fast, cost effective, multi-level triggering system that parallels the logic of your off-line analysis program. Control and values used in your algorithm can be down-loaded via CAMAC. In addition, these trigger conditions can be read back and included with the data for off-line trigger verification.

LeCroy . . . for the performance, service and support you can count on today and in the future.

Noise-immune, inexpensive ECL buses link the modules. LeCroy's *FERA* Fast ADC and TDC System, *PCOS III* Multi Wire Proportional Chamber System and our *FASTBUS* High Density ADC and TDC Systems communicate with ECLine via these same ECL buses.

DON'T SETTLE FOR LESS THAN PHYSICS IN YOUR TRIGGER!
Contact your regional LeCroy sales office for assistance, specifications, Application Notes and Technical Data Sheets.



LeCroy

700 Chestnut Ridge Rd., Chestnut Ridge, NY 10977-6499, USA. Tel: (914) 578-6013
Route du Nant-d'Avril 101, CH-1217 Meyrin 1-Geneva, Switzerland. Tel: (022) 82.33.55

Volume 27
N° 8
October
1987

CERN COURIER

International Journal of High Energy Physics

Editors: Gordon Fraser, Brian Southworth, Henri-Luc Felder (French edition) / Advertisements: Micheline Falciola / Advisory Panel: R. Klapisch (Chairman), H. Bøggild, H. Lengeler, A. Martin

Laboratory correspondents:
Argonne National Laboratory, USA
M. Derrick
Brookhaven National Laboratory, USA
N. V. Baggett
Cornell University, USA
D. G. Cassel
Daresbury Laboratory, UK
V. Suller
DESY Laboratory, Fed. Rep. of Germany
P. Waloschek
Fermi National Accelerator Laboratory, USA
M. Bodnarczuk
KfK Karlsruhe, Fed. Rep. of Germany
M. Kuntze
GSI Darmstadt, Fed. Rep. of Germany
G. Siegert
INFN, Italy
M. Gigliarelli Fiumi
Institute of High Energy Physics, Beijing, China
Wang Taijie
JINR Dubna, USSR
V. Sandukovsky
KEK National Laboratory, Japan
K. Kikuchi
Lawrence Berkeley Laboratory, USA
W. Carithers
Los Alamos National Laboratory, USA
O. B. van Dyck
Novosibirsk Institute, USSR
V. Balakin
Orsay Laboratory, France
Anne-Marie Lutz
Rutherford Appleton Laboratory, UK
A. D. Rush
Saclay Laboratory, France
A. Zylberstejn
SIN Villigen, Switzerland
J. F. Crawford
Stanford Linear Accelerator Center, USA
W. W. Ash
Superconducting Super Collider, USA
Rene Donaldson
TRIUMF Laboratory, Canada
M. K. Craddock

Copies are available on request from:
China —
Dr. Qian Ke-Qin
Institute of High Energy Physics
P.O. Box 918, Beijing,
People's Republic of China
Federal Republic of Germany —
Gabriela Martens
DESY, Notkestr. 85, 2000 Hamburg 52
Italy —
INFN, Casella Postale 56
00044 Frascati
Roma
United Kingdom —
Elizabeth Marsh
Rutherford Appleton Laboratory,
Chilton,
Didcot
Oxfordshire OX11 0QX
USA/Canada —
Margaret Pearson
Fermilab, P.O. Box 500, Batavia
Illinois 60510
General distribution —
Monika Wilson
CERN, 1211 Geneva 23, Switzerland

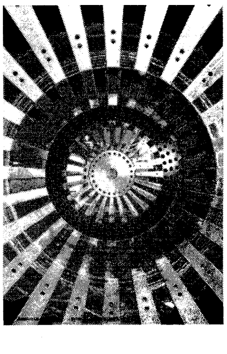
CERN COURIER is published ten times yearly in English and French editions. The views expressed in the Journal are not necessarily those of the CERN management

Printed by: Presses Centrales S.A.
1002 Lausanne, Switzerland

Published by:
European Laboratory for Particle Physics
CERN, 1211 Geneva 23, Switzerland
Tel. (022) 83 61 11, Telex 419 000
(CERN COURIER only Tel. (022) 83 41 03)
USA: Controlled Circulation
Postage paid at Batavia, Illinois

Around the US Laboratories

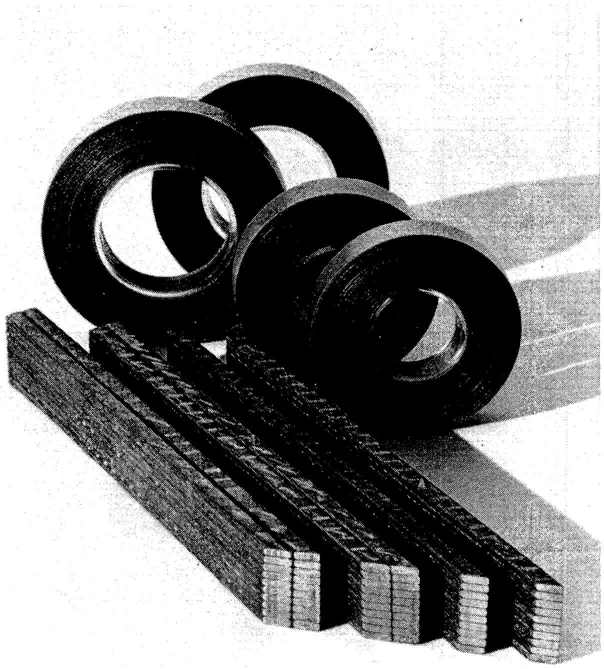
Around the other Laboratories



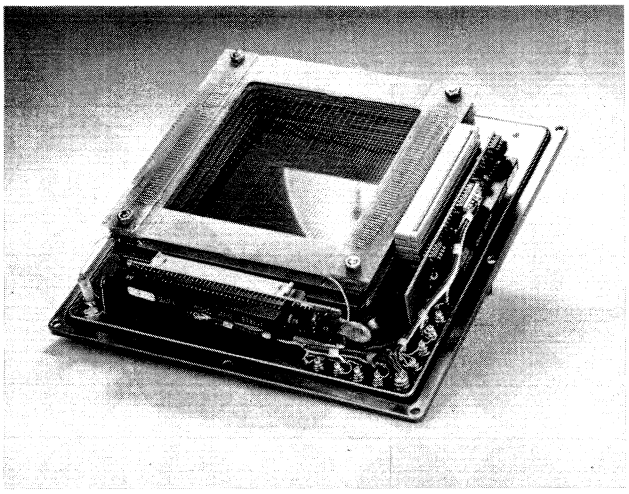
Cover photograph:
Endview of the magnet for an experiment at Brookhaven by a Brookhaven/Princeton/TRIUMF (Canada) collaboration for a precision study of charged kaon decays (Photo Brookhaven).

Insulating Materials with High Radiation Resistance

The Swiss Insulating Works together with CERN carried out detailed tests about the radiation resistance of numerous high voltage insulating materials. The results published in the "CERN Publication 85-02 of the Technical Inspection and Safety Commission" prove the usability of selected insulation under working conditions with high radiation. A radiation dose of 5x10^7 Gy affects only very little the break down voltage of our conductor insulating tape Grade 366.16 which consists of samicapor, glass fabric and silicone resin. Our high voltage insulating material for motors and other electrical apparatus behaves similarly good: Samicatherm consisting of samicapaper, glass fabric and epoxyresin withstands a dose of 1x10^8 Gy and retains at the same time 50% of its original flexural strength.



Your reliable partner for electrotechnical insulation problems



The chambers in VETRONITE G-10 are manufactured and machined by Swiss Insulating Works.

Your specialist in base materials for printed circuit boards

- Base material for FR-4
- Multilayer
- Multiwire ®
- Base material for CC-4 Additive Process ®
- Flexible Copper Clad Laminates with modified epoxy adhesive (a Sheldahl product)
- Base materials for microelectronics

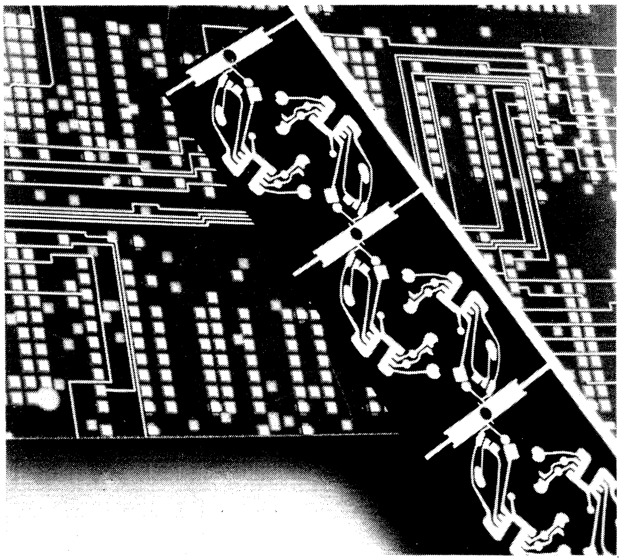
(® Trade Mark of PCK-Technology)

The Swiss Insulating Works Ltd
CH-4226 Breitenbach/Switzerland
Tel. 061/80 21 21 Telex 62 479
Fax 061/80 20 78

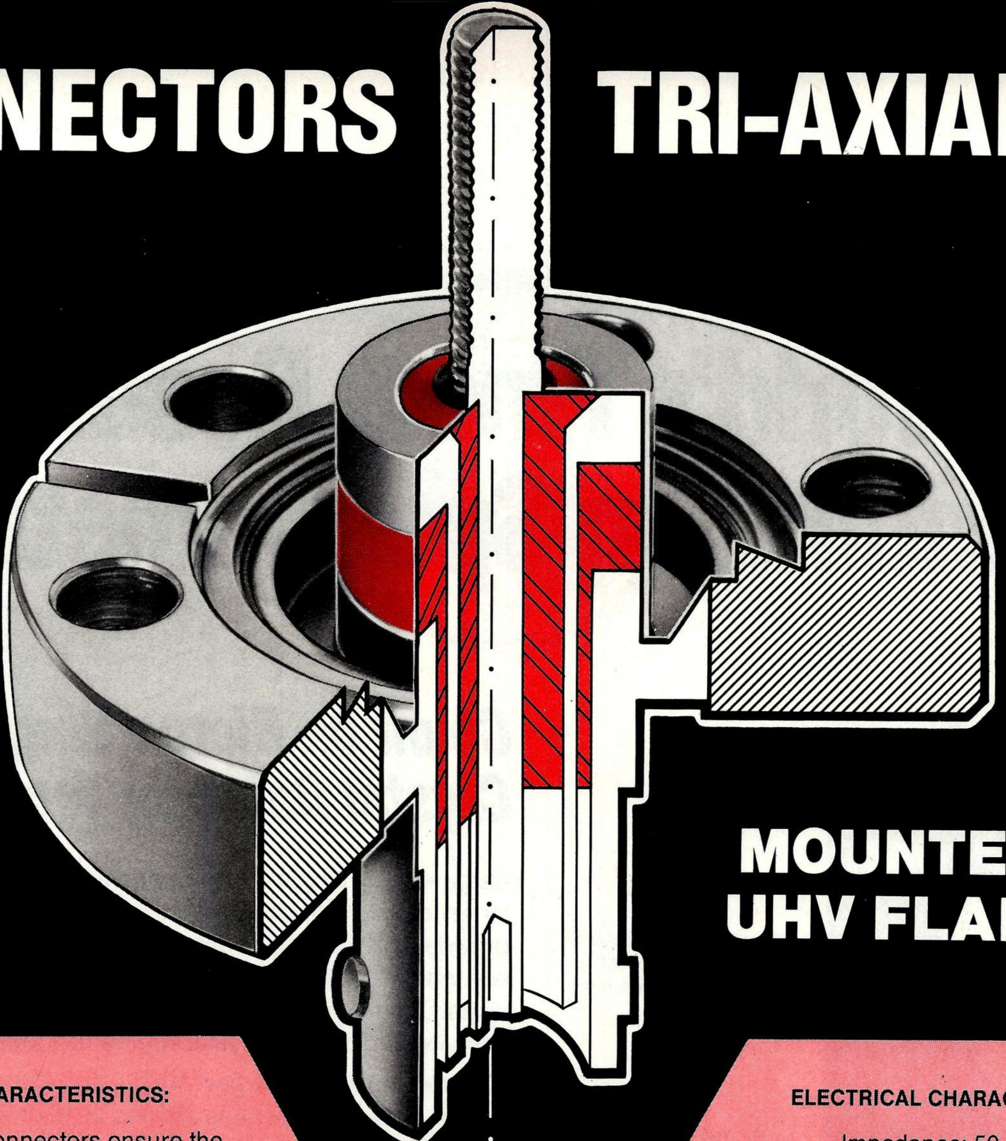
Our manufacturing programme includes also Varnishes and Resins for the manufacture of electrical machines and for the electronic equipments with excellent dielectric and protective properties.

ISOLA

We also obtained excellent results with our Laminates Epoxy Glass Cloth VETRONITE G-10 and VETRONITE G-11 as well as with Epoxy Glass Mat DELMAT. Radiation Doses of 10^7 Gy for example lead not to a substantial loss of the mechanical properties.



CONNECTORS TRI-AXIAL BNC



MOUNTED ON UHV FLANGES

NUCLEAR • MILITARY • VACUUM • HIGH VACUUM • HIGH PRESSURE • LASERS

GENERAL CHARACTERISTICS:

These connectors ensure the electrical continuity of:

- The central connector,
- The first shield to ground,
- The second shield (insulated from the first) joined to the body of the connector.

A glass moulding insulates them from each other.

ELECTRICAL CHARACTERISTICS:

Impedance: 50 Ω

Working frequency: 10 GH$_3$

Test voltage:

- Between connector and inner shield: 1 500 V.DC.
- Between the first and second shield: 2 500 V.DC.

•

Working temperature (when not connected): — 55° to + 350 °C.

Insulation between conductor and inner shield 10^{12} Ω at 1 000 V.DC

Coupling is by bayonet.

Proofing > 1.10^{-9} Atm.cm^3/s

CRYOGENY • AIR AND SPACE • ASTRONOMY • ALTERNATIVE ENERGI

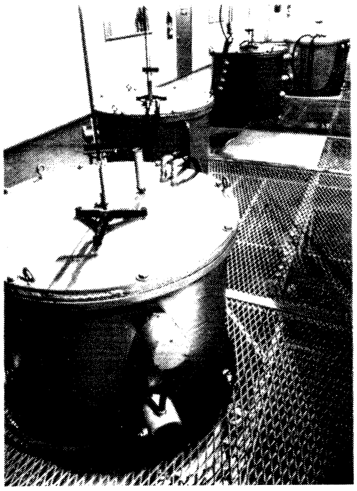
GLASS-METAL WELDING/ALUMINA-METAL BRAZING/GLASSWARE

VERELEC

Zone d'activités de la Plaine Haute
17 à 21, rue des Entrepreneurs
91560 CROSNE - FRANCE
Tél. : 16 (1) 69 83 89 00 (5 lignes groupées)
Télex : 603 862 F

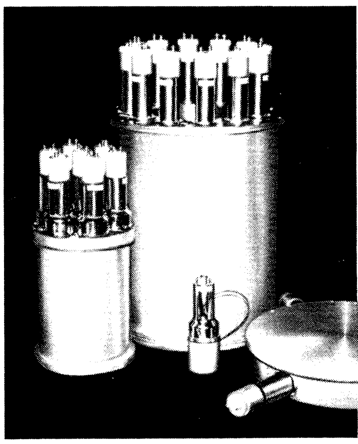
POINT 44 Tél. (1) 43 76 06 93

The World's Finest Resolution Scintillation Spectrometers



Bicron has designed and built the largest, most advanced furnaces in the industry.

Large NaI(Tl) ingots, up to 27 inches in diameter, are routinely grown at Bicron.



Bicron custom designed spectrometer systems — single crystal detectors and compton shields — provide unmatched performance.

Count on Bicron Single Crystal Detector Technology

Large volume single crystals are critical to producing large, low resolution detectors. This is because they provide high photopeak efficiency without the light distortion which results from interfacing crystal segments. Previously, large spectrometers could only be assembled by coupling two or more crystal segments together.

We grow the world's largest NaI(Tl) and CsI ingots at Bicron. This capability has allowed us to deliver large, unsegmented spectrometers to researchers investigating intermediate energy physics. Resolutions as low as 1.5% @ 22.6 MeV have been reported in spectrometers up to 11.5″ in diameter × 15″ tall.

Now Bicron, a pioneer in large crystal growth technology, has engineered and brought on line new furnaces capable of growing quality ingots over 20″ in height *and* diameter. The availability of the even larger detectors made possible by Bicron technology is recognized by investigators as a breakthrough in the study of higher energies.

To complement our growth technology, Bicron has further refined assembly techniques. Detectors are compensated at 6 MeV to predict and optimize performance for high energy applications.

Contact Bicron today for the latest information on Bicron's large unsegmented crystals for physics research.

BICRON®

Bicron Corporation
12345 Kinsman Road • Newbury, Ohio 44065
(216) 564-2251 • Telex 980474

Bicron Corporation European Office
P.O. Box 271 • 2410 AG Bodegraven • The Netherlands
1726-14243 • Telex 39772

Standard Model festival

The 'Standard Model' of modern particle physics, with the quantum chromodynamics (QCD) theory of inter-quark forces superimposed on the unified electroweak picture, is still unchallenged, but it is not the end of physics. This was the message at the big International Symposium on Lepton and Photon Interactions at High Energies, held in Hamburg from 27-31 July.

'The conference is a celebration of the Standard Model', admitted Graham Ross of Oxford, given the task of looking beyond. He pointed out a few interesting clouds on the horizon, and echoed the increasing belief that experiments at higher collision energies (1000 GeV for constituent quarks inside nucleons or for electrons) would probe deep inside the Standard Model and reveal something new.

Carlo Rubbia of CERN flew in at the end of the meeting with some suggestions for future machines to explore these far horizons. 'However our preoccupation with high energy should not exclude other interesting topics,' he warned, mentioning solar neutrino studies, particle mixing, CP violation, the search for proton decay and supernova detection ('We should be better prepared next time!').

The conference business began with Satoshi Ozaki of the Japanese KEK Laboratory describing the new TRISTAN electron-positron collider, currently providing the world's highest electron-positron collision energies for physics. Collision rates are good, with the luminosity almost at the 10^{31} cm^{-2} s^{-1} design level. 'With other machines following close behind, we also had to push the physics programme,' Ozaki remarked. TRISTAN experiments have logged about 30 hadronic events per day, and are providing interesting new information to take over where the electron-positron machines at Stanford (US) and DESY (Hamburg) left off.

With other machines on its heels, TRISTAN also has to push its collision energy. While runs this year should see 27 or 28 GeV per beam, this could be increased to 30 or even 33 GeV next year after the installation of superconducting accelerating cavities.

F. Takasaki of KEK covered the physics results from the TRISTAN experiments, emerging at an impressive rate. As yet, no new thresholds indicate the arrival of new quarks. The VENUS detector has seen some signs of the unexplained single muons accompanying produced hadrons, reported by some studies at the PETRA ring at DESY (see September issue, page 37), but TOPAZ and AMY further round the ring had nothing yet to report on this subject. However AMY does see a slight excess of isolated energetic photons, but it is too early to draw conclusions. Although starting later than the other big experiments, TOPAZ has now logged a comparable amount of data.

At another newly commissioned machine – the Fermilab Tevatron proton-antiproton collider – Roy Schwitters of the big CDF detector covered progress so far. The machine has performed excellently,

The Hamburg Lepton-Photon Symposium also marked the tenth anniversary of the discovery at Fermilab of the upsilon particle (beauty quark and antiquark bound together). At a Fermilab celebration of the discovery earlier this year were (left to right) Alvin Tollestrup, Sandy Anderson (with balloon), Hwa Yoh, Leon Lederman, Janine Tollestrup, Drummond Rennie, Martyl Langsdorf and Vivian Bull.

Carlo Rubbia – future machines.

with collision luminosities already not far from design values (over 10^{29} cm^{-2} s^{-1} compared with 10^{30}) at collision energies of 1.8 TeV (1800 GeV) – the highest in the world.

Schwitters hoped that summary tapes to extract physics data should be available later this year. The detector has seen candidate events for the production of the W and Z carrier particles of the weak nuclear force (discovered in a similar way at lower energy at CERN in 1983).

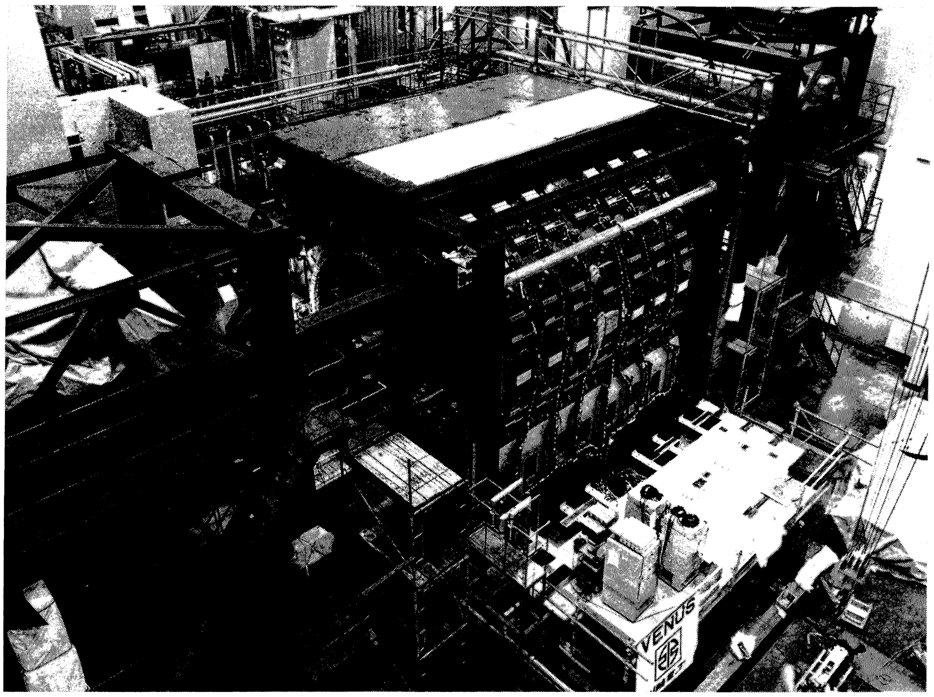
The physics of the W and Z particles garnered from experiments at CERN's proton-antiproton collider was described by Peter Jenni. 'The first phase of proton-antiproton physics has not threatened the Standard Model', he declared, pointing out nevertheless that the UA1 experiment has seen a couple of unusual W decays at high transverse momentum. These have been pounced on by adventurous theorists.

CERN collider results so far suggest that the long-awaited sixth ('top') quark is heavier than about 45 GeV, while the number of possible neutrino types is now less than about five, leaving little room beyond the three known species. The machine is now embarking on a second phase of operation, with the antiproton supply boosted with the new ACOL antiproton collector.

In his conclusion, Rubbia underlined the need for a (spontaneous symmetry breaking) mechanism to explain the very different ranges of the electromagnetic and weak forces in the electroweak picture. The currently advocated 'Higgs' solution is 'clumsy', he maintained, and went on to point out that whatever the mechanism is, there are good hopes that proposed future proton colliders will find evidence for it.

Elsewhere in the electroweak sector, things are in good shape. However A. Sirlin of New York stressed the need for highly accurate calculations (with full radiative corrections) to pin down any telltale discrepancies due to new physics.

Less clear-cut is the quark-gluon side of the Standard Model, where James Stirling of Durham picked his way carefully through the 'minefield' of QCD calculations. Because series solutions are not necessarily convergent, QCD can only be handled confidently if the kinematics are right. However experiments using different physics conditions report comparable results for QCD parameters, and predictions are becoming more precise. Stirling highlighted the spectra of hadron 'jets' seen in proton-antiproton annihilation, showing how calculations agree



The VENUS detector at the TRISTAN electron-positron collider at the Japanese KEK Laboratory. VENUS, and its TOPAZ and AMY counterparts elsewhere in the ring, produced data from the initial TRISTAN runs with impressive speed for the summer conference season.

with the data over an impressive range of kinematics. To extend this range, the first hard data from the CDF detector at the Fermilab Tevatron collider are eagerly awaited. While QCD calculations are becoming more reliable, they are laborious, with effort measured 'in terms of man-years,' according to Stirling.

Another sector full of implications for QCD was particle production using electron and muon beams, covered by Rudiger Voss of Munich. These experiments also see the subtle changes in the quark structure of nucleons (structure functions) due to nuclear environment. The intense theoretical speculation of recent years seems to be waning as the experimental picture firms up. Nevertheless 'an ultimate theory is urgently needed,' concluded Voss.

Away from nuclear effects, the quark structure of the proton has to be known accurately to provide input for calculations, and Voss remarked how the slight difference in proton structure measurements could improve the agreement between the predicted and observed levels of W and Z production with energy in proton-antiproton annihilations. According to Voss, it is not always easy to reconcile measurements from different experimental conditions. However the ratio of longitudinal to transverse production rates from experiments at Stanford and CERN agrees with QCD predictions.

Production of hadron 'jets' in hard interactions is now a powerful way of probing quark behaviour. W. Hofmann of Berkeley described attempts to understand the way quarks and gluons (which do not appear as free particles) produce these characteristic narrow showers of particles.

