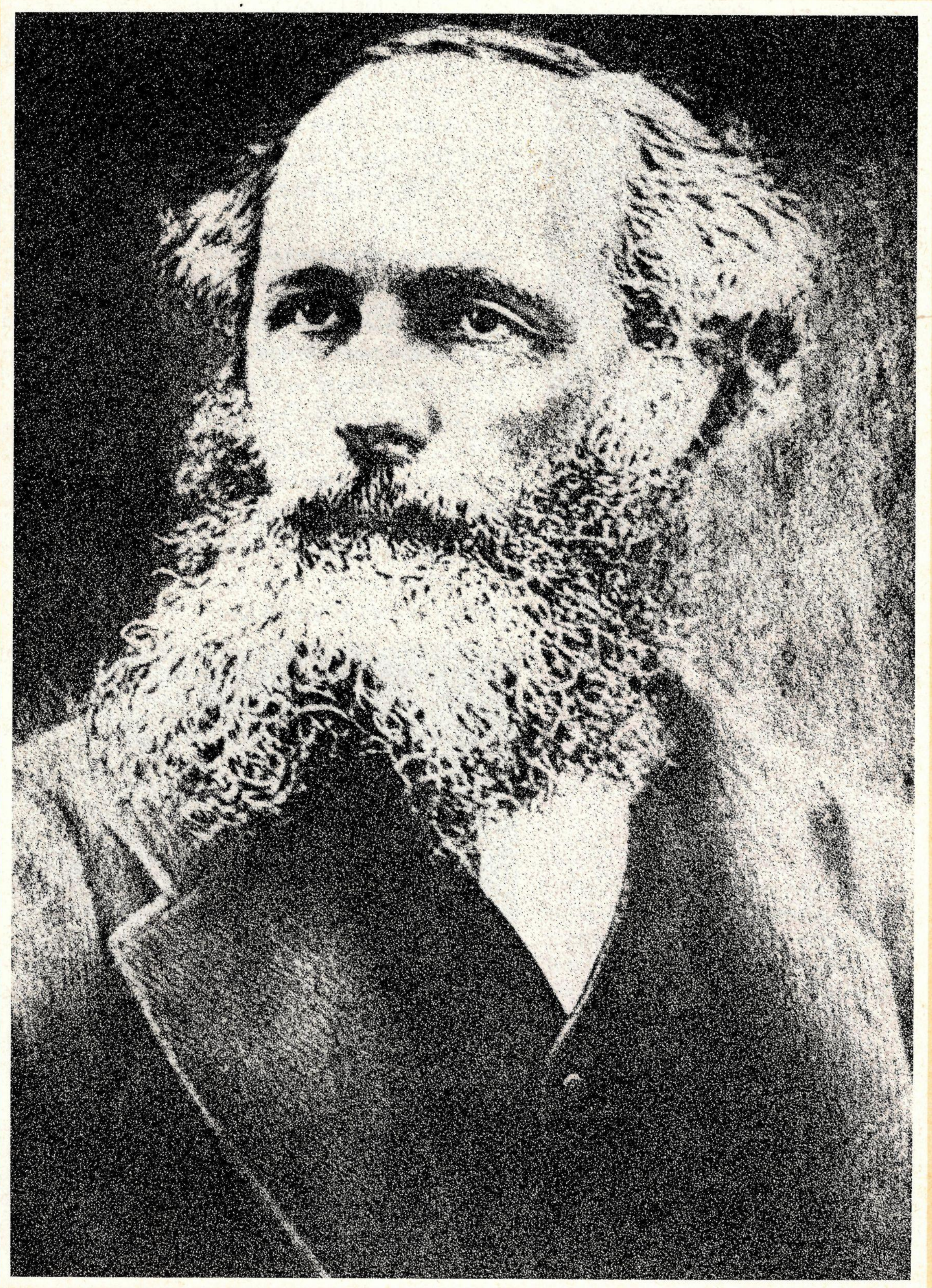
CERN COURIER

NO. 9 VOL. 19 DECEMBER 1979



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

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

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

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

Published by:
European Organization for Nuclear Research
CERN, 1211 Geneva 23, Switzerland
Tel. (022) 83 61 11, Telex 23698
(CERN COURIER only Tel. (022) 83 41 03)
USA: Fermi National Accelerator Laboratory
P.O. Box 500, Batavia, Illinois 60510
Tel. (312) 840 3000, Telex 910 230 3233

Contents

Around the Laboratories

Cover photograph: This year marks the centenary of the death of James Clerk Maxwell, creator of the theory of electromagnetism (see page 412). By coincidence, this year also sees the award of the Nobel Prize for Physics to Sheldon Glashow, Abdus Salam and Steven Weinberg for the theory which goes a step further and unites electromagnetism with the weak force (see page 395).

Nobel Prize for Physics, 1979

Abdus Salam

Physics' most prestigious accolade goes this year to Sheldon Glashow, Abdus Salam and Steven Weinberg for their work in elucidating the interactions of elementary particles, and in particular for the development of the theory which unifies the electromagnetic and weak forces.

This synthesis of two of the basic forces of nature must be reckoned as one of the crowning achievements of a century which has already seen the birth of both quantum mechanics and relativity.

Electromagnetism and the weak force might appear to have little to do with each other. Electromagnetism is our everyday world — it holds atoms together and produces light, while the weak force was for a long time known only for the relatively obscure phenomenon of beta-decay radioactivity.

The successful unification of these two apparently highly dissimilar forces is a significant milestone in the constant quest to describe as much as possible of the world around us from a minimal set of initial ideas.

'At first sight there may be little or no similarity between electromagnetic effects and the phenomena associated with weak interactions', wrote Sheldon Glashow in 1960. 'Yet remarkable parallels emerge...'