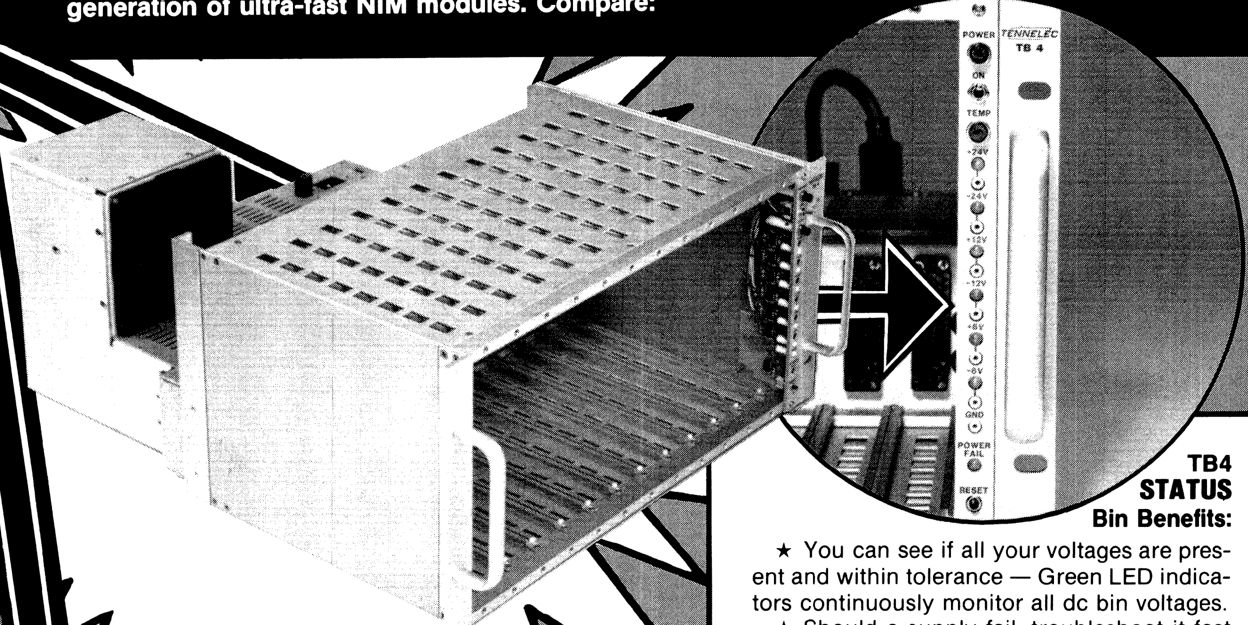
As well as providing input for QCD, electron-positron annihilation at high energy (covered by Sau-Lan Wu of Wisconsin) shows the delicate interference between weak and electromagnetic effects and gives the lifetime of the B meson (about a picosecond). Annihilations giving a photon plus 'nothing' (unobserved particles) give a handle on neutrino production, showing that the number of neutrino types has to be less than about five, in accord with what is seen in proton-antiproton annihilation.

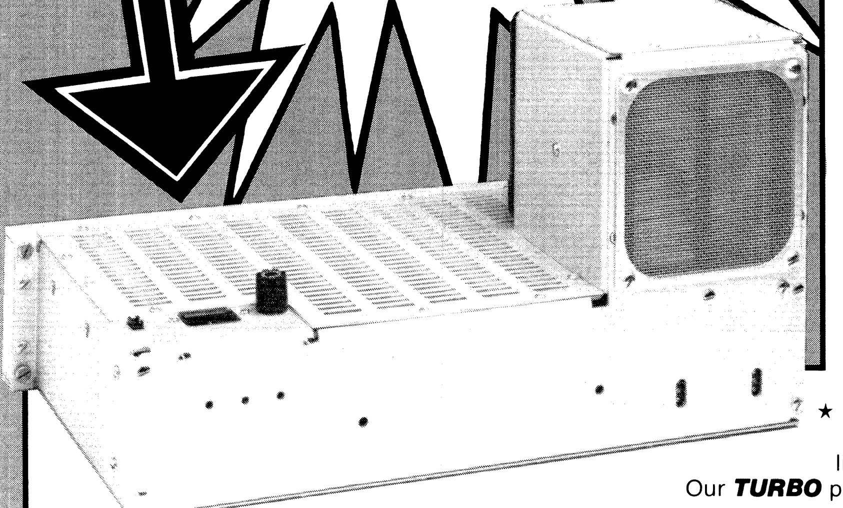
The Lepton-Photon Symposium ten years previously had also been held in Hamburg, when the big news had been the sighting of the first bound state – the upsilon – of the beauty quark and antiquark. Juliet Lee-Franzini of Stony Brook showed how upsilon spectroscopy has developed over the ensuing decade, providing a valuable additional means of probing inter-quark forces.

D. Hitlin of Caltech reviewed the weak decays of charmed particles and heavy (tau) leptons. The earlier report of an unorthodox decay of the tau (see April issue, page 10) has been overturned in a 'flood' of null results, but the total map of tau decays still has to be charted accurately.

Hitlin's talk carefully avoided the physics of the B mesons (carrying the beauty quark) as this had been reserved for W. Schmidt-Parzefall of DESY, who was able to report the first observation, in the ARGUS detector at the DORIS electron-positron ring at DESY, of the decays of the mesons without producing charm (see September issue, page 4). In general, the pattern of B meson decays looks tidier than a year ago, when there was talk of a 'charm deficit'.

The implications of these weak decays was taken up by M. Shifman of Moscow (ITEP), who admitted to being initially 'surprised' by the amount of charmless B decay seen by ARGUS. However this surprise had evaporated on closer inspection. Shifman pointed out


POWER
TENNELEC
TB 4
ON
TEMP
+24V
-24V
+12V
-12V
+6V
-6V
GND
POWER FAIL
RESET



Electron-positron collider notables at Hamburg – Satoshi Ozaki (KEK, Japan, left) and Burton Richter (Stanford).

that while the Standard Model reigned supreme, many of its parameters had still to be measured.

One continual enigma is the subtle asymmetry (CP violation) in the decays of the neutral kaons. Italo Mannelli of Pisa emphasized how little has been learned in the 23 years since the effect was first observed. However precision experiments continue to probe this area. Mannelli highlighted the NA31 experiment at CERN which has studied millions of neutral kaon decays. Results from this and other ongoing studies could help understand this mystery.

Whatever else is happening, neutrino physics can usually be relied on to be controversial. However Hamburg neutrino rapporteur R. Eichler of ETH Zurich admitted that even the standard model of neutrinos looked to be in 'good shape'.

The longstanding disagreement between theoretical predictions for the rate of neutrino emission by the sun and the observed level seen in Ray Davis' underground detector is still there, but very soon the Kamiokande underground detector in Japan could supply an independent measurement. Experiments measuring the mass of the electron neutrino still give a spread of values, but with the Zurich group saying the neutrino is lighter than 18 electronvolts and the ITEP Moscow team reporting a mass greater than 17 electronvolts, Eichler said there was not necessarily any disagreement!

Neutrino physics took a big step forward earlier this year with the observation of particles from a supernova explosion (see May issue, page 1). At Hamburg, M. Koshiba (Kamiokande, Japan), O. Saavedra (Mont-Blanc, Europe) and D. Casper (IMB, USA) reviewed the experimental evidence.

The implications were taken up by Dave Schramm of Chicago. The big push for constructing these big underground detectors had followed the prediction about ten years ago by the then-emerging theories of the 'grand unification' of the strong nuclear and electroweak forces of an unstable proton. Although odd events have turned up, proton decay has yet to be proved. Schramm quoted Luis Alvarez – 'the neutrino detection of the 1987a supernova is a great success for grand unified theories'.

Neutrino parameters inferred from the supernova counts agree broadly with laboratory measurements, but Schramm pointed out that now these detectors have shown what they can do, it should be possible to pick up signals from the additional supernovas whose light is blotted out by dust.

M. Turner, another Chicagoite, reviewed the 'renaissance' in cosmology through advances in particle physics. 'Heavenly laboratories' can supplement what we know from terrestrial experiments. One of the current cosmological puzzles is the 'dark matter' of the universe

W. Schmidt-Parzefall of DESY's ARGUS collaboration – charmless beauty decay.

– electromagnetically inert stuff which nevertheless makes up the gravitational bulk of the universe. Turner advocated that the current 'passionate theoretical predictions' should be counterbalanced by attempts at measurement.

Another tenth anniversary at Hamburg was that of ICFA – the International Commitee for Future Accelerators. Chairman Yoshio Yamaguchi reviewed ICFA's achievements and plans.

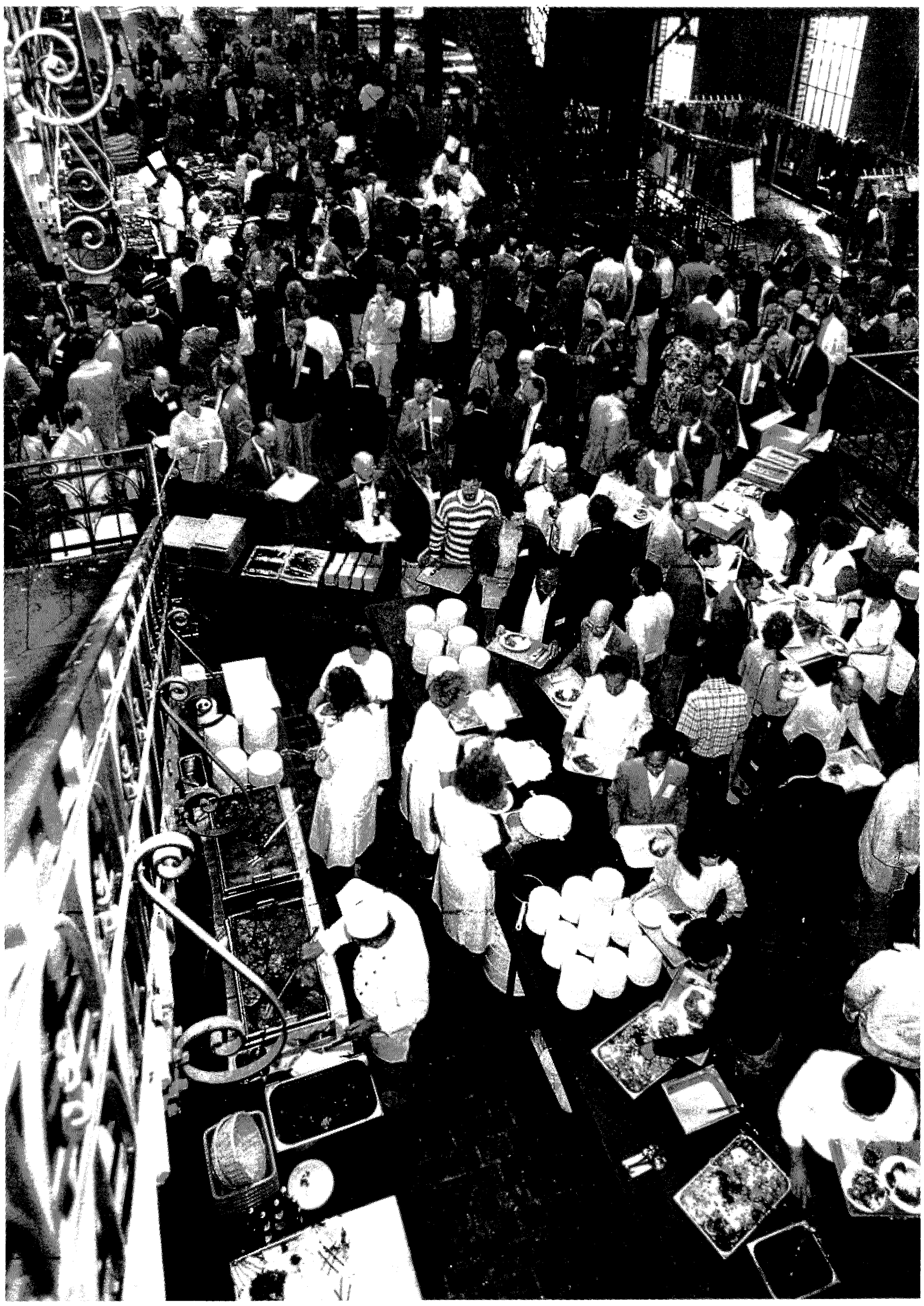
A. Polykanov of Moscow's Landau Institute had been scheduled to speak on the final day of the meeting, but a last-minute indisposition led to an even later-minute substitution by Sheldon Glashow, who looked at the implications of a not so standard model for future experiments, particularly at the LEP machine at CERN.

Hard electromagnetic processes (F. Richard, Orsay) are providing valuable physics input, while high energy neutrino beams (J. Panman, CERN) are giving broadly consistent results, with the mysterious excess of like-sign muons beginning to disappear. High energy photoproduction (M. Witherell, Santa Barbara) provides good information on particle properties (charm lifetimes). Summarizing the very active field of photon-photon interactions, J.-E. Olsson of DESY found himself having to contend with an 'appreciable percentage of all papers contributed to the conference!'.

A session on new projects summarized the status of machines just around the corner – the Stanford Linear Collider (Burt Richter), CERN's LEP electron-positron collider (Albert Hofmann) and DESY's HERA electron-proton collider (Gus Voss).

But it was left to Carlo Rubbia to look further into the future, examining 'highly complementary' projects for a big hadron circular collider and an electron-positron linear collider, both to probe around the magic 1 TeV collision energy at the electron/constituent quark level, pointing out the 'dilemma' of opting for existing technology, or of embarking on schemes needing a substantial development effort to get them off the ground.

Report by Gordon Fraser



Conference dinner in Hamburg's Fischauktionshalle.

(DESY photos by Jürgen Schmidt)


DIMENSIONS AHEAD IN SCINTILLATION
CRYSTAL TECHNOLOGY
Crystal Materials for your applications.
HILGER
Analytical
1983

Old soldiers

by Michael Riordan

Twenty years ago this month, an experiment began at the Stanford Linear Accelerator Center in California that would eventually redraw the map of high energy physics. In October 1967, MIT and SLAC physicists started shaking down their new 20 GeV spectrometer; by mid-December they were logging electron-proton scattering in the so-called deep inelastic region where the electrons probed deep inside the protons. The huge excess of scattered electrons they encountered there–about ten times the expected rate–was later interpreted as evidence for pointlike, fractionally charged objects inside the proton.

The quarks we take for granted today were at best 'mathematical' entities in 1967 – if one allowed them any true existence at all. The majority of physicists did not. Their failure to turn up in a large number of intentional searches had convinced most of us that Murray Gell-Mann's whimsical entities could not possibly be 'real' particles in the usual sense, just as he had insisted from the very first.

Jerome Friedman, Henry Kendall, Richard Taylor and the other MIT-SLAC physicists were not looking for quarks that year. SLAC Experiment 4B had originally been designed to study the electroproduction of resonances. But the proddings of a young SLAC theorist, James Bjorken, who had been working in current algebra (then an esoteric field none of the experimenters really understood), helped convince them to make additional measurements in the deep inelastic region, too.

Over the next six years, as first the 20 GeV spectrometer and then its 8 GeV counterpart swung out to larger angles and cycled up and down in momentum, mapping out this deep inelastic region in excruciating detail, the new quark-parton picture of a nucleon's innards gradually took a firmer and firmer hold upon the particle physics community. These two massive spectrometers were our principal 'eyes' into the new realm, by far the best ones we had until more powerful muon and neutrino beams became available at Fermilab and CERN. They were our Geiger and Marsden, reporting back to Rutherford the detailed patterns of ricocheting projectiles. Through their magnetic lenses we 'observed' quarks for the very first time, hard 'pits' inside hadrons.

These two goliaths stood resolutely at the front as a scientific revolution erupted all about them during the late 1960s and early 1970s. The harbingers of a new age in particle physics, they helped pioneer the previously radical idea that leptons, weakly interacting particles, of all things, could be used to plumb the mysteries of the strong force. Who would have guessed, in 1967, that such spindly particles would eventually ferret out their more robust cousins, the quarks? Nobody, except perhaps Bjorken–and he wasn't too sure himself.

In the late 1970s, following the momentous discoveries at the SPEAR electron-positron ring at SLAC, these venerable old spectrometers fell into disuse and disrepair. Were it not for the efforts of a dedicated group of nuclear physicists from American University (Washington DC), who doggedly kept the study of nucleon structure alive at SLAC, they would most probably have followed their contemporary detectors into oblivion, scavenged for parts to be used elsewhere. Or perhaps it was out of respect for their truly pivotal role in particle physics that they were allowed to remain largely intact, silent relics of the glory years to be shown to the busloads of tourists who visit SLAC every month.

Michael Riordan (above) did research using the 8 GeV spectrometer at SLAC as an MIT graduate student during the early 1970s. Now a research physicist with the University of Rochester, he was spokesman of the recent axion search done with this device. He is also author of 'The Hunting of the Quark', an illustrated history of particle physics being published this month in the US by Simon and Schuster.

Whatever the case, it is indeed gratifying to see one of these vingtagenarians sharing the spotlight again, in the autumn of its years. When the 'EMC effect' surfaced in 1983, suggesting that inside nuclei quarks might come bagged in sixes as well as threes, it was the 8 GeV spectrometer that supplied the quickest and best confirmation – improving and extending the EMC results. The resurrection of ten-year-old empty target data by Arie Bodek and company proved, once and for all time, what a precision tool this detector is.

This versatile cyclops has since become a primary player in the burgeoning field of high energy nuclear physics that grew up in the wake of the EMC effect. A rigid, focusing spectrometer that can be pivoted from one angle to another in minutes without altering its optical properties, the 8 GeV device is unique in physics. Its ability to separate one form factor or structure function from another with high accuracy insures that a steady stream of experimenters will want to use it in the near future. The recent precision measurement of the ratio of scattering contributions due to longitudinally and transversely polarized photons reported at Berkeley in 1986 and again this summer, at Uppsala and at Hamburg, is surely only the first in a long sequence of similar separation experiments.

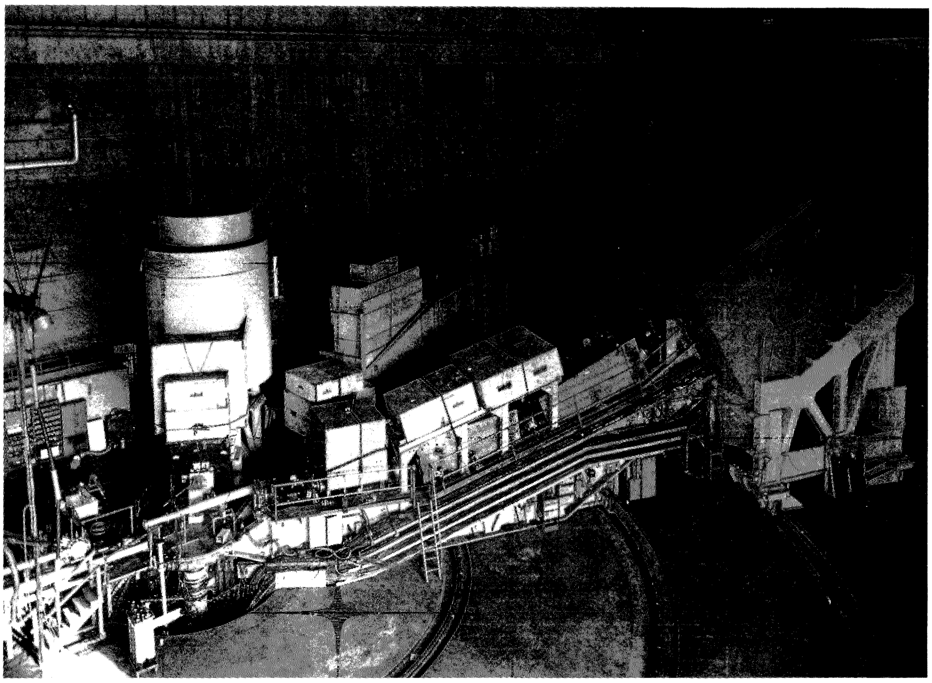
When correlated electron-positron peaks turned up in 1985 at Darmstadt (GSI), raising eyebrows throughout nuclear and particle physics, this trusty old detector was pressed into service once again, in a hasty search for a putative 1.8 MeV axion that some noteworthy theorists had suggested as the source. By rolling the 8 GeV spectrometer into the line of the beam, physicists from Rochester, American University, Caltech, Fermilab, Massachusetts, and SLAC were able to measure the flux of high energy positrons emerging behind a short beam dump inserted into the electron beam upstream of End Station A. The lack of any excess gave definitive proof that the puzzling GSI phenomenon was not due to an elementary axion.

So the 8 GeV spectrometer seems to have an industrious old age ahead of it, with plenty of work to do at the busy new interface between nuclear and particle physics. No doubt worthy employment will be found there for its 20 GeV companion, too. What other detectors, in all of high energy physics, could boast such a long and productive lifetime? Few other machines have had as great an impact upon the way we do physics today. The fact that these old soldiers are still churning out important data twenty years later is solid testament to the wisdom and farsightedness of their designers.

When I take friends now to visit End Station A, I often caution them that they are standing on hallowed ground. We walk among the dusty old hodoscopes and particle detectors littered about the cluttered floor, remnants of the retinas that once sat inside these tired old eyes and caught the first faint glimpse of quarks. I try to tell them what revolutionary changes these aging

The big spectrometers at End Station A of the Stanford Linear Accelerator Centre (SLAC) in 1967: right of the beamline, the 8 GeV spectrometer, and on the other side its 20 GeV and 1.6 GeV (extreme left) counterparts.

The same detectors almost two decades later, still soldiering on.



hulks have wrought in the minds of men and women – in the way we now perceive our entire Universe. Occasionally a bird flies past the massive open doors and into this vast concrete cavern, diving and screeching above, as if laughing at my futile efforts.

How is it possible to be so sentimental about mere artifacts – lifeless configurations of concrete and steel, lead, plastic, and glass? How can a scientist be so unscientific? Were he alive today, a famous American general, hero of World War II, would probably understand my feelings for these aged veterans. 'Old soldiers never die,' he said when relieved of his command during the Korean War; 'They just fade away.'

The pion's pioneers

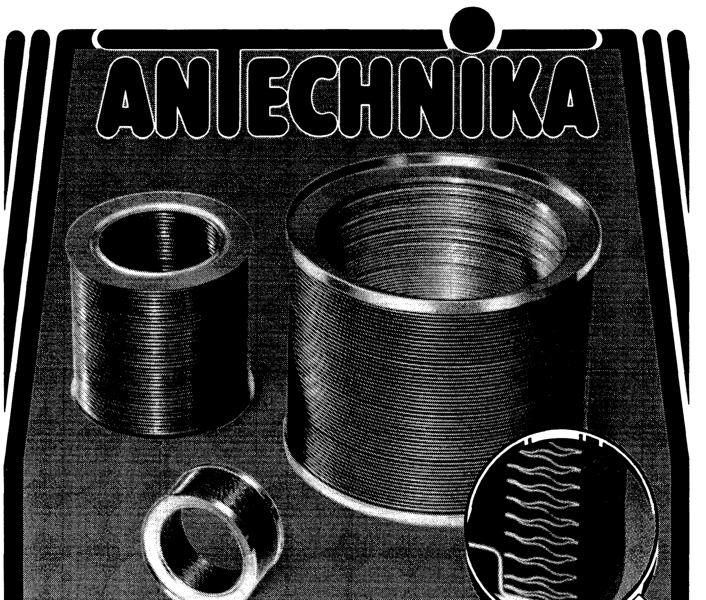
In 1946, a band of intrepid physicists took a batch of a new kind of photographic emulsion up the Pic du Midi in the French Pyrenees to expose them to cosmic rays. After analysing the results at Bristol, C. M. G. Lattes, H. Muirhead, G. P. S. Occhialini and C. F. Powell were able to announce early the following year that they had seen the long-awaited pi meson, or pion, postulated by Yukawa in 1935 as the carrier of the strong nuclear force. This landmark discovery quickly revitalized particle physics after all its wartime upheavals.

At the end of July, the H. H. Wills Physics Laboratory at Bristol was the scene of an unusual and memorable international conference to mark the 40th anniversary of this discovery.

40 years ago, Lattes was a young research worker brought to England from Brazil by Occhialini, also recently arrived from that country at the instigation of P. M. S. Blackett, with whom he had worked in the Cavendish Laboratory in the early 1930s developing the counter-controlled cloud chamber technique. Muirhead was a young research student who had graduated at Bristol in 1946 while Powell, then a Reader in Physics in the Wills Laboratory, had spent many years perfecting the nuclear emulsion technique.

What these workers observed in new Ilford nuclear research emulsions exposed to the cosmic radiation at mountain altitudes were clear-cut examples of the decay of a heavy meson (about three hundred times heavier than an electron) to a lighter meson (about two hundred times the electron mass) of unique energy – a two-body

Peter Fowler recounted the pion discovery at the Bristol 40th anniversary meeting. Fowler, whose association with Bristol stretches over a comparable span, is a grandson of Rutherford. His father, Ralph Fowler, a key theorist at the Cavendish Laboratory in Cambridge, was married to Rutherford's only daughter Eileen.


ANTECHNIKA

decay process. At the very same time and quite independently R. Marshak and H. Bethe announced their two meson hypothesis to account for the apparent failure of the meson normally observed in cosmic rays to behave like Yukawa's particle.

Both Lattes and Muirhead were present at the meeting but Occhialini, who is living in retirement in Italy, was unable to come although he sent a message by his wife, Connie Dilworth, who attended one of the sessions. Cecil Powell died in 1969 but his wife Isobel was present throughout the Conference.

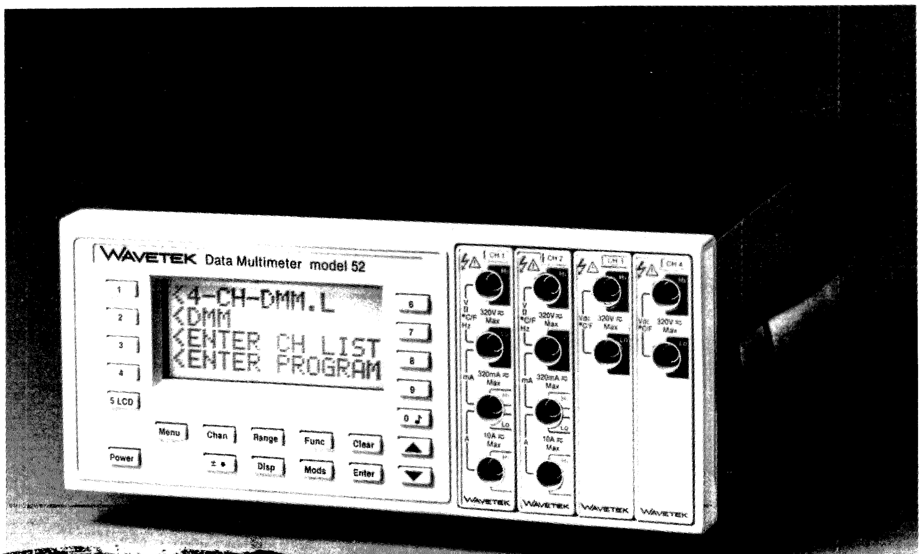
The list of about 100 participants included some of the famous names in cosmic ray and particle physics, many of them now retired; E. Amaldi, Sir Clifford Butler, M. Conversi, R. H. Dalitz, P. H. Fowler, Sir Charles Frank, H. Fröhlich, W. Jentschke, N. Kemmer, R. E. Marshak, Sir Rudolf Peierls, D. H. Perkins, J. Pniewski, G. D. Rochester, R. D. Sard and V. L. Telegdi, to name but a few. The Chancellor of the University, Dorothy Hodgkin, was also present.

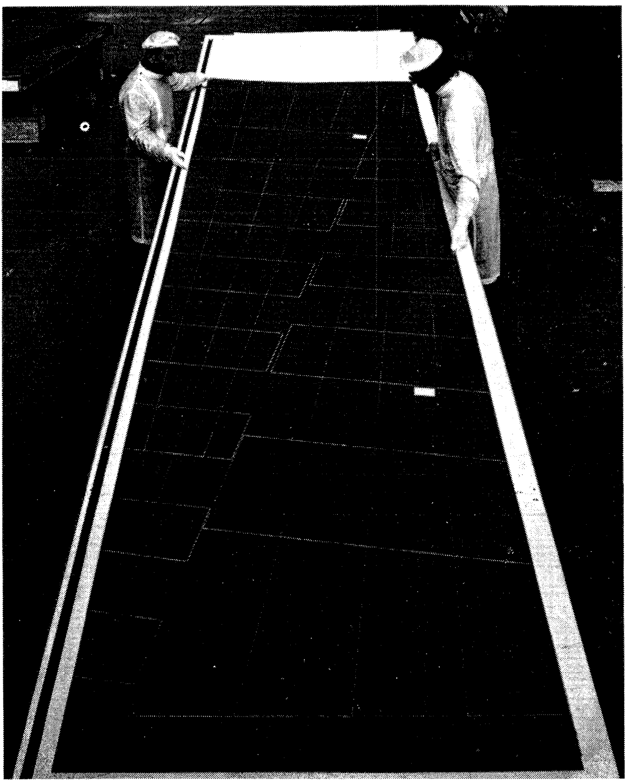
The first invited paper was from Marcello Conversi – 'From the discovery of the "mesotron" to that of its leptonic nature.' He recalled the early work on muons carried out in Rome under the German occupation by Pancini, Piccioni and himself, and how to escape Allied bombs they had to move their apparatus through the blacked-out streets of the city to sanctuary near the Vatican. Then N. Kemmer ('Waiting for the Pion') reviewed the theory of the 1930s, including his famous 1938 paper formulating a meson theory with positive, negative and neutral mesons giving exchange forces between nucleons independent of their electric charge.

It was Cesare Lattes (left) and Hugh Muirhead who, together with G. P. S. Occhialini and Cecil Powell, discovered the pion at Bristol in 1947. The two met again at Bristol in July at the meeting to mark the 40th anniversary of the epic discovery.

Peter Fowler described the actual pion discovery in the early months of 1947. He stressed that the discovery was made possible by the development by Ilford Ltd (and later Kodak) of special nuclear research emulsions, under contracts placed by the UK Ministry of Supply as soon as the war had ended as part of the UK effort to restart pure science. The university physicists improved the processing methods so that it became possible to develop thicker emulsions, greatly improving the technique.

These new emulsions, only 50 microns thick and 2 × 1 cm in area, were taken by Occhialini to the Pic du Midi in 1946. When developed and examined in Bristol, Powell later recalled in his autobiography 'it was as if, suddenly, we had broken into a walled orchard, where protected trees had flourished and all exotic fruits had ripened in great profusion'. Powell and his co-workers soon saw examples of slow mesons captured by nuclei and causing a disintegration, as did Don Perkins, then at Imperial College, in emulsions he had exposed in an aeroplane. However, it was Lattes, Muirhead, Occhialini and Powell (or rather Marietta Kurz and Irene Roberts – wife of the late Max Roberts of CERN's EP Division) who had the good fortune to find within a few days two examples of the now well known decay of a pion into a muon. Since the mass difference between the two particles is relatively small, the muon only had an energy of about 4 MeV, corresponding to a range of about 600 microns in emulsion. If it had been much greater the muon would have escaped the thin emulsions initially


WAVETEK Data Multimeter model 52
4-CH-DMM.L
DMM
ENTER CH LIST
ENTER PROGRAM
Menu
Chan
Range
Func
Clear
Power
Disp
Mods
Enter



used and the event would not have been recognized.

Fowler recalled that in order to get more events by exposing emulsions at higher mountain altitudes, Lattes travelled to Mount Chacaltaya in Bolivia, where there was a meteorological station at 5300 metres. The then Head of the Department, A. M. Tyndall, suggested that he should fly British – BOAC as it then was – to Rio de Janeiro but Lattes preferred the Brazilian airline Varig which not only had a new type of plane – a Constellation – but also served thick steaks. A wise choice as the BOAC plane crashed at Dakar with no survivors.

In the discussion following Fowler's paper, Lattes was able to correct a story which has been current for forty years. It was often said that artificially produced pions were only seen in emulsions exposed at the Berkeley Cyclotron when Lattes arrived there early in 1948 and showed how to correctly develop the emulsions. In fact Lattes said that at the time Gardner (who was making the exposures) was not well and did not have time to scan the emulsions systematically. Lattes had the time and knew exactly where to look, which is why he found the first examples of artificially produced pions.

One of the persons all emulsion physicists present at the Conference were pleased to see was C. Waller, for many years Chief Chemist at Ilford and together with the late M. A. Vincent the man largely responsible for the production of the Ilford Nuclear Research Emulsions, and especially the electron-sensitive G5 type. One highlight of the Conference was Waller's short talk, including a practical demonstration of the preparation of nuclear emulsion, frequently stopping his delivery to give the emulsion mixture a stir or two in a large glass jar!

Cecil Powell's research group at Bristol in 1949. Rear row, left to right; A. R. Gattiker, Mary Cole, Mrs. M. L. Andrews, Mary Merritt, Alex Cole, Peggy Ford, Miss P. Dyer, June Cowie, Grace Hussey, Mrs. B. Moore, Mrs. J. Van der Merwe, Mary Jones, Margaret Stott. Middle row; W. O. Lock, J. H. Davies*, D. T. King*, H. Heitler, S. O. C. Sorensen*, Mrs. I. Powell*, C. F. Powell. Front row; T. Coor, H. Muirhead*, U. Camerini, C. Franzinetti, N. Tobin, P. H. Fowler*. (Those indicated with an asterisk were present at the Bristol meeting this year.)*

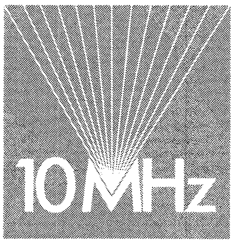
(Photo University of Bristol)

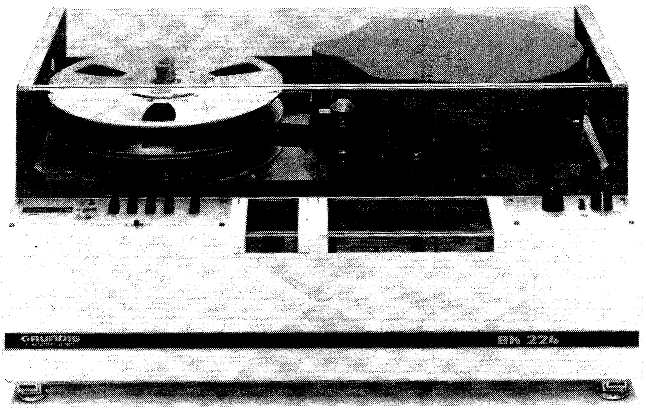
Electron-sensitive emulsions (sensitive to particles of minimum ionization) became commercially available in 1948 first from Kodak as NT4 and then early in 1949 as Ilford G5. Owen Lock described how the Bristol group exposed the new emulsions first on the Jungfraujoch (Switzerland) and then higher up in the atmosphere by means of free balloons.

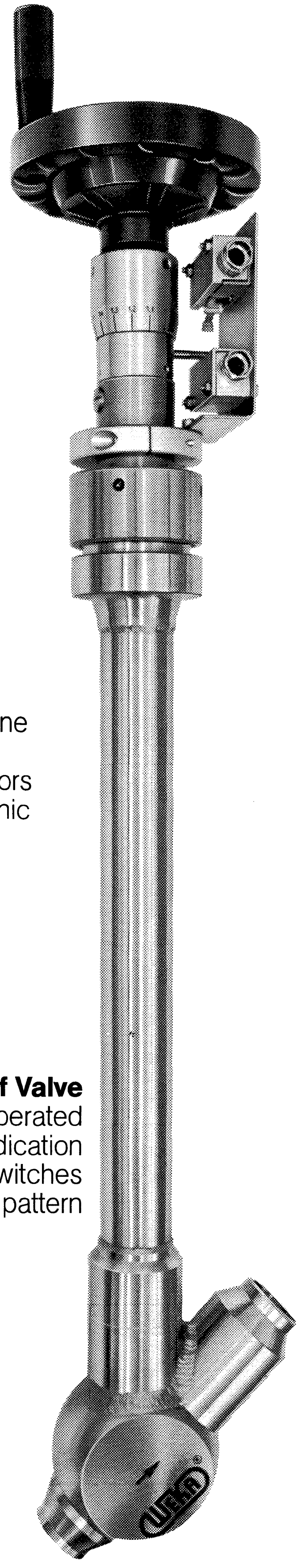
Almost at once the first example was found of a heavy meson decay into three charged pions (later called the tau-meson and finally reidentified as a kaon) while the analysis of the events found in emulsions flown on a single balloon flight at 70 000 feet for 90 minutes provided enough material for a series of now classic papers published in the Philosophical Magazine in the years 1949 to 1951. In these studies the production and interaction properties of the charged pions were established and evidence also obtained for the creation of neutral pions, with even an estimate of their lifetime at less than 5×10^{-14} seconds, a remarkable achievement, made possible by the micron resolution obtainable in the emulsion.

Don Davis followed with a comprehensive survey of the subsequent use of emulsion for the study of hyperfragment physics, the determination of the magnetic moments of the lambda and sigma hyperons and more recently for charm and beauty searches.

The year 1947 also saw the discovery in cloud chamber pictures of the charged and neutral kaons – then called V-particles – by Rochester and Butler at Manchester. The second day of the Conference began with two historical talks by the pair. George Rochester, still sprightly despite his advancing years, gave an excellent account of the early cosmic ray work at Manchester which led up to the discovery of the V-particles in a small cloud chamber operated at sea level. As with the first 'tau-meson', no further examples


10 MHz


GRUNDIG
BK 224



Particle physics research in the late 1940s. Owen Lock (right) and Max Roberts prepare a balloon for launching.

of these new and strange events were found for more than two years, which unnerved the authors (both in Bristol and in Manchester)!

It was soon realized that more events might be obtained by moving the apparatus to the mountains, easy and even essential for emulsions, but difficult for a cloud chamber and its large magnet. In those days there was no telepherique to the top of the Pic du Midi in France while the facilities on the Jungfraujoch could not handle the 3-ton magnet base plate. In his 'Physics on the Mountaintops' talk Clifford Butler described how Occhialini persuaded his old friend and colleague Blackett to transport the so-called Blackett magnet of the Manchester cloud chamber to the Pyrenees in 1949. The Manchester contingent there was soon joined by a group from Leprince-Ringuet's Ecole Polytechnique in Paris with Armenteros, Astier, Gregory, Lagarrigue, Muller, Peyrou and others. A little later a new cloud chamber and magnet from Manchester was installed on the Jungfraujoch by the late J. A. Newth and others and the operation of this facility was later turned over to CERN – hence the reference to cosmic rays in the CERN Convention.

The Conference concluded with a masterly theoretical survey of the whole field of pion physics by Dick Dalitz and with concluding remarks from Don Perkins. Earlier, at the Conference dinner, Edoardo Amaldi spoke on 'The beginnings of particle physics – from cosmic rays to CERN'. As a suitable finale Peter Fowler showed a series of short films of some of the balloon launches of emulsion stacks in the various expeditions to Italy in the 1950s.

The highly successful Conference brought together many of those active in the cosmic ray field in the immediate post-war years, who were able to record their recollections for the benefit of historians of particle physics and all those interested in the development of the subject. Many friends and colleagues from those exciting pioneer years met once again, in many cases for the first time in twenty or more years and in a few cases for the first time in thirty-five years! Old friendships were taken up as if they had never been interrupted. The only regret of the participants was that they did not have more time to talk to each other.

The efficient Organizing Committee was chaired by Peter Fowler, with Brian Foster as Organizing Secretary. Sponsors were the UK Science and Engineering Research Council and the Institute of Physics, together with Bristol University. The Proceedings will be published by Adam Hilger as the publishing house of the UK Institute of Physics. In addition to the papers and subsequent discussion, selected reprints of seminal papers will be included. In the near future the University of Bristol will republish the fragment of autobiography on which Cecil Powell was working at the time of his death, together with some photographs from Mrs Isobel Powell and from the archives of his department. The booklet 'Cecil Powell: Fragments of Autobiography' is available from the Information Office, University of Bristol, 8 Priory Road, Bristol BS8 1T2, UK, price £ 2.50 (Cheques payable to 'University of Bristol').

The meeting came at a time when the support for pure science in the UK is being rethought. The pioneering cosmic ray work in the UK had a strong influence on the emergence of particle physics in Europe and many of the early international collaborations formed in those days helped to create the favourable atmosphere for the subsequent creation of CERN in the early 1950s. Those at Bristol took the opportunity to send an open letter to British Prime Minister Margaret Thatcher appealing to her to intervene personally to prevent a 'tragedy' that might befall British science if the United Kingdom pulled out of CERN.

By Owen Lock

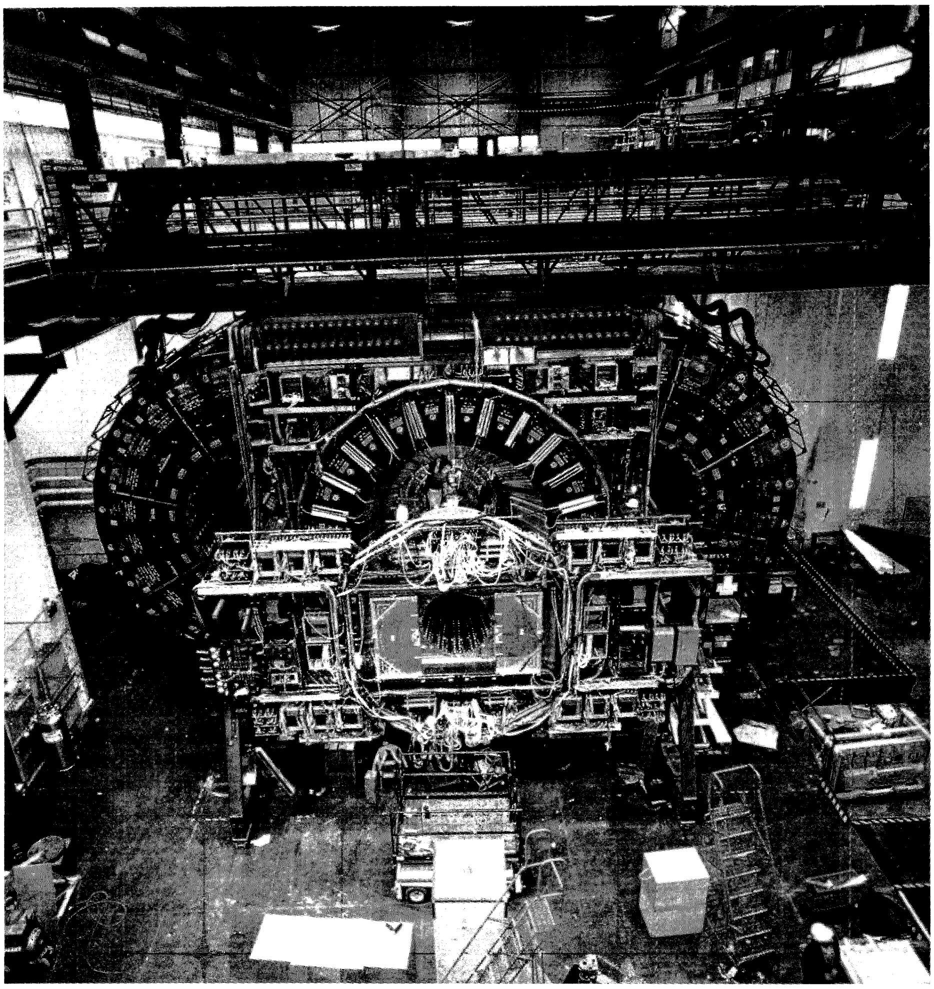
Around the US Laboratories

Brian Southworth was in the US this summer to monitor progress at several major Laboratories and ongoing projects. His report from Brookhaven featured in the September issue, page 19.

FERMILAB
Physics from top to bottom

After the long period of construction and development to achieve and master the world's highest energy hadron beams, Fermilab is committed to several years of non-stop physics. With the 900 GeV per beam proton-antiproton collider and a fixed target programme using 900 GeV proton beams, Fermilab is uniquely placed to study some new areas of physics including extending the search for the long-awaited sixth ('top') quark to higher energies and uncovering the properties of the bottom (or beauty) quark, discovered at the Laboratory in 1977.

The Collider had a five-month run in the first half of this year and both the machine and the main detector (Collider-Detector Facility, CDF) performed well. The antiproton source achieved world record stacking rates of 1.2 mA per hour. Peak luminosity reached 10^{29} (a tenth of the design figure, but a creditable performance in so short a time) and the overall integrated luminosity for the run was over 50 nb^{-1}. There is some entertaining debate on the precise luminosity measurements with the accelerator physicists pitching for a lower figure than the experimenters!

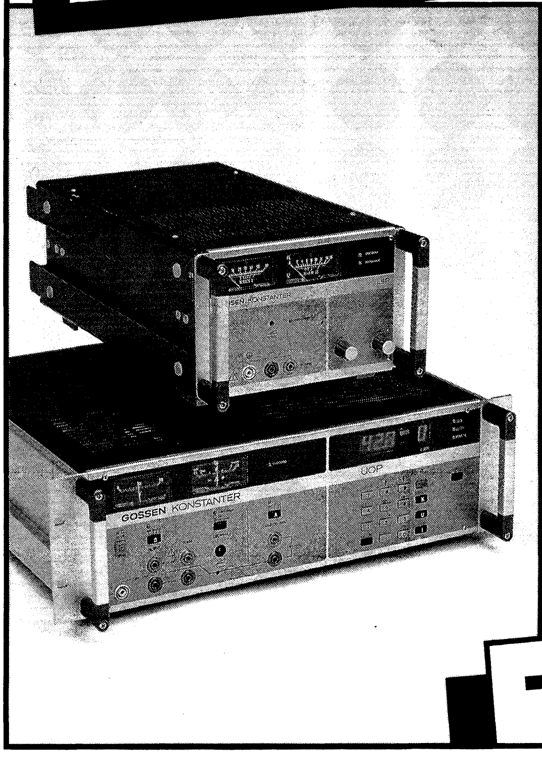


An 'exploded' view of the big CDF detector at the Fermilab Tevatron Collider, now poring over its initial data.

Much work remains to be done to improve reliability – better than expected in the Collider mode, but there have been some difficulties in bringing on the fixed target programme after a lapse of some 18 months, with reliability in the first weeks averaging around 70%. The fixed target run is aiming for 2×10^{13} protons per pulse at 900 GeV every 55 s with 20 s spill times.

Some major actions are being implemented, such as duplicating the cold box at the central helium liquifier. Although the cryogenic system has caused virtually no machine downtime, a failure here could shut off the superconducting ring for several months. There are some difficult machine problems – beam instabilities in the Main Ring can lead to subsequent quench of a superconducting magnet in the Tevatron (recovery time from a quench is about 20 minutes); persistent currents in the superconducting magnets make injection into the Tevatron tricky. This is the main culprit causing antiproton loss, limiting the antiproton transmission through the whole system to some 35%. Also the cause of the limited luminosity lifetime (averaging about 10 hours, though stores of over 20 hours – the design target – have been achieved) is not understood.

The experimental physicist had much to feel happy about from the


GOSSEN KONSTANTER
SEN KONSTANTER
UOP

The silicon microstrip vertex detector for this Brazil / Canada / US experiment at Fermilab is designed to measure the decays of charmed particles to very high accuracy.

Collider run. The CDF worked well, there were enough collisions to begin to get to grips with W and Z physics (25 electron candidates sifted out of the data so far) and the jets at these higher energies are much clearer.

It remains to extract the physics reliably from the huge volume of data. This is proving tougher than handling the hardware. The philosophy is to do a complete analysis rather than being guided by scanning or initial triggers. One headache is that large pulses ('Texas towers') recorded in forward gas-based calorimeters due to soft neutrons can simulate very energetic particles.

From the present data, a detailed analysis can be prepared to look for the top quark. This search will continue over the 50 to 90 GeV range in the next run during the first half of 1988. During this run it is expected that the integrated luminosity will increase tenfold.

Meanwhile progress on the construction of the second large detector system, known as D0, for the Collider has been slowed by available funding. The collaboration has grown to 120 physicists. The first phase of experimental hall construction is complete and some detector installation has started. Extensive tests of many of the components are underway and some design modifications will be implemented so as to cope with an eventual upgrade of the Tevatron luminosity to 5 x 10^{31}. It is hoped that data-taking can start towards the end of next year with the completion of detector construction for a full physics run by the end of 1989.

In considering the low beta section to squeeze the beams for the D0 detector the accelerator team is trying to develop high field superconducting magnets using niobium-titanium-tantalum conductor operating at 1.8 K. The superconducting magnet work is obviously also being kept alive by the Laboratory's participation in the prototype magnet work for the proposed US Superconducting Super Collider.

The fixed target programme for the remainder of the year has experienced a change of lifestyle with larger collaborations (some 1200 physicists involved in the programme), very impressive thoroughly engineered detector set-ups and, more importantly, a dramatically increased output of data (orders of magnitude up on what has ever been recorded before on some of the physics topics) at the high beam energies available from the Tevatron. (This is also the last scheduled run on the 15 foot hydrogen bubble chamber. Thus the big bubble chamber era is coming to an end, though a 1 m heavy liquid chamber may continue to run for neutrino experiments.)

One alluring possibility with these high data levels is sampling new aspects of b quark physics, filtered out from the high hadronic background. This will be studied in a Workshop on High Sensitivity Beauty Physics to be held at Fermilab in November. It will be hard to pull out the data to study CP violation in B meson systems, but attempting to do so will demand detector abilities similar to those needed at proposed big hadron

colliders. Detector R and D would thus be pushed by a specific physics requirement. In the meantime there are experiments on a wide range of physics topics.

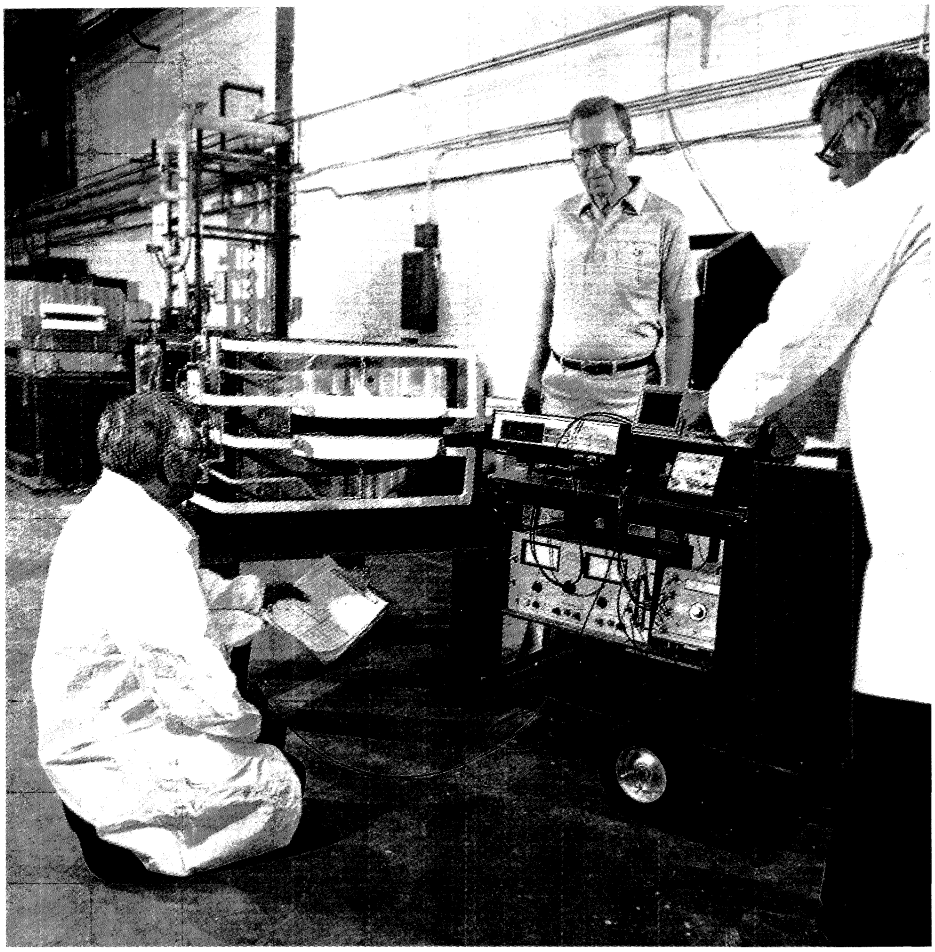
The possibility of using the intense antiproton beams at Fermilab for low energy experiments (as is done with the LEAR ring at CERN) has been studied under the title AMPLE (Anti-Matter Physics at Low Energy) but there is no decision to commit the $30 million or so until there is more conviction that top quality physics with such beams would remain to be done in a few years.

Parallel computing

The volume of data from fixed target experiments and from the collider is already causing problems of software and computing power, with some experiments filling tapes every five minutes. One impressive impact on this problem has come from the 'Advanced Computer Project' which began at Fermilab in 1983. Multi-microprocessor systems have been developed – the first coming into operation in the computer centre a year ago, working initially on the reconstruction of data on charm production from the tagged photon experiment. With its parallel processing capability, the system provided almost as much number-crunching power as the mainframe computers at one per cent of the cost. They are designed for very high data taking rates – over 100 Mbytes per s.

The system has standard VME modules – single board computers (each costing about $2k) with 2 Mbytes of memory running experiment reconstruction codes in Fortran at nearly the speed of a VAX 11/780. The parallel processing philosophy is ideally suited for analysing data from experiments, where each event can be treated separately, and has applications in accelerator physics for orbit calculations and in theoretical physics for lattice gauge calculations. The modules have proved almost completely reliable in operation and are now available commercially; the system received an IR-100 Award in 1986 as one of the hundred most significant technical developments in the US.

Incorporation into the architecture of the Computer Centre was painless. The 'front end', visible to the user, was incorporated into the familiar VAX VMS environment with a full simulator on the VAX Cluster at the Computer Centre. Two large experiments – the CDF and the MEGA experiment at Los Alamos – already use the multiprocessors in their FASTBUS data acquisition systems. Some ten other centres are acquiring systems now available commercially. With increased applications, it is expected that the cost per unit of performance will drop further by a factor of up to ten.



Philip V. Livdahl (facing camera) and Fermilab technicians reviewing the first of a series of dipole magnets to be produced at Fermilab for the proton medical accelerator to be built for the Loma Linda Medical Center, California.

(Photos Fermilab)

Preparing for proton therapy

Fermilab has been participating in the development of cancer therapy with particle beams for many years using neutrons drawn from redundant pulses of the proton linac. Neutrons however are not the ideal particles to attack tumours and their 'relative biological efficiency' has proved to be much lower than predicted. The use of protons in tumour treatment was proposed by Fermilab's first Director, Bob Wilson, as long ago as 1946 and the cyclotron he built at Harvard has been used to treat more patients than any other accelerator. Other proton machines have been used in Japan, Sweden and the USSR. Interest in proton therapy has been revived now that tumour location and size can be very precisely defined using CAT or NMR scanners. This has resulted in projects in the USA aided by Fermilab, and in Europe, aided by CERN (see March issue, page 25).

A Radiation Oncology Centre is being built at the Loma Linda University Medical Centre in California (see December 1986 issue, page 5) and Fermilab is helping in the design and construction of a proton source capable of providing beam energies between 70 and 250 MeV with 10^{11} protons per pulse and up to 1 s spill time. The accelerator is a synchrotron about 6 m in diameter with eight bending magnets. Beam can be directed to several treatment rooms and the aim is that most treatments can be given in less than a minute. Each patient will have an identification to tell the machine what dose and energy to provide (beam energy variation is used rather than degraders to reach tumours at different depths since degraders blur the beam quality).

The magnets are scheduled to arrive at Fermilab in October and the machine will be assembled and operated before being shipped to Loma Linda about a year later. It is hoped that treatments can start in the spring of 1989.

Fermilab's enthusiastic participation in this medical project provides another example of the contribution of accelerator technology to other fields.

One of the final arcs for the SLC Stanford Linear Collider – handling beams in three dimensions has not been straightforward.

STANFORD Collider operations reprogrammed

Turning on the world's first linear machine for colliding electrons and positrons is, not surprisingly, less straightforward than initially hoped. First operation of the SLC Stanford Linear Collider has been tentatively rescheduled for the end of the year.

The fundamental problem is to master the three-dimensional beam optics in the combined-function magnets (bending and focusing fields applied in the same units) bringing the 50 GeV electron and positron beams from the upgraded Stanford linac round the two arcs to the final collision point. These arcs, rather than being in the same plane where beam optics are well understood, follow the contours of the land, dipping up to 30 metres and with gradients of up to 10 per cent. The sensitivity of the beams under these conditions had been underestimated. To add to the problems, the optics cannot be adjusted, as in separated-function systems, by tinkering with focusing fields in quadru-

THE NEW STANDARD OF PERFORMANCE FOR ION CHAMBER SURVEY METERS.

MODEL 450 FROM VICTOREEN

Screwdriver calibration has now been replaced by our unique infrared communicator which allows calibration of the Model 450 and selection of International SI units from a remote terminal. The communicator connects to the Model 450 and to an ordinary CRT or printing terminal via an RS 232 interface.

Designed for a wide dynamic range, and stability equal to or better than vibrating reed instruments, the Model 450 has only two simple controls: an "on/off" button and a "freeze/integrate" button. Others aren't needed because the instrument is both autoranging and auto-zeroing. The "freeze" mode lets the Model 450 remember and display the highest dose rate measured. The "integrate" mode allows dose integration simultaneously with dose rate measurements.

Analog Bargraph and Digital Display readout is provided. The Model 450 field survey meter uses the latest microprocessor technology in a hermetically sealed, lightweight, ruggedized case – a unique instrument that you will want to use often.

Consider the survey meter that does the job without a lot of hand holding. For more information, contact

PTW-FREIBURG

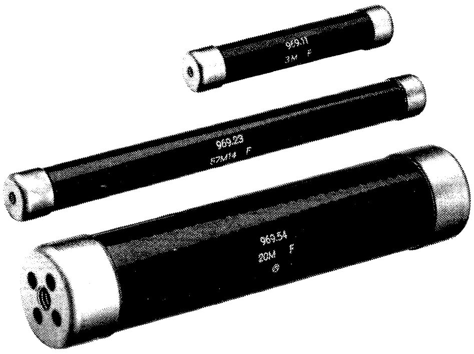
Loerracher Strasse 7
D-7800 Freiburg
Phone 0761/42311
Telex 7721439 ptwf d
Telefax 0761/492195

HIGH-VOLTAGE RESISTORS

high reliability, Metallux Patent

Ohm Range	5 KΩ ÷ 35 GΩ
Operating Voltages	5 kV ÷ 75 kV
Rated power at 40°C	3 W ÷ 105 W
Temperature coefficients	10 ÷ 250 ppm/°C
Voltage coefficients	1 ppm/V ÷ 10 ppm/V
Stability	△R/R < 0,5%, 1000 h, 40°C

Please ask for new techn. documentation!



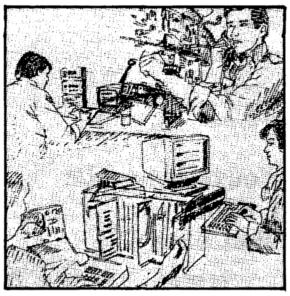
METALLUX
ELECTRONIC

Metallux AG
CH-6850 Mendrisio
Via A. Maspoli 10
Tel. 091/46 49 35-6
Telefax 091/46 52 10
Telex 842 257

Metallux GmbH
D-7305 Altbach
Stauferstrasse 3
Postfach 31
Tel. 07153/2 87 11

CBdK

switching power supplies

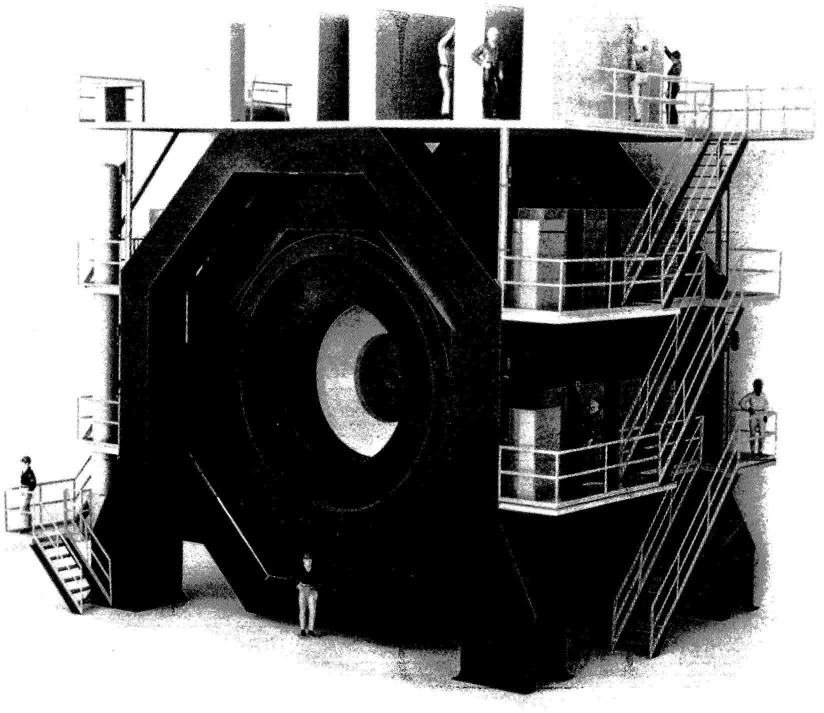


For Industrial
and Military
applications

computer power supplies

AEA

29, avenue Carnot - 91310 Massy - France
Tél. 33 (1) 69 20 84 71
Télex : AEA 691511 F



A model of the SLD detector which will eventually take over from Mark II at the SLC.

pole magnets, but require the combined-function magnets to be shifted.

A thorough attack on the problem will be made next year, but the plan is to get some physics out as quickly as possible in the meantime. It is hoped that initial adjustment can be completed and the machine shut down for several months to allow the Mark II detector to be rolled in. The restart is programmed for mid-December.

In general, all systems, including the positron channel, are working adequately at the 10^{10} particles per bunch level, and confidence was boosted in August when a five micron electron beam – finer than a human hair – was achieved (see September issue, page 26). If all goes well, the experimenters could have some 10 000 Z° particles (the neutral carriers of the weak nuclear force) by next summer, a hundred times more than have been laboriously amassed in proton-antiproton collisions at CERN and now at Fermilab.

The Mark II detector is ready and should be relatively easy to bring into action as it has been used many times before. A lot of work has been done on event analysis following an enlightening test initiated by Gary Feldman who provided some mock data with 'new physics' hidden in it. Confronted with a cunningly contrived cocktail of simulated data with confusing backgrounds, initial techniques to pull out particular signals were found wanting.

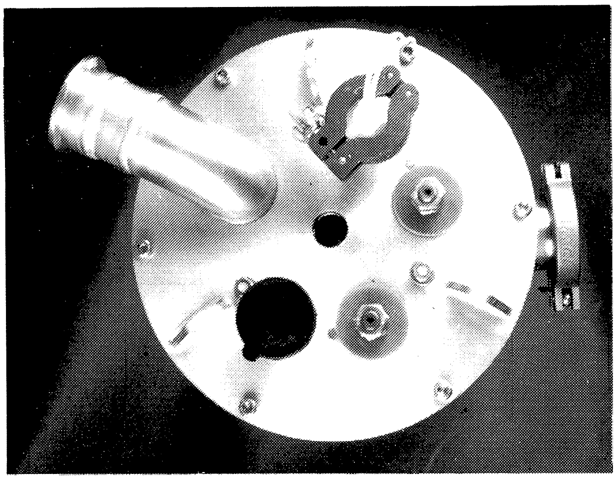
The collaboration looks forward to having first data this year. If the requisite number of Zs materialize by next summer, this should give a precision fix (mass, width) of the Z, and new limits on the number of neutrino species in the Universe and on the mass of the long-awaited sixth ('top') quark. After Mark II has done its work, the big SLD detector will take over the running.

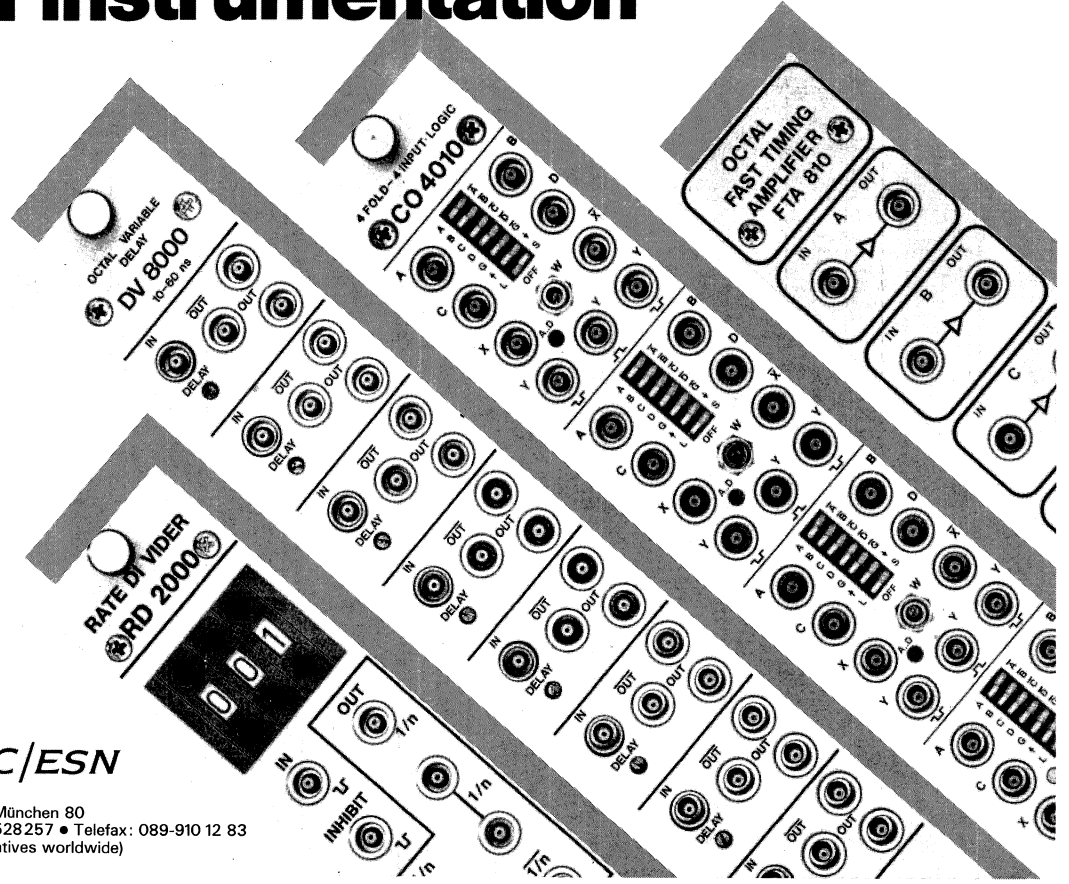
For the long term future, two groups have been set up at the Stanford Linear Accelerator Center to look into the accelerator problems and physics of a 500 GeV linear collider to fit into the Stanford campus (see September issue, page 8). It is hoped to have a scheme sketched out by 1990.

During the linear collider shutdown this fall, the main linac will continue to run, feeding the nuclear physics programme in End Station A (see page 9) and the SPEAR and PEP storage rings. These rings, particularly SPEAR, are exploited by a community of some 500 users for their synchrotron radiation. There is particular interest at the moment in PEP's extraordinary light source abilities, with a workshop organized for 20-21 October.

The synchrotron radiation beamline already installed at PEP is the world's brightest X-ray source by a factor of ten. This is far from being the end of the road since PEP's suitability improves with energy as the beam emittance goes lower. It could serve as an important testbed prior to the proposed Argonne 7 GeV dedicated light source for coherent radiation (see March issue, page 24), and may remain the most intense source of coherent radiation, given that the long straight sections, fitted for particle physics detectors, could allow undulators up to 15 metres long. PEP's light could probe below the one angstrom level.

The synchrotron light programme on SPEAR has been perturbed by all the SLC commisioning work with the main linac. However a new era of independence is imminent with construction of a 3 GeV injector synchrotron. Electrons are




OCTAL FAST TIMING AMPLIFIER FTA 810
4 FOLD-4 INPUT LOGIC CO 4010
OCTAL VARIABLE DELAY DV 8000 10-60 ns
RATE DI VIDER RD 2000
0 0 1
IN
OUT
DELAY
INHIBIT
1/n
A
B
C
D
X
Y
OFF
W

planned initially, but a high repetition rate (10 Hz) for the synchrotron would allow positron operation at a later date.

SUPERCOLLIDER Planning for experiments

To push forward the necessarily lengthy preparations for experiments at the proposed US Superconducting Super Collider, a Workshop on Experiments, Detectors and Experimental Areas was held at Berkeley from 7 to 17 July.

Participants looked ahead to the task of extracting physics (like the search for Higgs particles, supersymmetry or other heavy quarks and leptons) from the chaos of hadron collisions at 20 TeV beam energies with luminosities in excess of 10^{32}. The door would also have to be left open for unexpected physics in these higher energy regions.

Several conceptual designs were evolved in working groups, mostly for general purpose detectors but a few with very specific aims. They include a large solenoid (2 T magnetic field) detector of 4 m radius, a small solenoid 6 T detector of more futuristic design, a 'non-magnetic' detector where calorimetry is optimized without a magnet dominating the design, a muon spectrometer for precision muon measurements, and an 'L3 + 1' configuration on the lines of the L3 detector under construction for LEP at CERN.

SSC conditions are challenging – high precision vertex detectors will probably be unsuitable at the highest luminosities, new systems to reconstruct particle tracks (silicon strips, straw chambers, silicon pixel systems, scintillating fibres) will be needed since 'conventional' drift chambers could not cope with the track densities, calorimeters will have to be large enough to contain 1 TeV particles. Electron and muon identification does not seem to be so difficult. There are some new problems, such as the resistance to radiation of components, including electronics, in a harsh environment and of triggering and data handling with large backgrounds.

Even the most optimistic schedule for SSC construction still allows a few years for research and development. Hopefully the often-used 'interesting problem' label will not demand the impossible! Since SSC detectors have provisional price-tags of upwards of $200 million, careful groundwork and the quest for cost savings are of paramount importance.


At the Workshop on Experiments, Detectors, and Experimental Areas for the SSC, held in Berkeley in July.

The committee of experts to evaluate the proposals for the SSC site has been appointed by the US National Academy of Sciences and the National Academy of Engineering. The committee of nineteen includes well-known particle physics names such as Ernie Courant, Paul Reardon, Nick Samios, Roy Schwitters, Steven Weinberg and Stan Wojcicki. The submission date for the proposals from the interested States was delayed for a month until 2 September. The committee's evaluations will be presented to Energy Secretary John Herrington who is expected to name a site by July next year. After an environmental review, this decision should be confirmed in January 1989.

The budgeted $25 million to continue preparatory work on the SSC was authorized by Congress without difficulty. This was good news for the Central Design Group and provides more funds for the

At an informal meeting of the Executive Committee of the newly formed Users Organization for the proposed US Superconducting Supercollider (SSC) – left to right, Gail Hanson, Tom Kirk (secretary), and Lee Pondrom (president).

work on prototype SSC superconducting magnets.

Excellent results from a series of short model magnets was not repeated in the first two 17 m full-scale prototypes which trained poorly and settled unevenly at a peak field around 5.5 T (compared to the 6.6 T required for 20 TeV beams). The third full-scale magnet trained more slowly than expected but did climb slightly above design field. The problems have been located at the coil ends and the fourth coil package, wound at Brookhaven, has been opened up to strengthen the ends with additional impregnation of alumina. After winding at Brookhaven the coils are transported to Fermilab for installation in their cryostat and subsequent testing.

The plan for industrial production of magnets is taking shape. Interested companies will be invited to a briefing on the magnet production requirements, and a few of them will be invited to build a series of 36 magnets before the contract (or contracts) are placed.

Although Congress did not approve $10 million for SSC construction money, included in the President's budget as a symbol of the nation's commitment, the authorization which really matters will be for a much more substantial figure for construction in next year's budget.

Also helping to prepare the way for the SSC is a newly founded 'users' organization (UOSSC), with Lee Pondrom (Wisconsin/Madison) as president.

A UOSSC Town Meeting was held on 16 July as part of the Workshop on Experiments, Detectors, and Experimental Areas at Berkeley, where Pondrom outlined early activities for the organization. He announced plans to hold an annual meeting for all SSC users plus the establishment of a users office at Berkeley. A newsletter will be added soon.

H. H. (Brig) Williams, Pennsylvania, chairman of the International Advisory Committee on Generic Detector R & D for the SSC, presented a brief report at the Town Meeting (see September issue, page 51). Support levels were suggested at the level of $3M for the coming financial year.

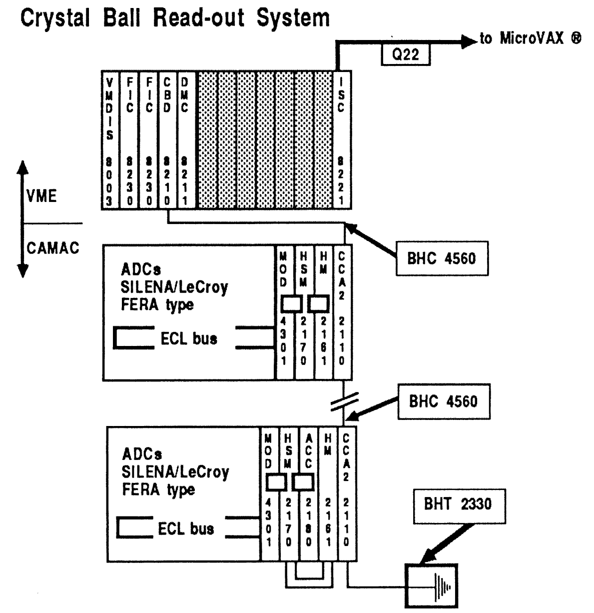
Satoshi Ozaki, KEK, reported on detector R & D plans in Japan. He noted that there is great interest in the SSC in Japan and that a coordinated programme of detector R & D has been set up between the US and Japan. Shigeki Mori, Tsukuba, and M. G. D. (Gil) Gilchriese, SSC Central Design Group (CDG) will coordinate it. Work has started on detector components, SSC large-scale integrated circuits, and a design study for a large superconducting solenoid magnet.

The UOSSC Executive Committee consists of Lee Pondrom, Wisconsin, Madison, President, and Tom Kirk, CDG, secretary, together with Guido Barbiellini, CERN; Ari Bodek, Rochester; Gail Hanson, SLAC; Taka Kondo, KEK; Robert Orr, Toronto; John Peoples, Fermilab; Frank Sciulli, Columbia; Mike Witherell, Santa Barbara; Gunter Wolf, DESY.

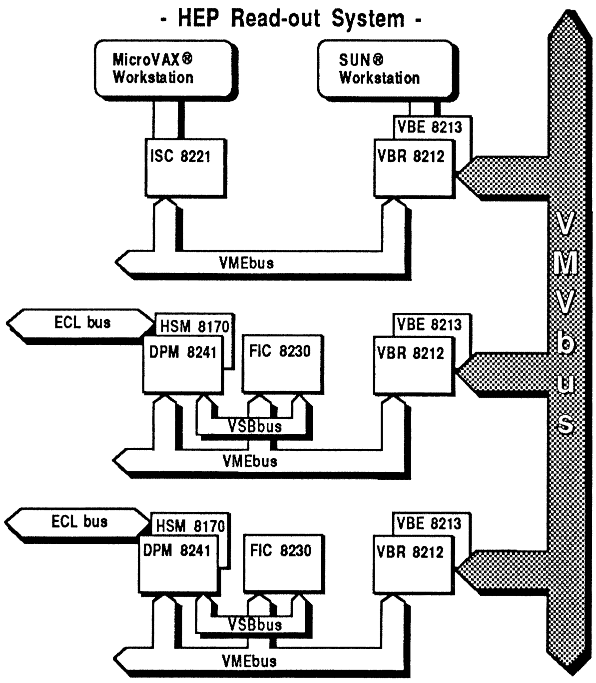
Futher information from
T. B. Kirk, SSC Users Office, c/o
LBL, 90-4040, 1 Cyclotron Road,
Berkeley, CA 94720, USA.

CEBAF
First steps towards physics

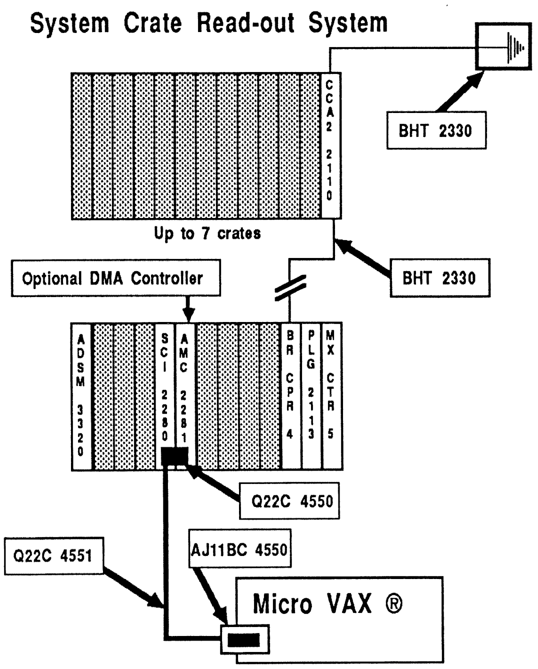
A Programme Advisory Committee for the Continuous Electron Beam Accelerator Facility, where con-



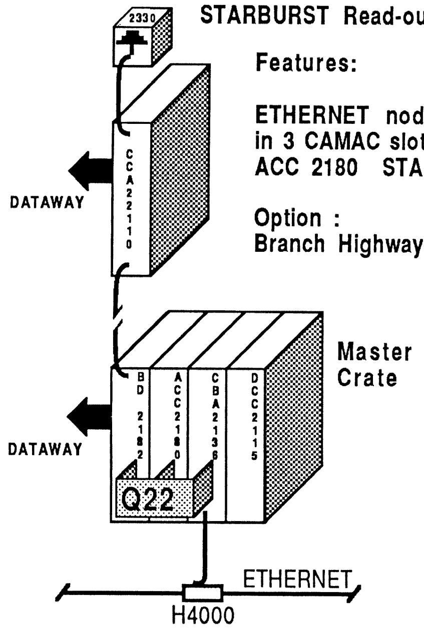
to MicroVAX ®
Q22
VME
CAMAC
VMDIS 8003
FIC 8230
FIC 8230
CBD 8210
DMC 8211
ISC 8221
BHC 4560
ADCs SILENA/LeCroy FERA type
ECL bus
MOD 4301
HSM 2170
HM 2161
CCA2 2110
BHC 4560
ADCs SILENA/LeCroy FERA type
ECL bus
MOD 4301
HSM 2170
ACC 2180
HM 2161
CCA2 2110
BHT 2330



- HEP Read-out System -
MicroVAX® Workstation
SUN® Workstation
ISC 8221
VBE 8213
VBR 8212
VMEbus
ECL bus
HSM 8170
DPM 8241
FIC 8230
VBE 8213
VBR 8212
VSBbus
VMEbus
ECL bus
HSM 8170
DPM 8241
FIC 8230
VBE 8213
VBR 8212
VSBbus
VMEbus
VMVbus



CCA2 2110
BHT 2330
Up to 7 crates
BHT 2330
Optional DMA Controller
ADSM 3320
SCI 2280
AMC 2281
BR CPR 4
PLG 2113
MX CTR 5
Q22C 4550
Q22C 4551
AJ11BC 4550
Micro VAX ®



2330
DATAWAY
CCA2 2110
DATAWAY
BD 2182
ACC 2180
CBA 2136
DCC 2115
Q22
Master Crate
ETHERNET
H4000

IMAGING?

We supply solutions . . . from X-ray to IR

Detail of microchannel plate.

Philips range of channel multipliers is comprehensive. It's also advanced, as illustrated by the 12.5 μm MCP with its open area of up to 80% . . . just one example of our contribution to progress over the last 20 years.

Used primarily as an amplifying element in image intensifiers, MCPs are also the 'eyes' of particle and VUV radiation satellite experiments.

Fibre-optic faceplate technology combined with unmatched know-how in phosphor and photocathode technologies brings you the best in modern imaging.

For example: our XX1380 image intensifier features a resolution of over 50 line pairs/mm.

And our 16" PMT proposal for the DUMAND neutrino astrophysics collaboration enables ^{40}K ocean noise suppression by resolving single- and multi-electron events.

Other Philips advanced devices for imaging include:

- X-ray Image Intensifiers
- TV Camera Tubes
- CCD Imaging Devices
- High-resolution Image Intensifiers
- IR Thermal Imaging Devices

With Philips you therefore get single - stop shopping for all your imaging needs. For more information contact:

Philips Industries,
Electronic Components
and Materials Division,
Eindhoven,
The Netherlands
Telex: 35000/nljeveo

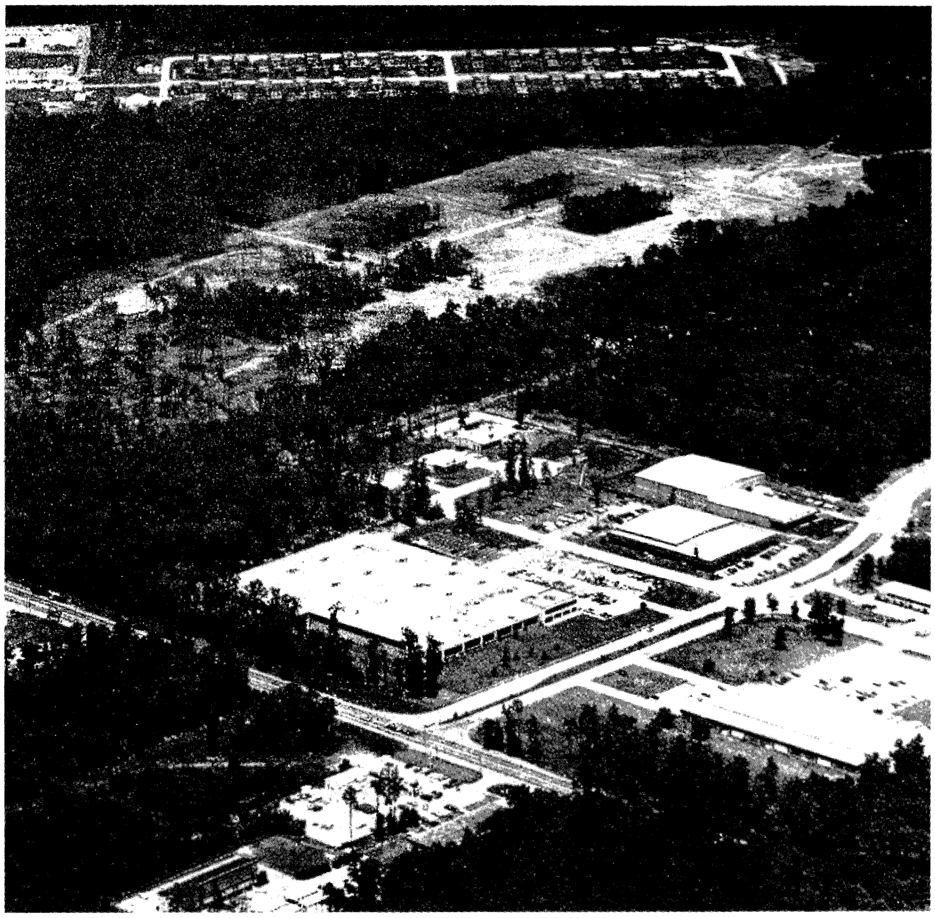
We've set the standard for over 20 years

PHILIPS

Electronic
components
and materials

PHILIPS

Site clearing at Newport News, US, for the CEBAF Continuous Electron Beam Accelerator Facility, top, with laboratory buildings below.

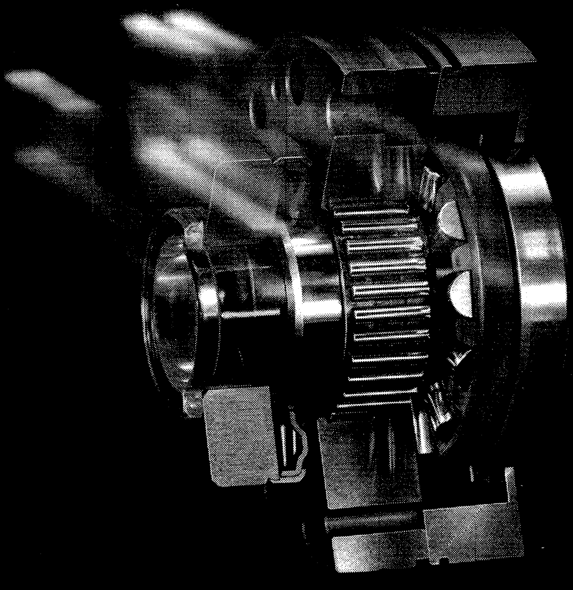


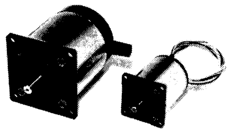
struction began at Newport News in the US in February of this year, will consider letters of intent for the initial experiments when it meets in October. Actual physics proposals will be discussed next April. Completion of the 0.5 to 4 (or 6) GeV machine is scheduled for 1992 and sophisticated experimental stations will need to be ready to make use of the refined abilities of the accelerated beams (100% duty cycle, 200 microamps current, 5 x 10^{-5} energy spread).

At its first meeting, priorities were set and seven themes were listed where CEBAF could make a significant physics contribution: (1) precise measurement of form factors in simple nuclear systems (helping towards the understanding of nuclei in terms of their underlying quark-gluon structure) – a polarized electron beam, fairly straightforward to achieve in a linac like CEBAF, and polarized targets will be particularly useful for these measurements; (2) refined hypernuclear spectroscopy, where resolution at the 200 keV level should allow the study of nuclear states which have never been accessible before; (3) multihadron production, which could yield more thorough information on two-nucleon systems in nuclear matter; (4) reactions involving single nucleons, where the sensitivities available at CEBAF should push the limits by some three orders of magnitude in the search for new insights into hadronic structure and improved understanding of the nucleus; (5) study of parity violation to test the Standard Model by measuring the electroweak mixing angle at low energies to high accuracy – an interesting complement to what is anticipated from high energy studies at SLC at Stanford and LEP at CERN and, being at radiative correction levels, could be sensitive to new effects; (6) studying the behaviour of nuclear resonances – polarized beams and targets will be a particular advantage here also; (7) deep inelastic scattering experiments which, with coincidence studies profiting from the high CEBAF duty cycle, could reveal more about subtle quark effects.

To accommodate this experimental programme, three independent experimental end-stations are to be built. Two of them will be equipped initially – one with a large acceptance spectrometer and the other with high resolution spectrometers (electron and hadron). Decision on equipping the third end-station is being left open for the time being. The nuclear physics community interested in using CEBAF now numbers nearly 500 scientists from 27 countries.

Site clearing for the machine is now well advanced and the test laboratory for the crucial superconducting radiofrequency cavities – the accelerator's most adventurous components – is being equipped. Over 400 of these five-cell niobium cavities of the type developed at Cornell (see April 1986 issue, page 17) will sit in two antiparallel 0.5 GeV linear accelerators through which the electrons can be recirculated to reach a peak energy of 4 or potentially 6 GeV. Large magnet arcs will connect the linacs so that beam quality will not be impaired seriously due to increasing energy spread and synchrotron radiation.






SWISS
QUALITY

Around the other Laboratories

The prototype work on the cavities at CEBAF, at Cornell and at five industrial companies is going very well. To reach the design energy of 4 GeV requires an accelerating gradient of 5 MV/m (and a quality factor of 2.4×10^9 at 2 K) and this required performance is being consistently exceeded. The best performance yet, in a Cornell cavity, has been 15 MV/m and a commercially built cavity has reached 12 MV/m. Pairs of five-cell cavities are now being installed in cryostats for tests with all the associated components – tuners, feeds, mode dampers.

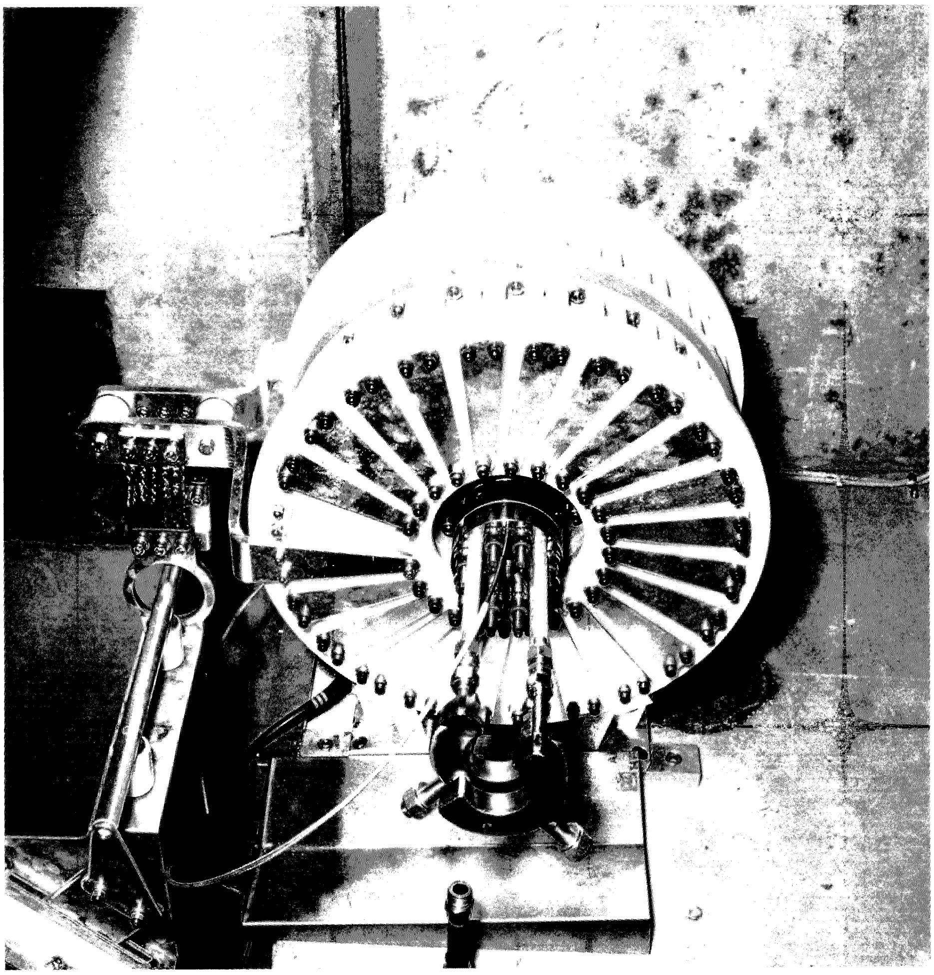
CEBAF has now clearly become the main centre in the USA for superconducting r.f. cavity work and, in addition to the immediate aim of ensuring the required performance of the machine, there is continuing research to improve cavity performance. It is intended to work on cavity surface coatings, including niobium-tin, and progress with new high temperature superconductors is being closely watched. There will also be studies of the fundamental limitations of cavity performance – the origin of defects, suppression of field emission, the source of residual surface resistance and so on. Other structure and cryostat designs will be investigated. In the long term this work could contribute to electron-positron linear colliders and to the possible upgrade of CEBAF itself.

CERN
More antiprotons

CERN's new ACOL antiproton collector complex is being put through its paces. The goal is to handle ten times more antimatter than before, so that the big UA1 and UA2 experiments can intercept many more proton-antiproton collisions in the SPS and add to their already impressive physics score.

ACOL consists of the AA Antiproton Accumulator ring, commissioned in 1980, and the new AC Antiproton Collector, together with an improved production target (see September issue, page 26).

After carefully setting up ACOL with proton beams (so as not to waste precious antiprotons) early in August, the new antiproton production target, consisting of an iridium wire, with the emerging particles focused by a lithium lens, was exposed to a 26 GeV proton beam and the resulting antiprotons circulated happily in the AC ring – the first time the new machine has handled antimatter. The antiproton production rate is already about ten times higher than before, promising well for the future. The next task is to control these stronger beams with the ACOL beam cooling systems to prepare for the first SPS collider physics runs using the new beams later this year.

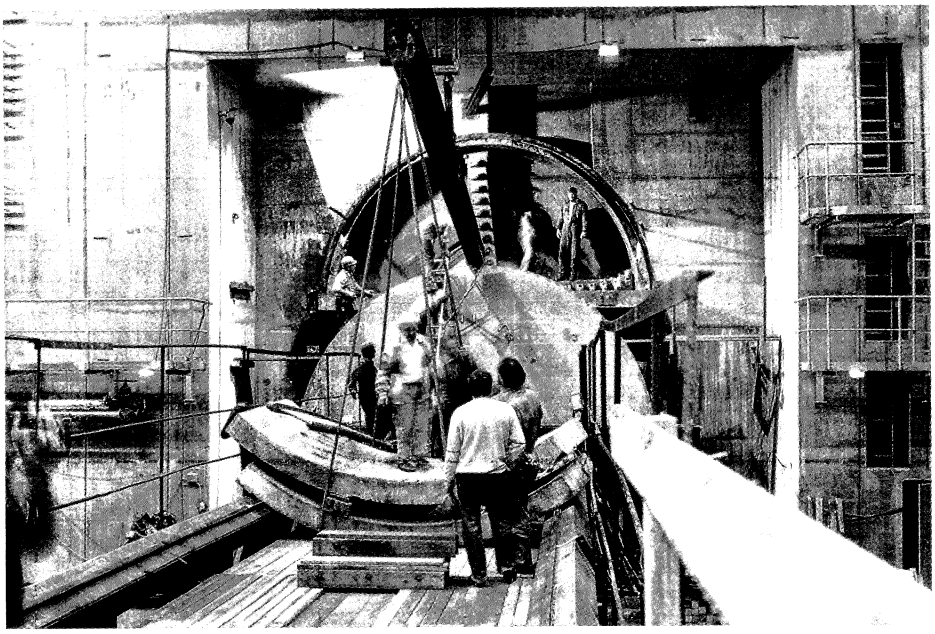


The lithium lens used to initially focus the antiprotons in CERN's ACOL Antiproton Collector is based on earlier designs from Fermilab and Novosibirsk.

(Photo CERN X850.9.86)

The 'HERACLES' machine boring the ring tunnel for the HERA electron-proton collider at the German DESY Laboratory in Hamburg arrives back at the South Hall, completing the 6.3 km circuit it began on 6 May 1985.

(Photo DESY)



DESY HERA tunnelling complete

The 'HERACLES' boring machine finished its work on the 6.3 km ring tunnel for the HERA electron-proton collider in Hamburg on 19 August, news already carried in our September issue (page 15). The machine reached the South Hall where it started out on its journey on 6 May 1985, within the established schedule, thus surprising many of the ever-sceptical tunnelling experts.

The success was mainly due to the 'Mixshield' and 'Hydroshield' drilling procedures developed since 1972 under the direction of project manager Volkmar Grosse for the Wayss & Freytag Company and realized now by a consortium including Dyckerhoff & Widmann AG, Hochtief AG, Philipp Holzmann AG and Aug. Prien GmbH. Tunnelling machine manufacturer Herrenknecht supplied the Mixshield drilling machine according to the Wayss & Freytag specifications. Much was learned on the way. Towards the end, crew and machine were working 'like a pit-stop wheel-changing team' – as a visitor expressed it with admiration.

A steel tube about 6 metres diameter, carrying the boring head and the leading part of the machine, was pushed through the ground by twelve hydraulic rams of 150 t each. The machine was articulated and had a laserbeam controlled guidance system, which kept it on the required course with deviations smaller than a few centimetres.

Sand, earth and stones up to 20 cm diameter suspended in 'bentonite' (a thixotropic clay mixture) were 'pumped' out through pipes.

Six precast concrete segments and a key were inserted in 1.2 metre steps inside the steel shield, screwed together and made watertight with neoprene gaskets. As the steel tube moved forwards, additional concrete was injected in the remaining gap.

With the tunnel running 15 to 25 metres under inhabitated houses, no harm to surface buildings and no measurable soil settlements were observed.

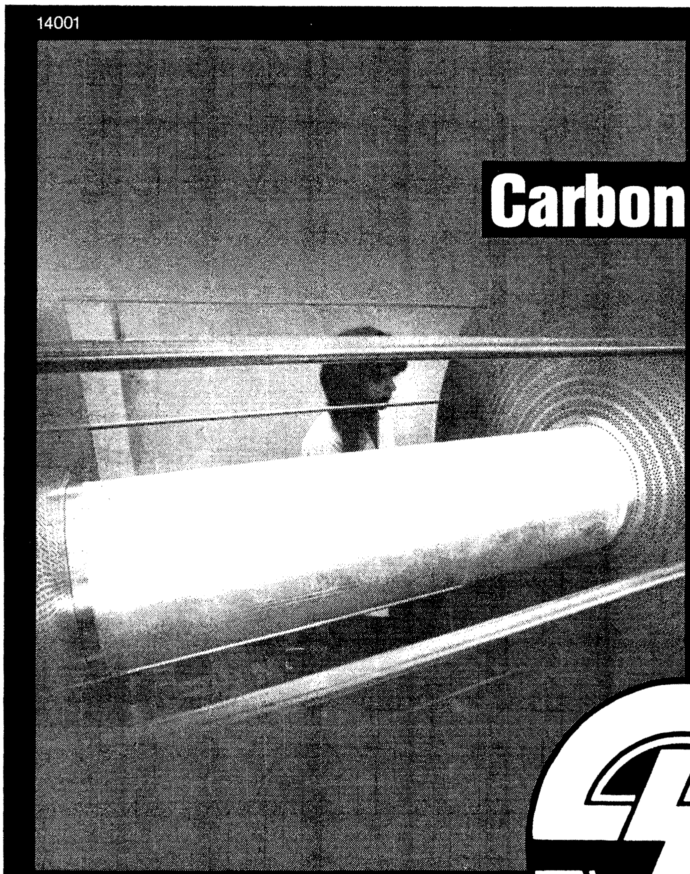
ICFA Instrumentation school

74 students, including 45 from developing countries, ten lecturers and nine laboratory instructors participated in the novel instrumentation school held in June at the International Centre for Theoretical Physics (ICTP), Trieste, Italy, sponsored by ICTP and arranged through the Instrumentation Panel of the International Committee for Future Accelerators (ICFA).

During the two weeks of the course, students had the chance to construct and test a proportional chamber, measure the lifetime of cosmic ray muons, operate and analyse the performance of an 8-wire imaging drift chamber, or study noise and signal processing using a silicon photodiode.

Principal instructors for the four experiments were F. Sauli (CERN), D. Hartill (Cornell), D. Christian (Fermilab) and G. Hall (Imperial College, London). The setups were assembled at ICTP before the school with the help of the high energy physics group of the University of Trieste.

Supplementing the hands-on experience with the apparatus were lectures by specialists from all over the world covering instrumentation for future accelerators, together with implications for cosmic ray physics, non-accelerator experiments and medical applica-



14001

Well-founded informations give you a personal lead in any project management. Take for example

Carbon fiber construction elements

for specific use in experimental physics, for panels, pipes, shaped parts and combination products.

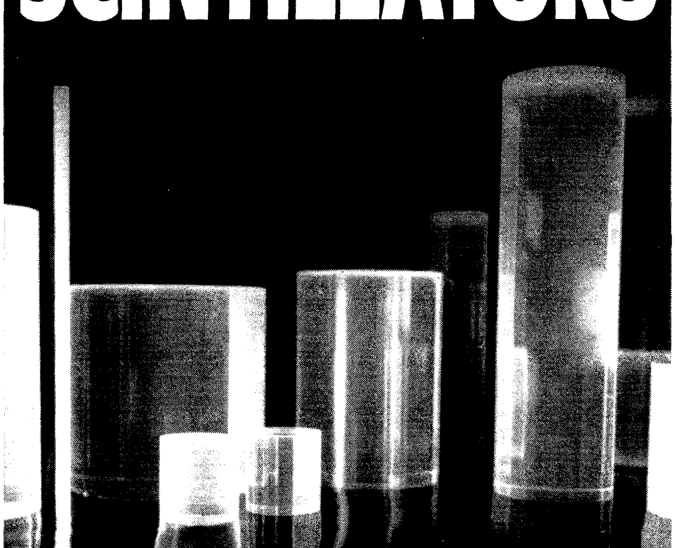
Please request detailed information. Mr H. Mauch will be glad to advise you personally.

We offer a range that is based on 30 years' experience and know how through successful collaboration with field specialists.

Stesalit AG Kunststoffwerk

CH-4249 Zullwil SO Fax 061/80 06 04
Telefon 061/80 06 01 Telex 963182

We provide easily built-in safety in Know-how.

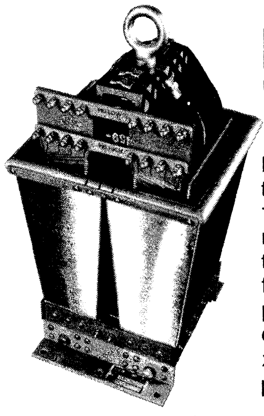


SCINTILLATORS

We have the expertise and the know-how for high-quality plastic scintillators.
High light output, excellent transmission and fast speed are the main features of our plastic scintillators. We manufacture all sizes to customers specifications. Rods, sheets, blocks and light guides with polished or coated surfaces will be manufactured within close tolerances.
Lithium-glass-scintillators are available in special shapes and sizes from powders for HPLC and flow cells, discs for neutron measurements etc. Various types from low background to very high efficiency are available.

ZINSSER ANALYTIC (UK) Ltd.
Howarth Road, Stafferton Way, Maidenhead, Berks. SL6 1AP
Telephone 06 28/2 45 70 · Telex 849 462

M & K



PEARSON

Very High Voltage &
Very High Current

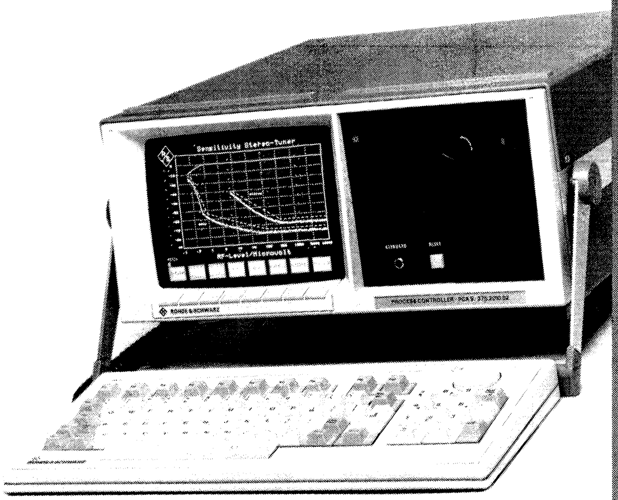
Pulse Transformers

Pearson Electronics specializes in the design of very high voltage (to 1,000,000 volts) and very high current (to 1,000,000 amperes) pulse transformers. Typical applications are for units supplying power to high power microwave tubes, particle accelerator injection systems, pulsed x-ray tubes, high power lasers and plasma physics.

Other Pearson pulse-modulator components include precision current transformers and coaxial capacitive voltage dividers. The current transformers for high voltage use feature double shielding and high voltage stand-off capabilities. Units for use with high currents are rated up to 1,000,000 amperes or more. The voltage dividers are rated up to 500 kV.

Inquiries regarding specific requirements for these components are welcomed.

PEARSON ELECTRONICS, INC.
1860 Embarcadero Road, Palo Alto, Calif. 94303, U.S.A.
Telephone (415) 494-6444 Telex 171-412



Contrôleur de processus PCA 5

de **ROHDE&SCHWARZ**

- Calculatrice à 16 Bit plus rapide et plus performante pour la commande de système de mesure et de test
- Système d'opération MS-DOS 3.10
- BASIC étendu, graphique
- 1 MBytes de RAM, 1.2 MBytes sur Floppy Disk
- Option: Winchester de 20 MBytes
- Bus IEC à 350 kBytes/s

ROSCHI
Télécommunication SA

CH-3063 Ittigen, Case postale
Téléphone 031 58 90 11
Télex 911 759

Représentation
générale et service
pour la Suisse

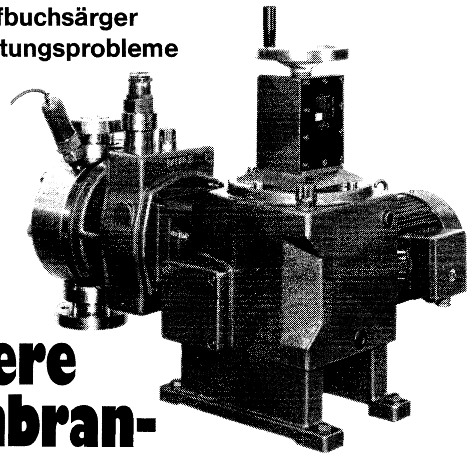
CAPTEURS

et appareils pour la mesure de:

- **Accélérations (0 - 1 / 0 - 100 000 g.)**
- **Angles**
- **Champs magnétiques**
- **Contraintes (jauges)**
- **DÉBITS (air)**
- **DÉPLACEMENTS (LVDT / pot. / sans contact)**
- **ÉPAISSEURS**
- **FORCES (± 10 g à 0 - 1000 ton)**
- **HUMIDITÉ**
- **INCLINAISONS**
- **MOMENTS DE TORSIONS**
- **PRESSIONS (0 - 0,5 mbar à 0 - 7000 bar)**
- **TEMPÉRATURES**
- **VITESSES linéaires**
- **VIBRATIONS**

et aussi
Datalogger
Terminals RS 232
Interface Modules mV - V - mA - A - Temp. - Imp ... / RS 232

RIKENTA AG
Motorenstrasse 21, 8005 Zurich
Tél. 01/44 29 90, Télex 823 015



LEWA

Hermetisch geschlossen
Kein Stopfbuchsärger
Keine Wartungsprobleme

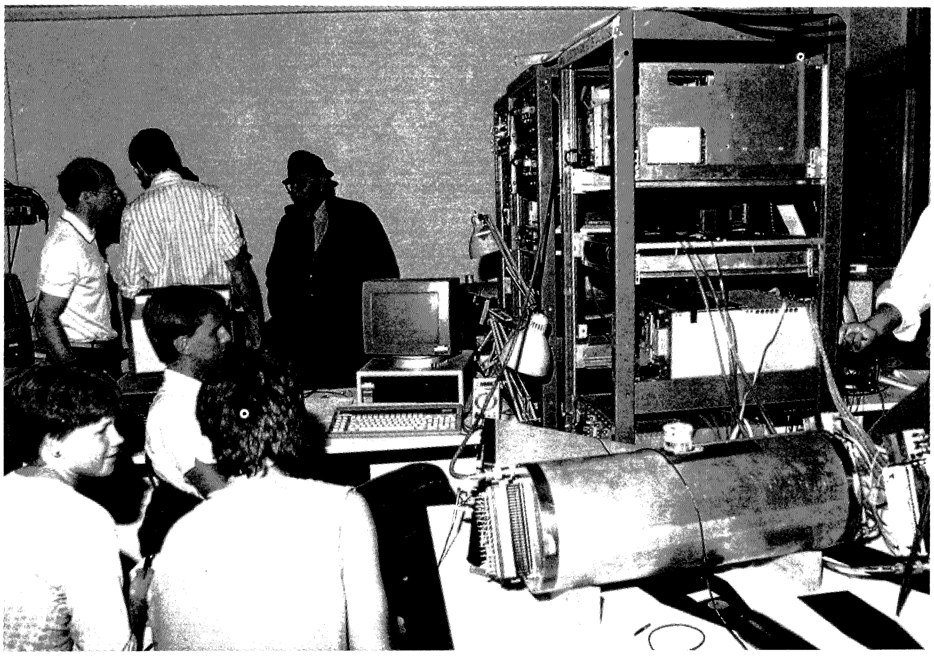
Die sichere Membran-Dosierpumpe

Für alle umweltgefährdenden, kritischen Fluide (übelriechende, giftige, radioaktive, aber auch sterile oder abrasive). In vielen Ausführungen für nahezu alle Betriebsanforderungen. Auch mit "Remote-Head". Förderströme von 5 ml/h bis über 100 m^3/h, Drücke bis 3500 bar.
Mit der patentierten LEWA-Sandwichmembran bietet sie ein Höchstmaß an Betriebssicherheit.

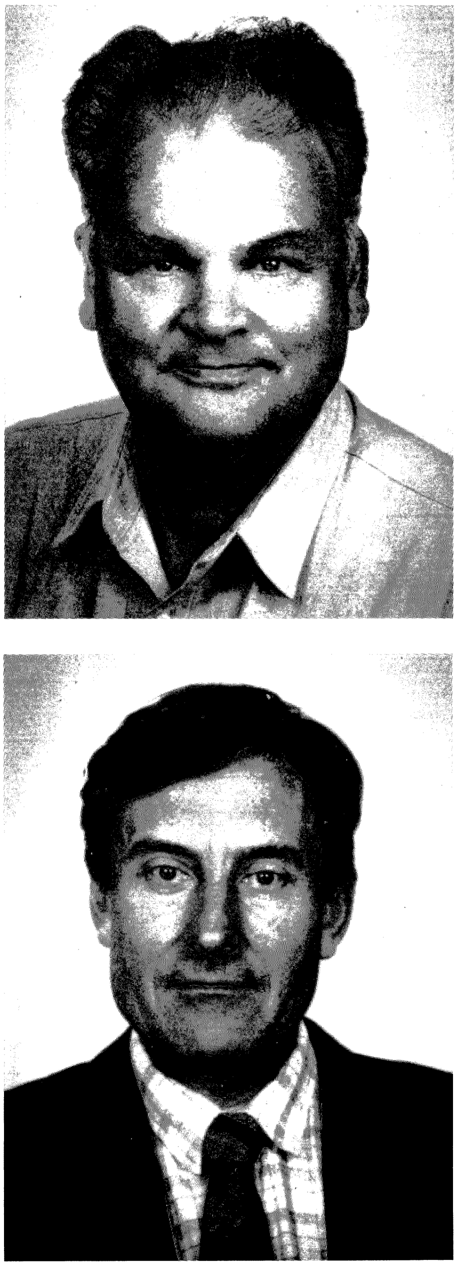
Weitere Informationen: Broschüre D 2-200 bitte anfordern.

HERBERT OTT AG
Missionsstrasse 22, Postfach, CH-4003 Basel
Telefon 061/25 98 00, Telex 964 562 (hoc)

Grappling with a drift chamber - students at the recent Instrumentation School at the International Centre for Theoretical Physics (ICTP), Trieste, Italy. In the background (with hat) lurks ICTP Director Abdus Salam.



Prizewinners for Achievement in Accelerator Physics and Technology – Klaus Halbach (top) and Lars Thorndahl.



tions. Discussion sessions helped to monitor and reinforce students' progress.

Student response was very positive, many of them suggesting that the course could be extended to four weeks so that there would be the chance to handle all four experiments (in two weeks only two setups could be covered).

Thanks to the ICTP support, the highly professional assistance from the local Trieste group, the enthusiasm of the instructors, and, last but not least, the motivation of the students, the school was a great success.

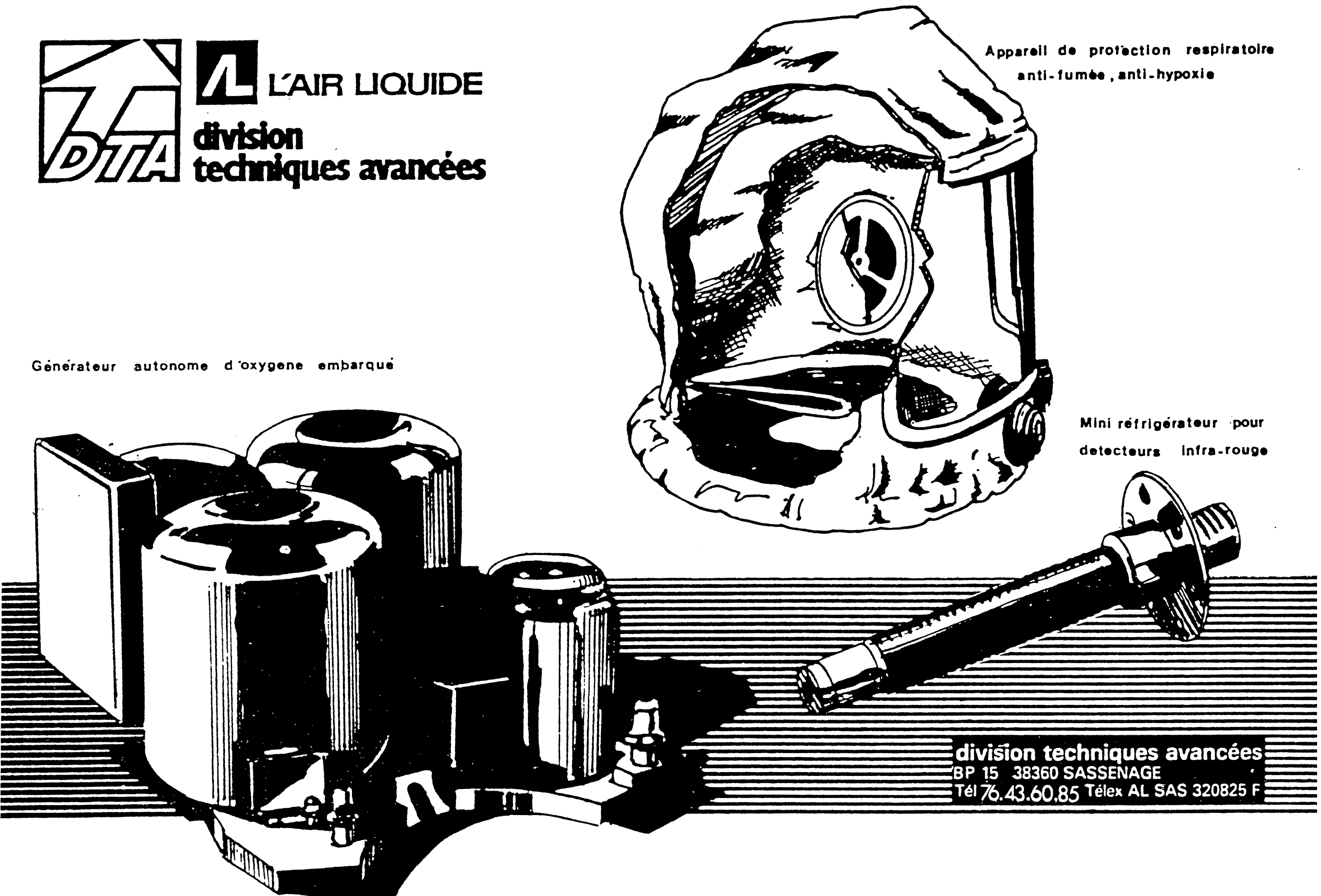
ACCELERATORS
School prizes

Dedicated to its goal of encouraging scientists and students to work in the field of particle accelarators, the US Particle Accelerator School (operating since 1981) has switched to a new format. Starting this year, it will offer in alternate years basic accelerator physics plus advanced subjects in both university and symposium styles over four weeks. Expanding the school from two to four weeks gives additional flexibility, and undergraduate participation should be encouraged by university credits being offered for particular courses. In the intervening years, the school will organize six-day topical courses.

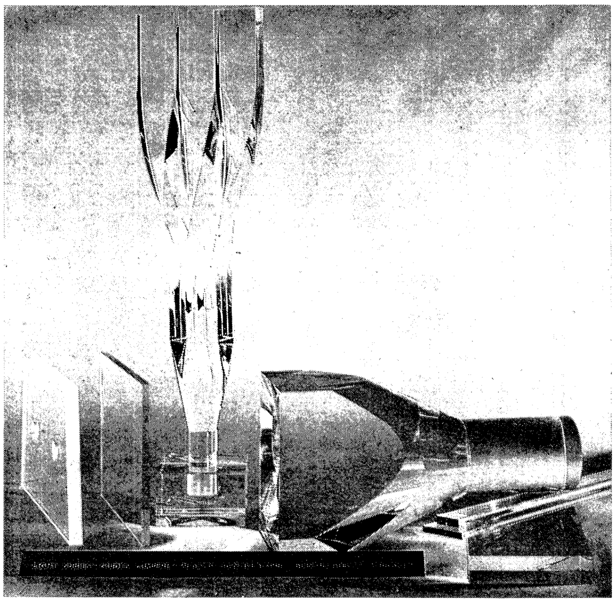
This year's school was at Fermilab, with two weeks of university style courses at the end of July preceding two weeks of symposium style lectures at the beginning of August, during which the 1987 Prizes for Achievement in Accelerator Physics and Technology were awarded to Klaus Halbach of Berkeley and Lars Thorndahl of CERN.

Halbach was cited for 'making high field permanent magnets practical tools for accelerator technology'. He has pioneered the use of modern permanent magnets in accelerators, and his work has had a major impact on synchrotron radiation and free electron laser projects throughout the world.

Thorndahl was cited for 'essential theoretical and experimental contributions to the stochastic cooling of particle beams'. Stimulated by Simon van der Meer's idea, Thorndahl initiated in 1971 the first test of stochastic cooling (increasing the beam density by



Appareil de protection respiratoire
anti-fumée, anti-hypoxie
Génerateur autonome d'oxygene embarqué
Mini réfrigérateur pour
detecteurs infra-rouge



People and things

electronic means) at the CERN Intersecting Storage Rings (ISR), and has since been a driving force in the continual push for intense antiproton beams.

(The Director of the US Particle Accelerator School is Mel Month, and the School can be contacted through Marilyn Paul at Fermilab, MS 125, Batavia, Illinois, 60510, USA.)

On people

One of the recipients of this year's E.O. Lawrence Memorial Awards from the US Department of Energy is Miklos Gyulassy of Berkeley, recently a visitor in CERN's Theory Division.

Dirac medals

The 1987 Dirac medals of the International Centre for Theoretical Physics (ICTP), Trieste, Italy, have been awarded to Bruno Zumino of Berkeley and Bryce de Witt of Austin, Texas.

For the past 25 years, Zumino has been a world leader in field theory. With Julius Wess, he made landmark contributions, including pioneer work in supersymmetry. With Stanley Deser, he constructed one of the first supergravity theories in four dimensions. He has also played an important role in the application of modern geometrical ideas.

De Witt has made fundamental contributions to the study of classical and quantum gravity and other gauge theories, and his work underlies much modern formalism. The Wheeler-de Witt equation provides an important starting point for quantum cosmology, while the Schwinger-de Witt expansion is widely used in studying new field theories.

Meetings

Advanced Study Institute on Techniques and Concepts of High Energy Physics, sponsored by the NATO Advanced Institutes Programme, US Department of Energy, US National Science Foundation, Fermi National Accelerator Laboratory and the University of Rochester, will be held from 14-25

Yoichiro Nambu, left, receives one of the 1986 Dirac Medals of the International Centre for Theoretical Physics (ICTP) in Trieste from ICTP Director Abdus Salam (centre) and CERN Director General Herwig Schopper. Meanwhile Bruno Zumino of Berkeley and Bryce de Witt of Austin, Texas, have been selected for the 1987 awards (see above).

High Energy Physics Research Associates

There are vacancies for Research Associates to work with groups in high energy physics. Groups from the Rutherford Appleton Laboratory are working on experiments at CERN, DESY, ILL, and SLAC. There is in addition a vacancy in the HEP Theory Group.

Candidates should normally be not more than 28 years old. Appointments are made for 3 years, with possible extensions of up to 2 years. RAs are based at the accelerator laboratory where their experiment is conducted, and at RAL, depending on the requirements of the work. Most experiments include UK university personnel with whom particularly close collaborations are maintained.

Please write for an application form quoting VN 567 to: **Recruitment Office, R20, Rutherford Appleton Laboratory, Chilton, Didcot, Oxfordshire OX11 0QX ENGLAND.**

serc Rutherford Appleton Laboratory

ISTITUTO NAZIONALE DI FISICA NUCLEARE (I.N.F.N.)

POST-DOCTORAL FELLOWSHIPS IN THEORETICAL, NUCLEAR AND PARTICLE PHYSICS

for non Italian citizens

Applications are invited. We envisage a minimum of 5 fellowships, available for one year, starting on September-October 1988.

The successfull applicants may carry on their research at any of the following laboratories and sections of I.N.F.N.:

- National Laboratories of Frascati (Rome)
- National Laboratories of Legnaro (Padua)
- National Southern Laboratories (Catania)
- INFN Sections in the universities of: Turin, Milan, Padua, Genoa, Bologna, Pisa, Rome "La Sapienza", Rome II, Naples, Catania, Trieste, Florence, Bari, Pavia, Perugia, Ferrara, Cagliari, Lecce and National Institute for Health (Rome).

The annual gross salary is lit. 24,000,000, corresponding to lit. 1,600,000 net per month, plus travel expenses from home Institution to I.N.F.N. Section or Laboratory and return.

Deadline for application is November 30, 1987.

Candidates should submit a curriculum vitae and a statement of their research interests, including three letters of reference.

For further information and applications, please apply to:

Prof. Nicola Cabibbo,
President,
Istituto Nazionale di Fisica Nucleare (INFN)
Casella Postale 56
00044 Frascati (Roma), Italy.

ISTITUTO NAZIONALE DI FISICA NUCLEARE (I.N.F.N.)

POST-DOCTORAL FELLOWSHIPS IN EXPERIMENTAL PHYSICS

for non Italian citizens

Applications are invited. We envisage a minimum of 6 fellowships, available for one year, starting on September-October 1988.

The successfull applicants may carry on their research at any of the following laboratories of I.N.F.N.:

- National Laboratories of Frascati (Rome)
- National Laboratories of Legnaro (Padua)
- National Southern Laboratories (Catania)

The annual gross salary is lit. 24,000,000, corresponding to lit. 1,600,000 net per month, plus travel expenses from home Institution to I.N.F.N. Section or Laboratory and return.

Deadline for application is November 30, 1987.

Candidates should submit a curriculum vitae and a statement of their research interests, including three letters of reference.

For further information and applications, please apply to:

Prof. Nicola Cabibbo,
President,
Istituto Nazionale di Fisica Nucleare (INFN)
Casella Postale 56
00044 Frascati (Roma), Italy.

TRIUMF
MESON RESEARCH FACILITY

UNIVERSITY OF
BRITISH COLUMBIA

Research Associate Positions

in Intermediate Energy Physics

Postdoctoral Research Associate positions involving participation in the experimental physics programs of the University of British Columbia group at the TRIUMF 500 MeV cyclotron are available. Since these positions are comparable in their educational nature to postdoctoral fellowships, candidates should have experience in the field of nuclear or particle physics and should have completed a Ph. D. in nuclear or particle physics within the past three years. Graduate students expecting to complete their degrees within the next few months are also invited to apply.

These appointments can be renewed annually (subject to the usual budgetary confirmation) up to a maximum period of three years. Salary will depend on experience, with a minimum of $ 26,000 per annum.

Curriculum vitae, list of publications and names of three referees should be forwarded as soon as possible to:

Dr. G. Jones
Department of Physics
University of British Columbia
6224 Agriculture Road
Vancouver, B. C. Canada V6T 2A6

The deadline for applications is November 2, 1987.

These positions are planned to be filled during the current calendar year.

In accordance with Canadian immigration requirements, priority will be given to Canadian citizens and permanent residents of Canada.

July 1988 at St. Croix, US Virgin Islands. Further information from T. Ferbel, Department of Physics and Astronomy, University of Rochester, Rochester, NY 14627, USA.

The third Lake Louise Winter Institute will be held from 6-12 March 1988 at the Chateau Lake Louise, Canada. This year the topic for the first three days of pedagogical lectures is 'Quantum Chromodynamics: Theory and Experiment.' This will be followed by a short topical conference with contributed presentations by participants. For further information contact: The Secretary, LLWI, Department of Physics, University of Alberta, Edmonton, Canada T6G 2J1.

The VIII International Workshop on Photon-Photon Collisions, organized by the Weizmann Institute, will be held from 24-28 April 1988 in Shoresh, Jerusalem Hills, Israel. Attendance is by invitation. Information from Ms. A. Weksler, Conference Secretariat, Physics Dept, Weizmann Institute of Science, Rehovot 76100, Israel (bitnet FAWEKSLR at WEIZMANN).

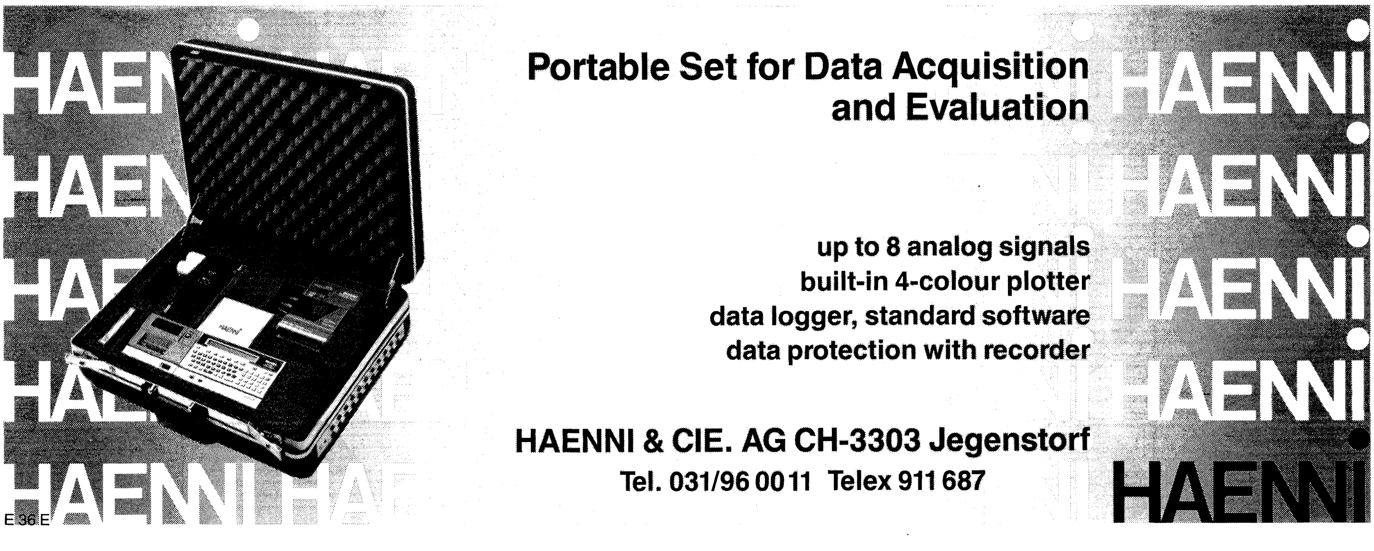
A symposium on the production and investigation of atomic antimatter will be held at the Kernforschungszentrum Karlsruhe (KfK), West Germany, from 30 November to 2 December. The objective is to review the possibilities for synthesizing atomic antimatter using modern antiproton sources and the physics that could follow. Further information from H. Poth, Institut für Kernphysik, Kernforschungszentrum Karlsruhe, Postfach 3640, D-7500 Karlsruhe 1, West Germany (Bitnet POTH at CERNVM).

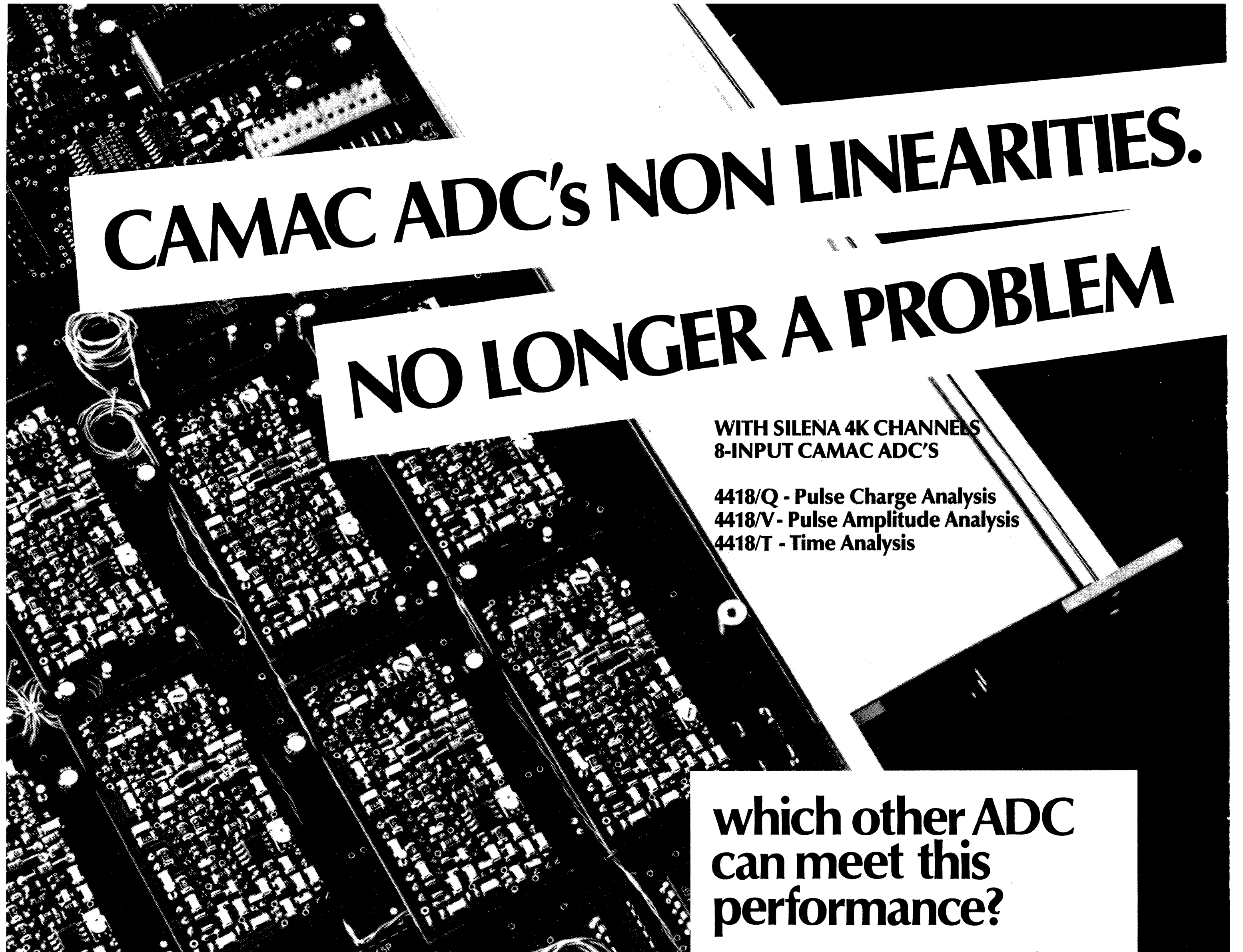
The Adriatico Conference on the impact of digital microelectronics and microprocessors on particle physics will be held at the International Centre for Theoretical Physics (ICTP), Trieste, Italy, from 28-30 March 1988. Sponsored by ICTP, the Italian INFN and CERN, the meeting continues a well established series – CERN (1981), Padua (1983), Guanajuato, Mexico (1984), Amsterdam (1985) and Asilomar, California (1987). Further information from the Conference Secretariat, International Centre for Theoretical Physics, PO Box 586, I-34100 Trieste, Italy (electronic mail MVXTSP::MICROCONF).

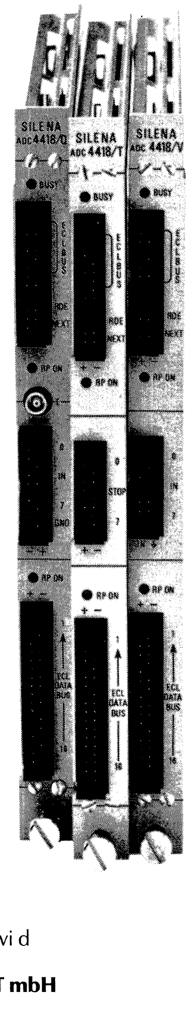
Electronic Mail

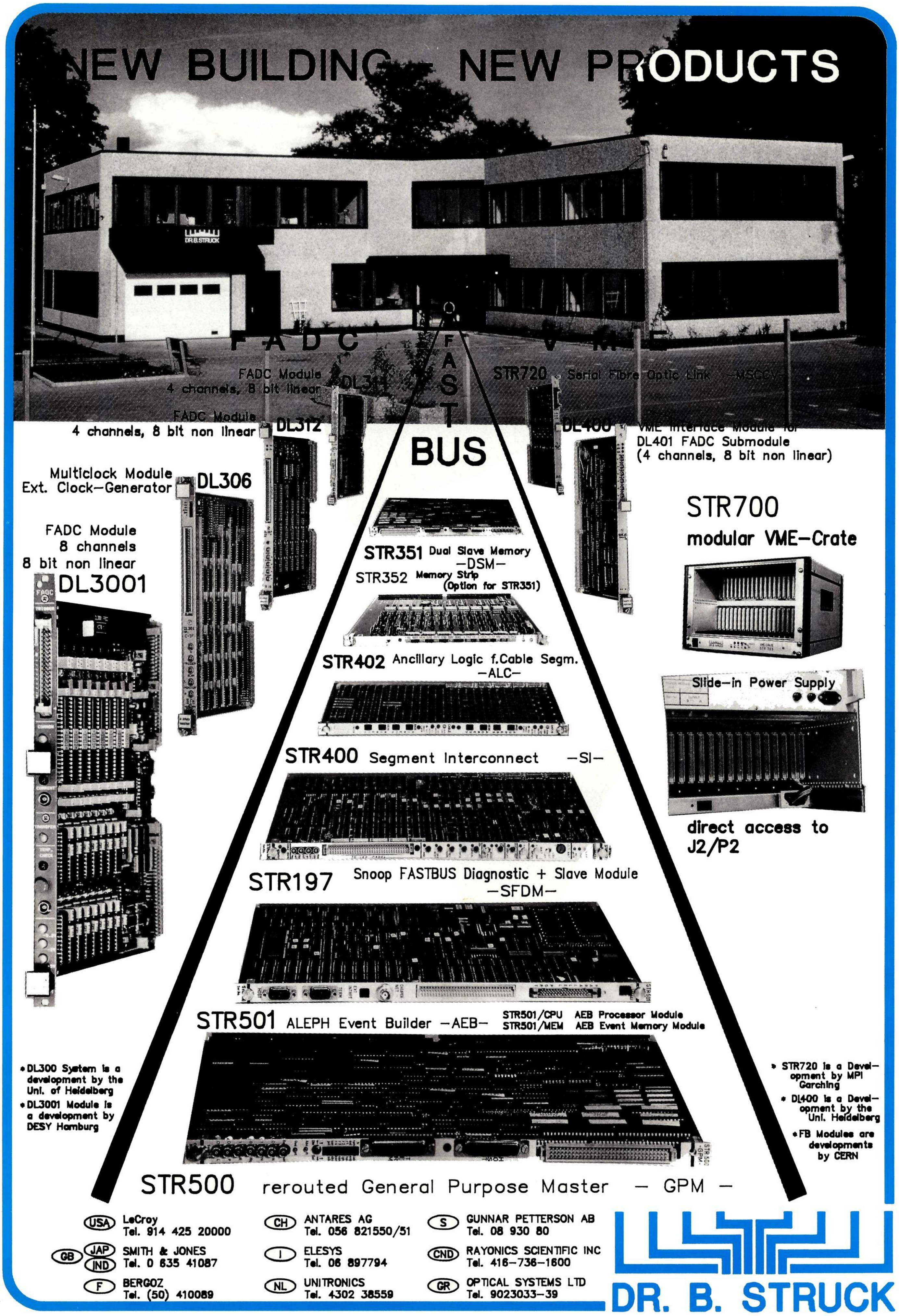
The CERN Courier editorial desk can be contacted through electronic mail using the EARN/BITNET communications network. The Editor's address is

COURIER@CERNVM






SILENA ADC 4418/Q
SILENA ADC 4418/T
SILENA ADC 4418/V
BUSY
ECL BUS
RDE
NEXT
RP ON
IN
STOP
GND
ECL DATA BUS



NEW BUILDING – NEW PRODUCTS

F A D C

FAST BUS

V M E

FADC Module
4 channels, 8 bit linear
DL314

FADC Module
4 channels, 8 bit non linear
DL312

Multiclock Module
Ext. Clock–Generator
DL306

FADC Module
8 channels
8 bit non linear
DL3001

STR720 Serial Fibre Optic Link –MSCCV–

DL400 VME Interface Module for
DL401 FADC Submodule
(4 channels, 8 bit non linear)

STR700
modular VME–Crate

Slide–in Power Supply

direct access to
J2/P2

STR351 Dual Slave Memory
–DSM–

STR352 Memory Strip
(Option for STR351)

STR402 Ancillary Logic f.Cable Segm.
–ALC–

STR400 Segment Interconnect –SI–

STR197 Snoop FASTBUS Diagnostic + Slave Module
–SFDM–

STR501 ALEPH Event Builder –AEB–
STR501/CPU AEB Processor Module
STR501/MEM AEB Event Memory Module

STR500 rerouted General Purpose Master – GPM –

- DL300 System is a development by the Uni. of Heidelberg
- DL3001 Module is a development by DESY Hamburg

- STR720 is a Development by MPI Garching
- DL400 is a Development by the Uni. Heidelberg
- FB Modules are developments by CERN

USA LeCroy
Tel. 914 425 20000

GB JAP IND SMITH & JONES
Tel. 0 635 41087

F BERGOZ
Tel. (50) 410089

CH ANTARES AG
Tel. 056 821550/51

I ELESYS
Tel. 06 897794

NL UNITRONICS
Tel. 4302 38559

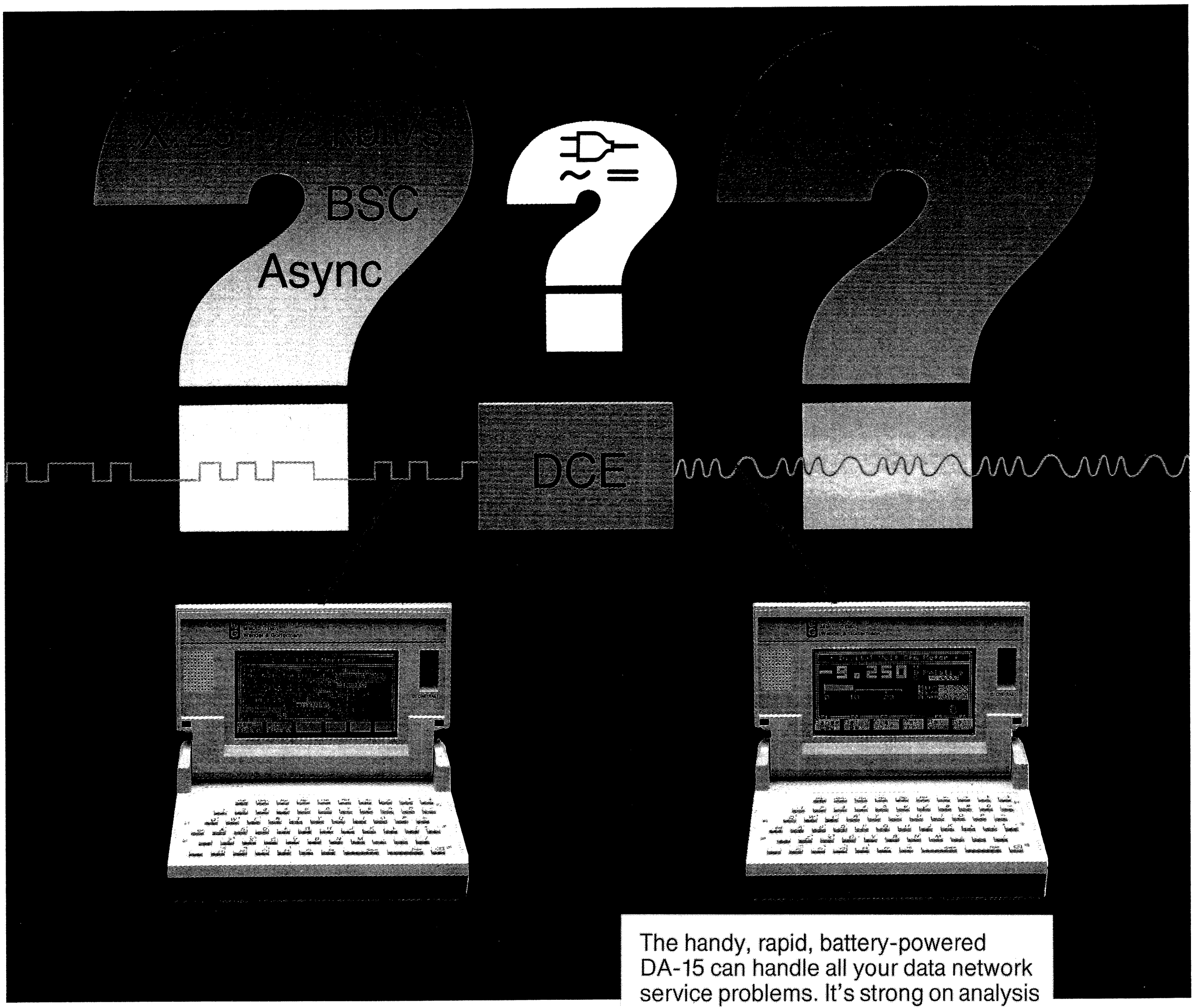
S GUNNAR PETTERSON AB
Tel. 08 930 80

CND RAYONICS SCIENTIFIC INC
Tel. 416–736–1600

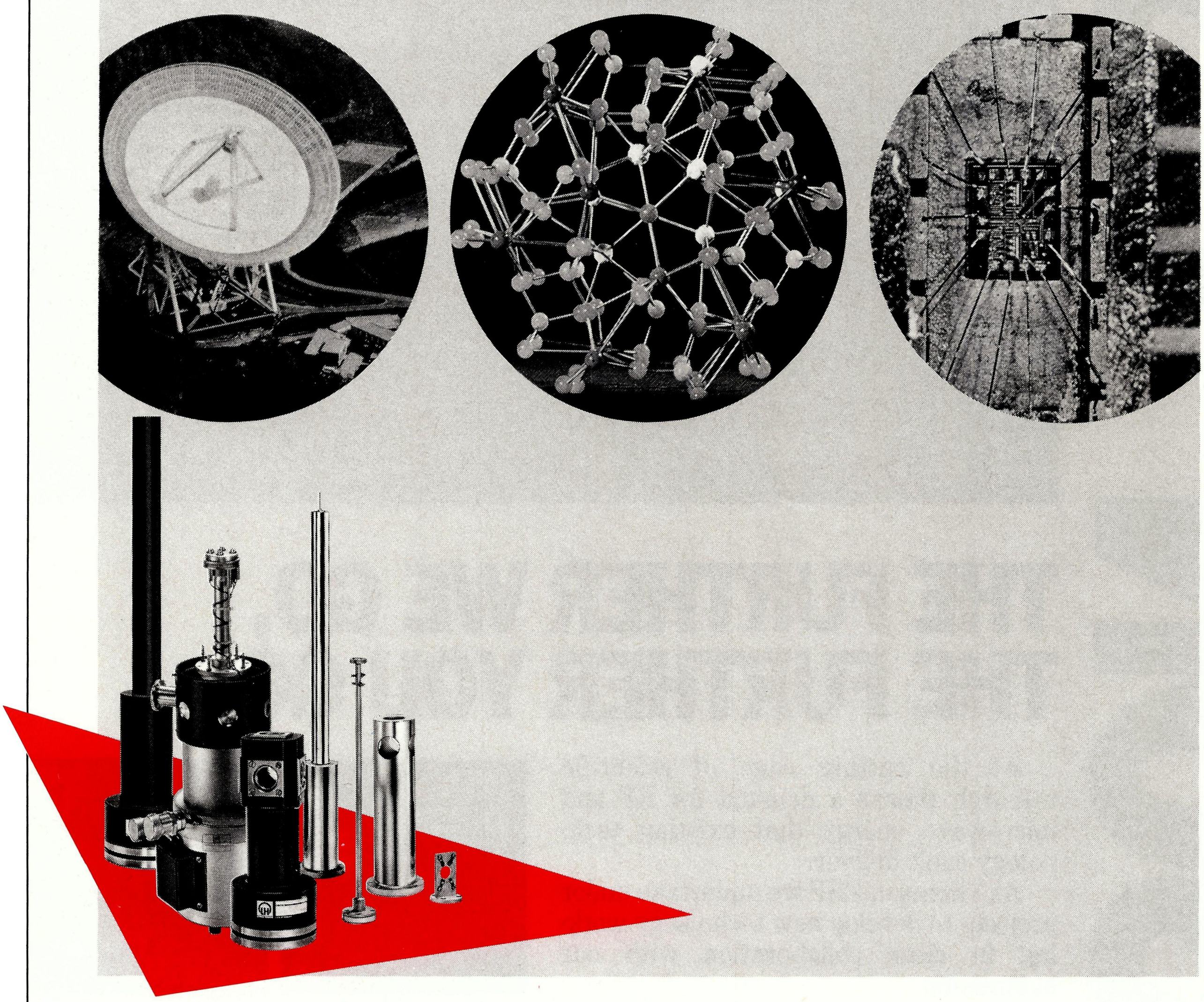
GR OPTICAL SYSTEMS LTD
Tel. 9023033–39

DR. B. STRUCK

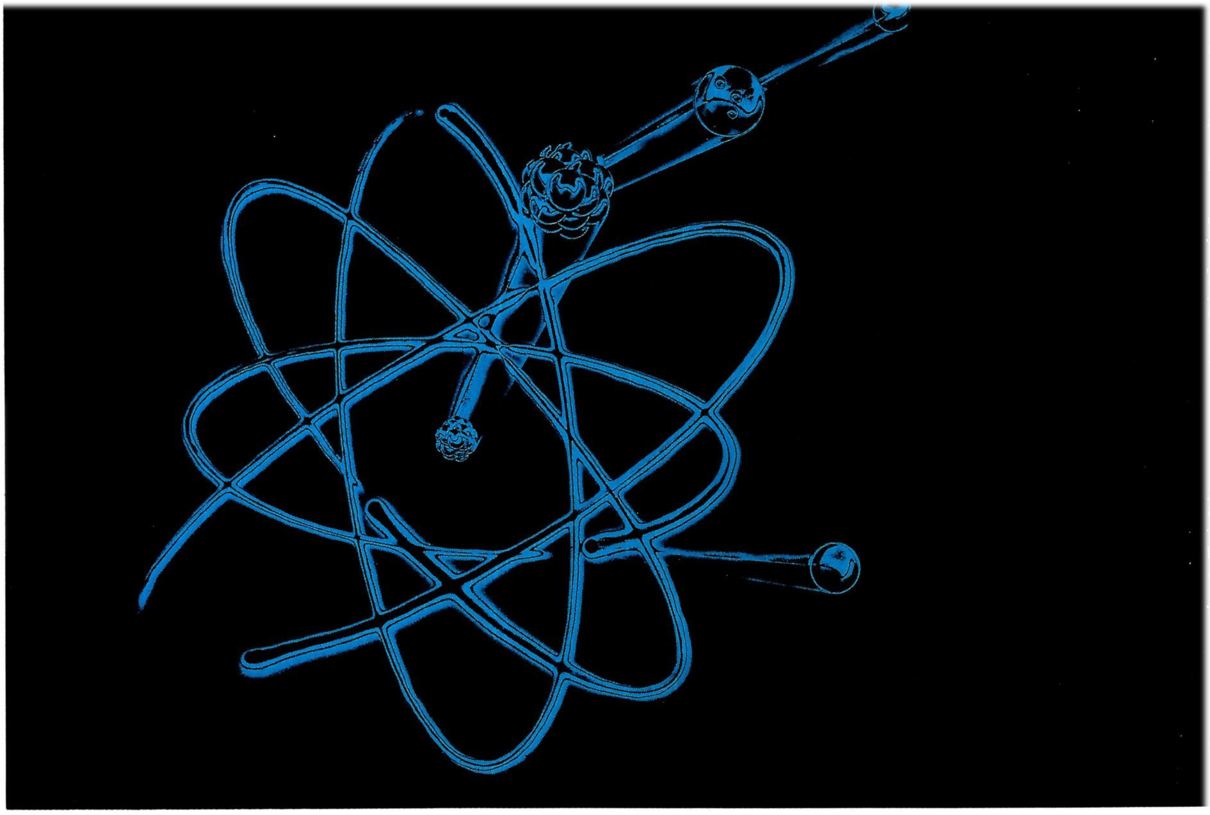
D - 2000 TANGSTEDT, P. O. Box 1147, FED. REP. of GERMANY
Telefon: (04109) 55 – 0
Telefax: (04109) 5533
Telex: 2 180 715 tegs



X.25 - 72 Kbit/s
BSC
Async
DCE



THOMSON-CSF



THE FURTHER WE GO, THE FURTHER YOU GO.

At the cutting edge of scientific research there's a demand for RF and microwave energy that existing technology can't deliver.

At Thomson-CSF we undertake major projects to develop new technology working in close collaboration with our customers.

What's vital is that we have the know-how to supply you with the very high power sources you need for particle accelerators and plasma heating.

Know-how acquired in fields such as high-power radars and broadcasting where Thomson-CSF is a leader.

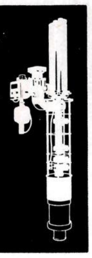
The successes obtained in these areas are due to Thomson-CSF technological innovations such as Pyrobloc® grids and our Hypervapotron® cooling system which guarantee the efficiency, reliability and long life of our tubes.

This high performance means important cost savings for the end user.

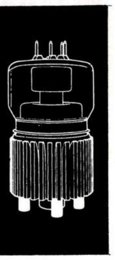
For special needs – including windows and oversized components capable of handling the required energy – we tailor our products to your requirements.

In radio and television, telecommunications, military and civil aviation, as well as in a wide range of scientific and medical applications, Thomson-CSF know-how gets your systems moving. Fast.

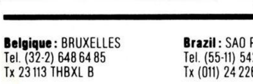
Gyrotron for plasma heating up to 200 kW peak power at 100 GHz.



Single-window high power pulsed klystrons for particle accelerators up to 35 MW/17.5 kW at 3.6 GHz.



A full range of high voltage switching tetrodes used in associated power supplies.



High power CW klystrons up to 1.2 MW at 352 MHz and 500 kW at 3,7 GHz (60 sec.).

High power tetrodes up to 2 MW CW (210 sec.) at 80 MHz (higher frequencies obtainable at lower power levels).

Our high-energy tubes have been chosen for the world's most important projects.

THOMSON-CSF
ELECTRON TUBES

THOMSON-CSF
Division Tubes Electroniques
38, rue Vauthier - BP 305
F-92102 BOULOGNE-BILLANCOURT CEDEX.
Tél.: (1) 46 04 81 75. Télex: THOMTUB 200772 F.

Belgique: BRUXELLES
Tel. (32-2) 648 64 85
Tx 23 113 THBXL B

Italia: ROMA

Brazil: SAO PAULO
Tel. (55-11) 542 47 22
Tx (011) 24 226 TCSF BR

Japan: TOKYO

Canada: MONTREAL-QUEBEC
Tel. (1-514) 288 41 48
Tx 5 560 248 TESAFI MTL

Sverige: TYRESÖ

Deutschland: MÜNCHEN
Tel. (49-89) 78 79-0
Tx 522 916 CSF D

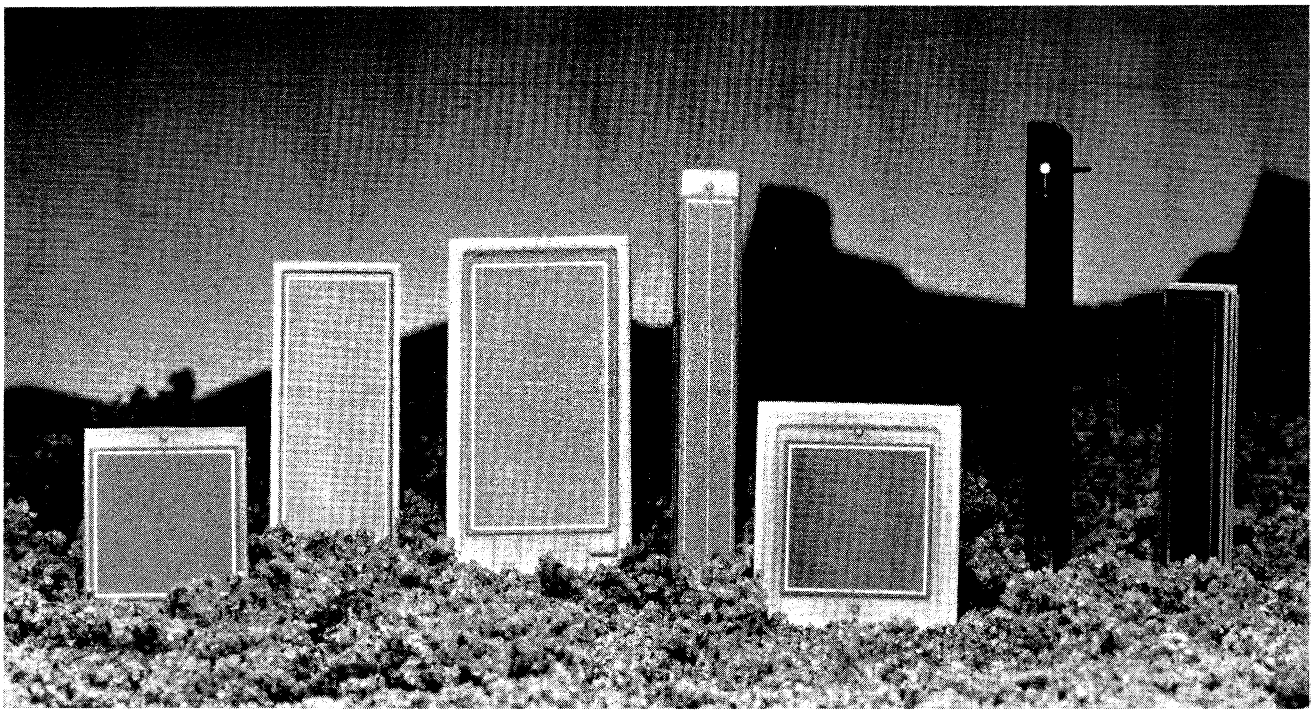
United-Kingdom: BASINGSTOKE
Tel. (44-256) 29 155

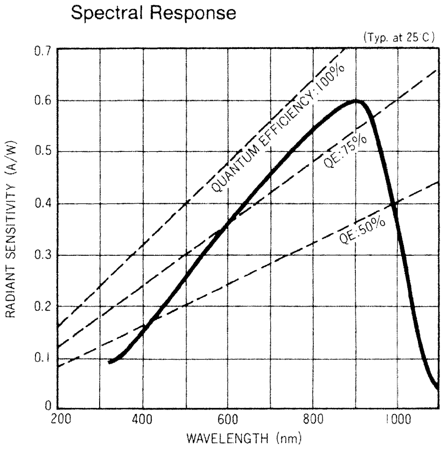
España: MADRID
Tel. (34-1) 405 16 15
Tx 46 033 TCCE E

U.S.A.: DOVER
Tel. (1-201) 328 1400

France: BOULOGNE-BILLANCOURT
Tel. (33-1) 46 04 81 75
Tx THOMTUB 200 772 F

Think Big





Let Hamamatsu Large-Area PIN Photodiodes expand your design horizons.

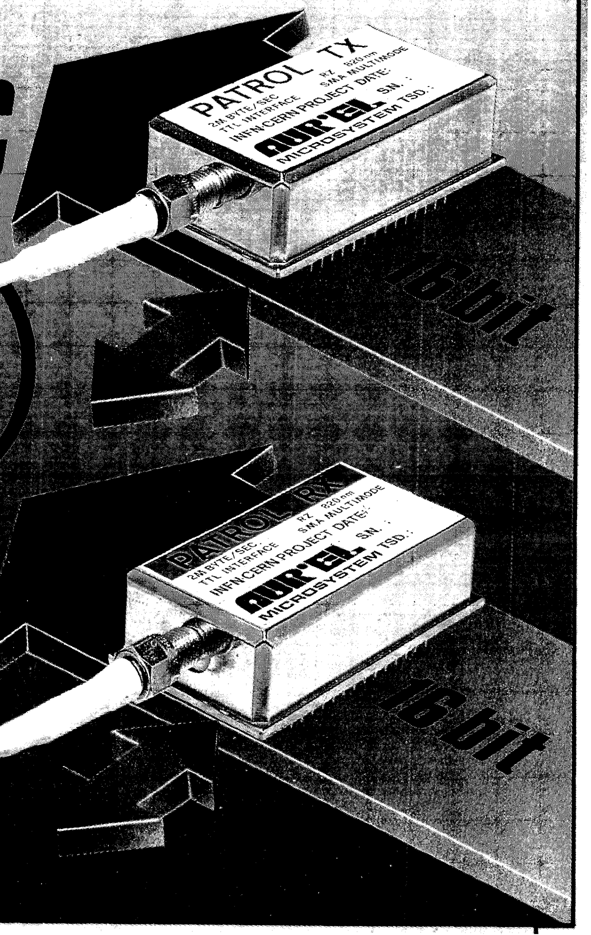
Now you can think a little bigger when you're designing instruments for scintillation detection and precision photometry. These compact silicon photodiodes feature large, uniform sensitive areas, from 1.2 x 29.1 to 10 x 20 mm. Yet they exhibit impressive energy resolution, high stability, low dark current and high speed time response. Ideally suited for optical coupling with scintillators such as BGO crystals. Custom sizes are also available.

For application information,
Call 1-800-524-0504
1-201-231-0960 in New Jersey

HAMAMATSU

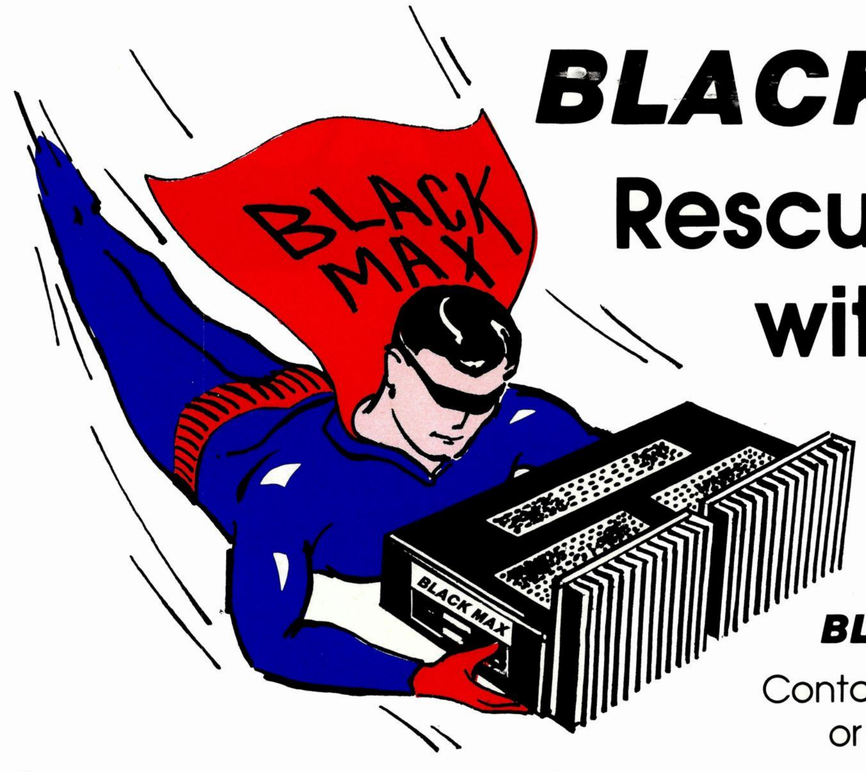
HAMAMATSU CORPORATION • 360 FOOTHILL ROAD, P. O. BOX 6910, BRIDGEWATER, NJ 08807 • PHONE: 201/231-0960

UNITED KINGDOM: Hakuto International (UK) Ltd. (phone: 0992-769090) • FRANCE: Hamamatsu Photonics France (phone: 46 55 47 58)
ITALY: Hesa S. P. A. (phone: [02] 34.92.679) • W. GERMANY: Hamamatsu Photonics Deutschland GmbH (phone: 08152-375-0)
SWEDEN, NORWAY, FINLAND, DENMARK: Lambda Electronics AB (phone: 08-620610) • JAPAN: Hamamatsu Photonics K.K.


PATROL TX
2M BYTE/SEC
TTL INTERFACE
RZ 820 nm
SMA MULTIMODE
INFN CERN PROJECT DATE:
SN.
AUR·EL
MICROSYSTEM TSD.
16 bit
PATROL RX
2M BYTE/SEC
TTL INTERFACE
RZ 820 nm
SMA MULTIMODE
INFN CERN PROJECT DATE:
SN.
AUR·EL
MICROSYSTEM TSD.
16 bit


1850
LEYBOLD
COLOGNE
1851
HERAEUS
HANAU
1967
LEYBOLD-HERAEUS GMBH
COLOGNE
1987
LEYBOLD AG
HANAU


OVERLOAD


BLACK
MAX
BLACK MAX

CATALOG

KOBOLD
MESSRING GMBH

Instrumenta
and control
FLOW RAT
PRESSUR
FLUID LEV
TEMPERATU

Flow measurement

Indicating instruments,
controllers and recorders

Pressure measurement

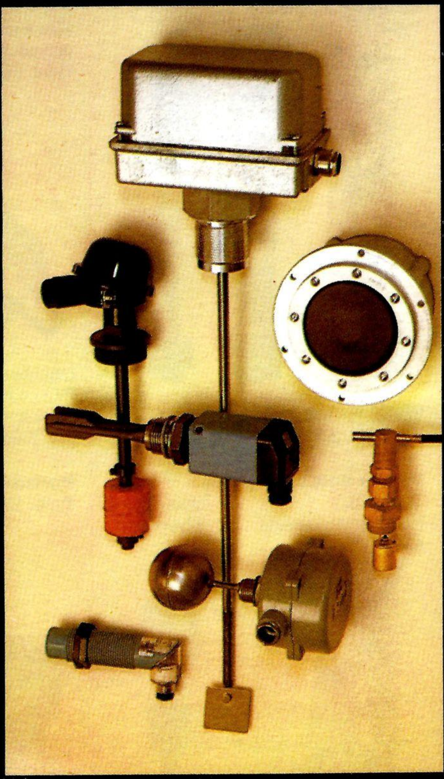
Liquid column devices and switches

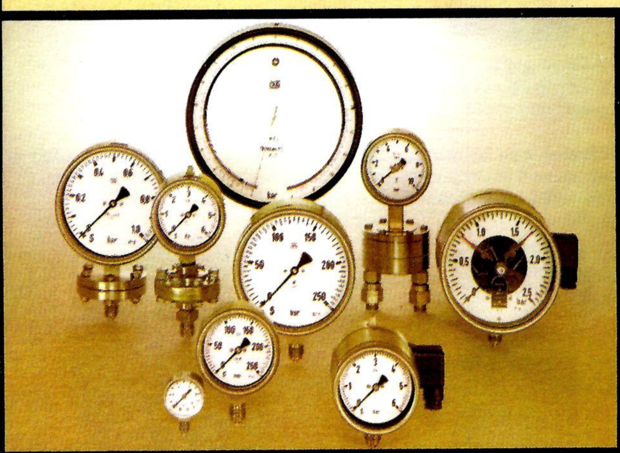
Level measurement

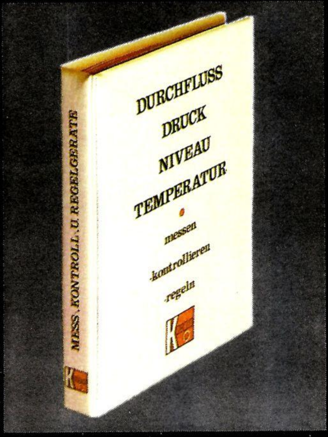
Indicating instruments,
controllers and recorders

Temperature measurement

Thermometers, controllers
and monitors





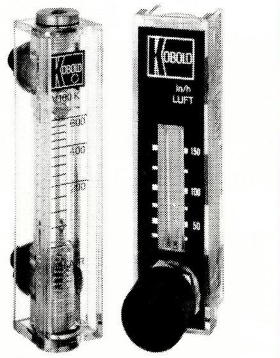


The Kobold Handbook will be sent
to you, free of charge, on request.

Sodener Straße 120
D-6233 Kelkheim
Postfach 2052
☎ (0 61 95) 69 11/69 72
Tx 4 072 326 komr d
Telefax (0 61 95) 6 50 00

Flow measurement

Microvolume flowmeters
with or without needle valve
in **polycarbonate, polysulfone and acrylic glass**

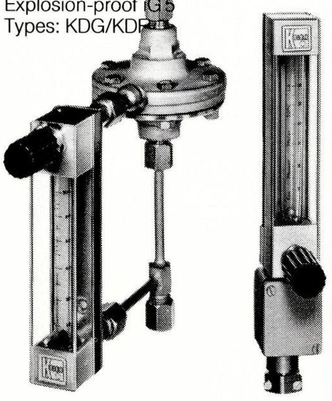


Water: 0.1-1.5 l/h to 5-80 l/h
Air: 0.5-5 L_n/h to 0.2-2.6 Nm^3/h

Microvolume flow controllers
Explosion-proof iG 5
Types: KSR and SVN

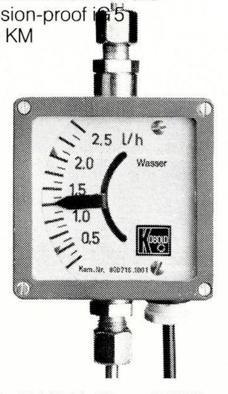
Water: 0.1-120 l/h
Air: 2 l_n/h-2 Nm^3/h

Microvolume flowmeter/ controllers
Explosion-proof iG 5
Types: KDG/KDF



Water: 0.002-0.02 to 16-160 l/h
Air: 0.03-0.3 l_n/h to 430-4300 l_n/h

All-metal microvolume flowmeter/controllers
Explosion-proof iG 5
Type: KM

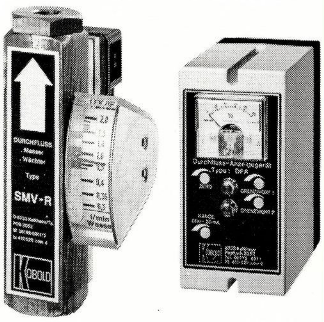


PN 40-PN 100/–20…+150 °C
Water: 0.1-1 l/h to 25-250 l/h
Air: 4.5-45 l_n/h to 0.8-8 Nm^3/h

Flowmeter/controllers
Explosion-proof iG 5
Type: SV-R/S-R

Water: 6-60 l/h to 0.5-9 m^3/h
Air: 0.2-2 Nm^3/h to 20-250 Nm^3/h

All-metal flowmeter/controllers with analog output
Explosion-proof iG 5
Type: SMV-R/VKM-G

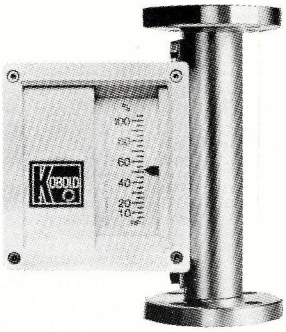


PN 350/–50 °C…+160 °C
Water: 3-60 l/h to 0.5-15 m^3/h
Air: 3-35 l/h to 20-400 Nm^3/h

Flowmeters and controllers with analog output independent of viscosity and location
Types: VKG and VKM

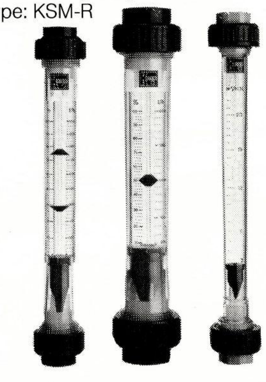
Viscosity range: 1-5000 mm^2/s
e. g.: 0.01-0.07 to 8-80 l/min of oil

All-metal flowmeters and controllers with analog output
Type: MC



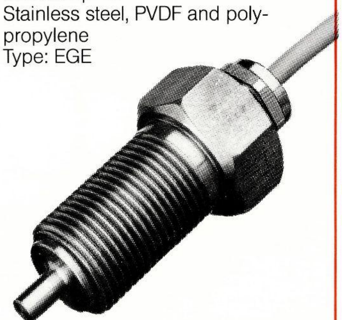
PN 40-PN 600/–50…+300 °C
Water: 2.5-25 l/h to 10-100 m^3/h
Air: 75-750 l_n/h to 180-1800 Nm^3/h

Trogamid and polysulfone flowmeter/controllers with analog output
Type: KSM-R



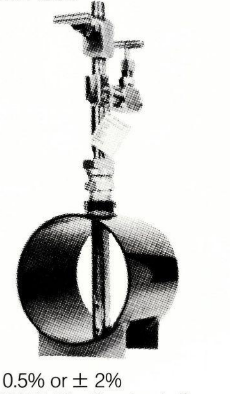
Water: 16-160 l/h to 2-20 m^3/h
Air: 0.25-2.5 Nm^3/h to 58-580 Nm^3/h

Electronic flow controllers
for gases, liquids and powders
Media: $\Delta p = 0$
Stainless steel, PVDF and polypropylene
Type: EGE



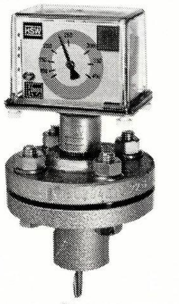
Liquids (incl. **highly viscous):**
0.01-4 m/s.
Gases: 0.1-15 m/s
PN 300/–40…+90 °C

Flow sensors proportional to differential pressure
Type: Beta-Probe



Error: ± 0.5% or ± 2%
R ½"-R 2"/DN 50 - 9 m lead dia
Liquids, gases and steam

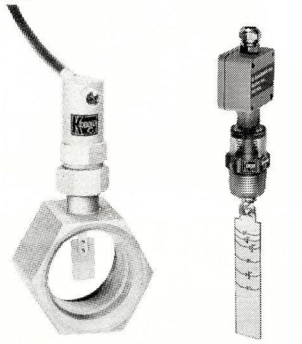
Paddle-bellows flowmeters and controllers for heavily contaminated media
Types: HSW-DWU/-DWP/-DWS



Pipe connection ⅜"-2"
Flange connection DN 10-DN 50
Slip-on flange for DN 40-DN 1000
1-4 l/min to 10 000 m^3/h
PN 6-PN 10/100 °C

Paddle flow controllers

Type: PSR	Type: PPS-3S
Brass and stainless steel	Polysulfone



3-5 l/min to 20-28 m^3/h	10-110 l/min
PN 16-PN 25/100 °C	PN 10/110 °C

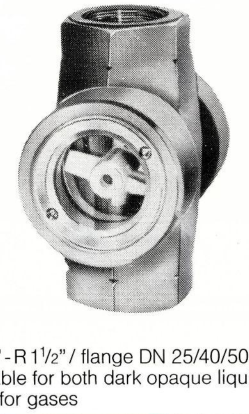
Horizontal ball-type flow indicator
Type: DA-KU

Range
Water: 0.3 l/min-90 l/min
Air: 0.015 Nm^3/min-200 Nm^3/h

Flow indicator, can be mounted in any position, with plastics rotor and **automatic sight-tube cleaner**
Type: DA-RA

R ¼"-R 1½"
PN 16/100 °C

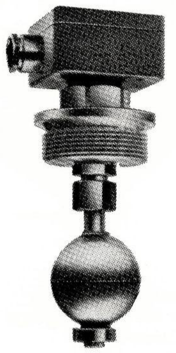
Flow indicator, can be mounted in any position, with Teflon rotor
Type: DA-R



R ¼"-R 1½"/flange DN 25/40/50
suitable for both dark opaque liquids and for gases

Measurement of level

Magnetic float switches
Type: N
180 different types in high-grade steel, titanium, brass, PPH, PVC, PVDF and PTFE

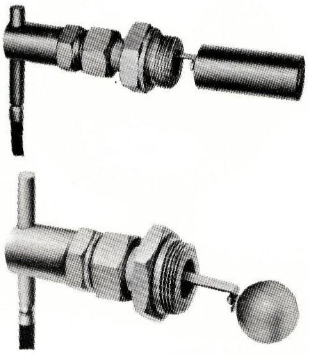


PN 100/180 °C
$\text{Den.}_{\text{liq.}}$ min ≥ 0.25 kp/dm^3

Magnetic float switches
Type: NS
for side-fitting

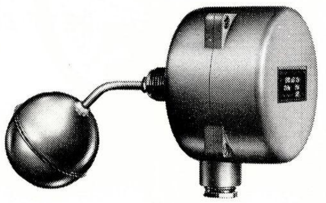
PN 100/180 °C
$\text{Den.}_{\text{liq.}}$ min ≥ 0.25 kp/dm^3

Magnetic float switches
Type: NV $^1/_2$" und NV $^3/_4$"
for side-fitting



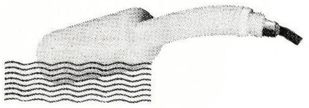
PN 18/110 °C
$\text{Den.}_{\text{liq.}}$ min ≥ 0.8 kp/dm^3

Float switches with spring contact
Type: FNS
for side-fitting



PN 16/350 °C
$\text{Den.}_{\text{liq.}}$ min ≥ 0.8 kp/dm^3
I_{max} = **10 A** bei 220 V ~

PTFE float switches
Type: NST
for side-fitting with **mercury contact**

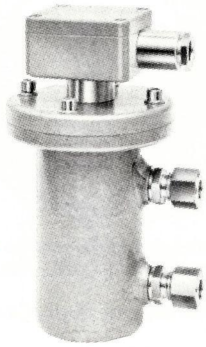


1 bar/160 °C
$\text{Den.}_{\text{liq.}}$ min ≥ 0.7 kp/dm^3
I_{max} = **4 A** bei 220 V ~

Bypass float switches
with spring contact
Type: FNS

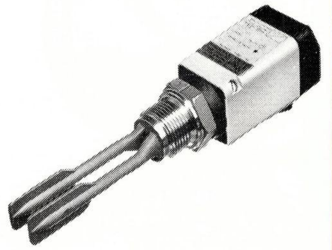
PN 16/350 °C
$\text{Den.}_{\text{liq.}}$ min ≥ 0.7 kp/dm^3
I_{max} = **10 A** bei 220 V ~

Bypass magnetic float switches
Type: NB-10



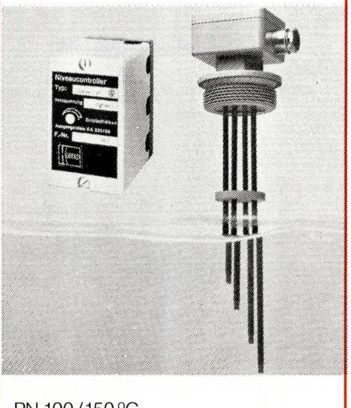
PN 10/150 °C
$\text{Den.}_{\text{liq.}}$ min ≥ 0.7 kp/dm^3

All-purpose limit switches
for liquids
Type: FTL 160



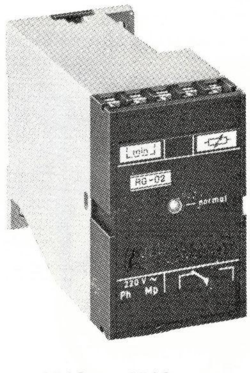
$\text{Den.}_{\text{liq.}}$ min: independent
max. viscosity: 2000 mm^2/s
PN 16/−40…+150° C
G x 5 Cr Ni Mo Nb 1810 austenitic steel

Limit switches for conductive fluids



PN 100/150 °C
single to quintuple electrodes

Thermal resistor switches for **nonconductive** liquids

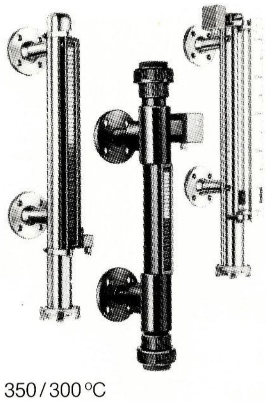


t_{max} = −25 °C… +55 °C
max. viscosity 10 °E

Level indicators
Level pick-ups
Type: NM

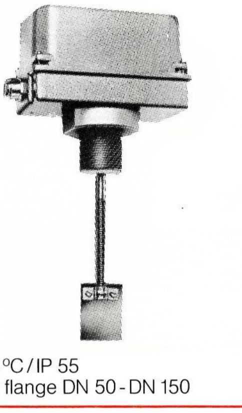
PN 25/−50 °C…+130 °C

Bypass level indicators
with magnetic transmitters
Type: BMG



PN 350/300 °C

Vibratory level signalling devices for heavy and viscous media with **flexible** vibratory sensor
Type: NBV

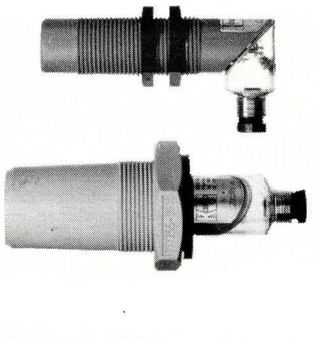


PN 6/80 °C/IP 55
R1$^1/_2$" or flange DN 50 - DN 150

Diaphragm-type level signalling devices for installation in silos, bunkers, etc. for coarse and fine **bulk goods**
Type: NMF

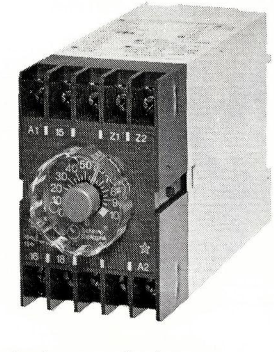
−30 °C…+200 °C
for Zone 11 explosion-proof rooms without ancillary equipment

Capacitive level switch
for fine and powder bulk goods
Type FTC 960



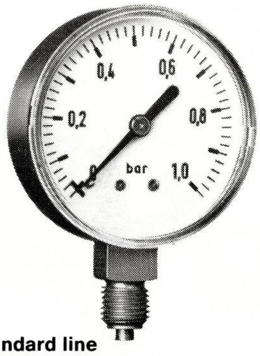
PN 6/−20…+80 °C
R1"/adapter R 1$^1/_2$"

Time-delay starting relays
Contact protector relays

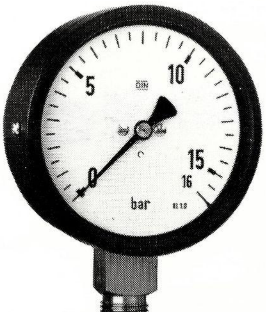


Explosion-proof relays - Zone O
Control systems

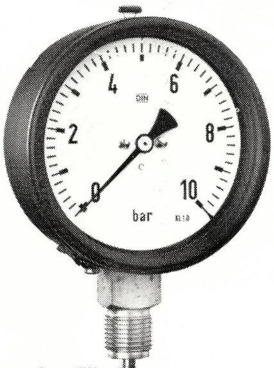
Pressure



Standard line
Diameter 40, 50, 63, 80, 100 and 160 mm,
Quality Class 2.5
Measuring range 0 - 1 bar to 0 - 400 bar

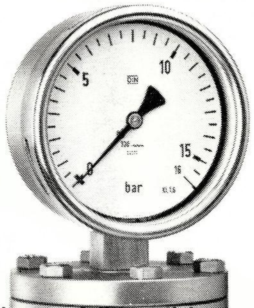


High-quality line
Diameter 52, 60, 63, 80, 100 and 160 mm,
Quality Class 1.0
Measuring range
0 - 60 mbar to 0 - 400 mbar
0 - 0.6 bar to 0 - 1600 bar

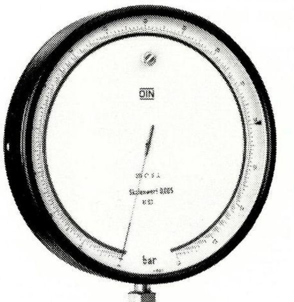


Glycerine-filled pressure gauges
Diameter 63, 100 and 160 mm
Quality Class 1.0 to 2.5
Measuring range
0 - 0.6 bar to 0 - 1000 bar

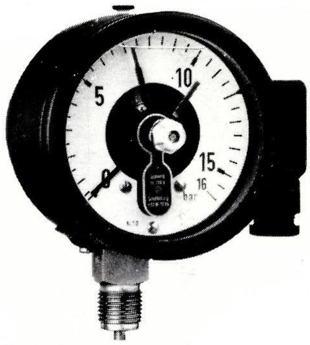
Chemical line
Diameter 40, 50, 63, 100 and 160 mm,
Quality Class 1.0
Measuring range
0 - 0.6 bar to 0 - 1000 bar



Bellows and differential pressure gauges
Diameter 100 and 160 mm
Quality Class 1.6
Measuring range
0 - 60 mbar to 0 - 400 mbar
0 - 0.6 to 0 - 25 bar

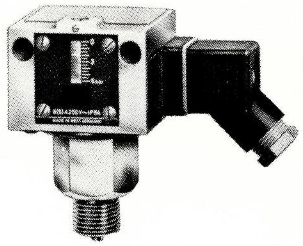


Precision pressure gauges
Diameter 160 mm, Quality Class 0.6 and 0.3
Diameter 250 mm, Quality Class 0.3, 0.2, 0.1
Measuring range
0 - 0.6 bar to 0 - 1600 bar



Contact pressure gauges
- Magnetic snap-action contacts
- Crawl contacts
- Inductive contacts
- Pneumatic contacts

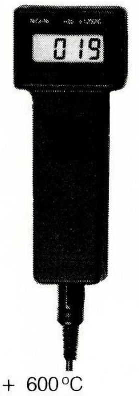
Pressure and differential pressure switches
Adjustable differential setting
Liquids, steam and gases
Type: KD / KV



–250 mbar to 100 mbar
15 bar to 63 bar
250 V AC, 10 A

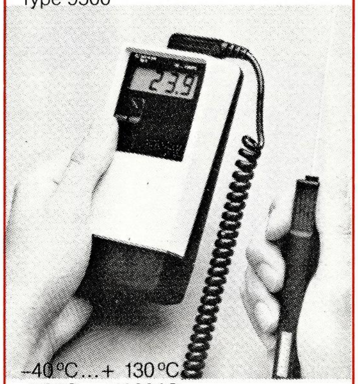
Temperature

Digital hand thermometers
Type: 7300 / 9300



–200 °C ... + 600 °C
– 40 °C ... +1200 °C

Digital hand thermometers
For **Zone 0** explosion-proof rooms
Type 9500

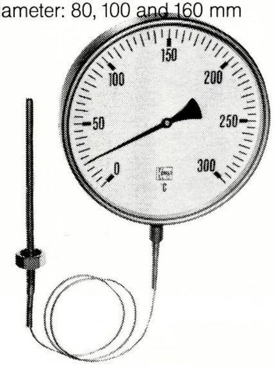


–40 °C ... + 130 °C
–70 °C ... +1200 °C
–50 °C ... +1750 °C

Precision dial thermometers
Nitrogen-filled
For food industry, etc.
Error: ±0.6 and ±1.0% of full-scale reading
Diameter: 80, 100, 160 and 250 mm

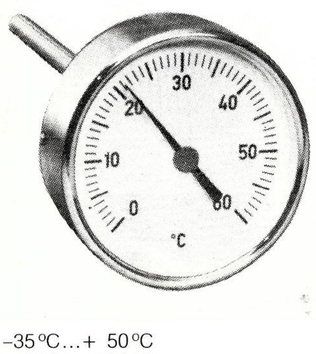
–250 °C ... +650 °C

Precision dial thermometers
Mercury-filled,
error ±1.0% of full-scale reading
Type: 610
Diameter: 80, 100 and 160 mm



–30 °C ... +500 °C

Machine thermometers
Bimetal
50, 63, 80, 100, 160, 250 mm

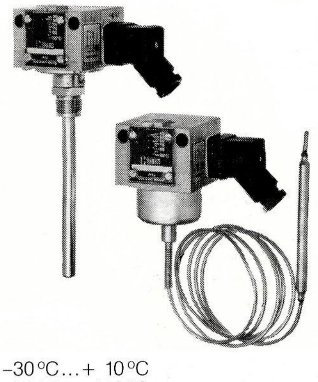


–35 °C ... + 50 °C
0 °C ... +300 °C

Digital 48x24 thermometers for panel mounting
Type: TT 4600

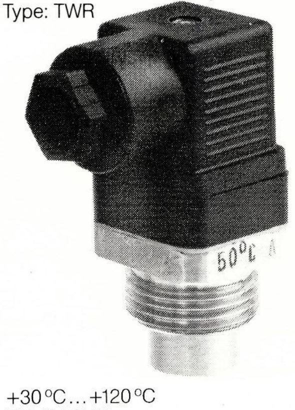
0 °C ... + 99.9 °C
–20 °C ... +600 °C

Temperature controllers
with adjustable set point
Type: KTAM/KTXM



–30 °C ... + 10 °C
+80 °C ... +130 °C

Temperature controllers and monitors with fixed set point
Type: TWR



+30 °C ... +120 °C
PN 16 / IP 65