Both kinds of interactions affect leptons and hadrons; both appear to be 'vector' interactions brought about by the exchange of particles carrying unit spin and negative parity; both have their own universal coupling constant which governs the strength of the interactions.

These vital clues led Glashow to propose an ambitious theory which attempted to unify the two forces. However there was one big difficulty, which Glashow admitted had to be put to one side. While electromagnetic effects were due to the exchange of massless photons (electromagnetic radiation), the carrier of weak interactions had to be fairly heavy for everything to work out right. The initial version of the theory could find no neat way of giving the weak carrier enough mass.

Then came the development of theories using 'spontaneous symmetry breaking', where degrees of freedom are removed. An example of such a symmetry breaking is the imposition of traffic rules (drive on the right, overtake on the left) to a road network where in principle anyone could go anywhere. Another

Harvard Professors Sheldon Glashow (left) and Steven Weinberg at a news conference at Harvard after it was announced that they share the 1979 Physics Nobel Prize with Abdus Salam.

(Photo Photopress)

example is the formation of crystals in a freezing liquid.

These symmetry-breaking theories at first introduced massless particles which were no use to anybody, but soon the so-called 'Higgs mechanism' was discovered which gives the carrier particles some mass. This was the vital development which enabled Weinberg and Salam, working independently, to formulate their unified 'electroweak' theory.

One problem was that nobody knew how to handle calculations in a consistent way. The way round this obstacle was shown by Gerard 't Hooft in the early seventies. With this, the initial ideas matured into a fully-fledged theory.

One by-product of the unification was a type of weak interaction which would not change the electric charges of the participating particles. For a long time all weak interactions were seen to shuffle electric charges around.

Then in 1973 came the discovery in the Gargamelle bubble chamber at CERN of the 'neutral current' of weak interactions, in which neutrinos interacted with target particles, but remained as neutrinos. This was the first vital piece of experimental evidence in favour of the unified electroweak theory. After this the remaining pieces of the puzzle soon fell together.

If there is a neutral current, it should be seen in other ways, for example the decay of a neutral kaon into a pair of muons. But this is only a very rare form of kaon decay. What inhibits the direct decay through the neutral current?

The exact answer had been provided by Glashow, who with J. Iliopoulos and L. Maiani, showed how the electroweak ideas could be fruitfully extended to cover quarks (the components of strongly interacting hadrons) as well as the leptons of the original theory.

Abdus Salam with members of the collaboration which worked with the Gargamelle heavy liquid bubble chamber. It was this detector which first saw the neutral current interaction predicted by the electroweak theory.

(Photo 392.10.79)

In this picture, the basic particles (the quarks and the leptons) can in general spin either right- or left-handedly (the neutrino however appears to have no right-handed form). The left-handed particles can be grouped into fours, each four being composed of a pair of quarks and a pair of leptons.

One set of four basic particles — the 'up' and the 'down' quarks together with the electron and its neutrino, provides all the source material for our everyday world of atoms whose nuclei are made from protons and neutrons. But there were still more basic particles to use up — there was the strange quark, the muon and its neutrino. To get a second set of four basic particles required a new type of quark.

This was the heavy 'charmed' quark, which could account for the problem of the neutral kaon decays. However charm was to exhibit itself much more vividly. In November 1974 came the simultaneous discovery by the teams of Sam Ting at Brookhaven and Burton Richter at SLAC of a remarkably stable heavy meson, the J/psi.

This was explained as a bound state of a charmed quark and its corresponding antiquark, and the spectroscopy of charmed particles was unravelled in further experiments at SLAC and at DESY. Particle physics had entered a new age, and the discoveries made by Ting and Richter were recognized in the award of the Nobel Prize in 1976.

However there was still a lot of work to be done. In particular, physicists had to look at the detailed behaviour of the neutral current interaction to see if it followed the rules set out by the simplest electroweak theory, or whether some more elaborate version would be required.

While inevitably odd transient things appeared in the ebb and flow of experimental statistics which did not agree with the theory, it is impressive how all the results which stood the test of time have been in line with the simplest model of electroweak phenomena, as originally formulated by Weinberg and Salam.

Particular mention should be made of the remarkable experiment at Stanford which measured right-left asymmetries (parity violation) in electron-nucleon scattering. These tiny effects are the result of the delicate interference between weak and electromagnetic interactions and provide an acid test of the theory (see July/August 1978 issue, page 245). The agreement between experiment and theory is excellent.

In addition, results continue to come in from neutrino experiments, at both high and low energies, which display further the remarkable power of the theory.

But probably the greatest prediction of all remains untested. Just as Maxwell's formulation of the electromagnetic field had to await confirmation through Hertz' discovery of electromagnetic radiation, so the electroweak theory awaits the discovery of its own radiation.

The theory makes very exact predictions for the heavy particles which provide this radiation, but which today is out of reach of any Laboratory. The proton-antiproton collider project now under construction at CERN and scheduled to begin experiments in the early 1980s, will for the first time open up the energy range where this radiation is expected to be seen.

Another vital ingredient of the theory which remains to be tested are the Higgs particles of the spontaneous symmetry breaking mechanism. Here the theory is still in a volatile state and no firm predictions are possible. But this mechanism is crucial to the theory, and something has to turn up.

The great success of the electroweak unification has led many theorists to become more ambitious and look for ways to bring in the strong interactions, and possibly gravity as well, to achieve a 'grand unification' of the forces of nature.

However it is sobering to remember that a hundred years had to pass between Maxwell's synthesis of electricity and magnetism and the new electroweak unification. If this pattern is repeated, grand unification would be for the 21st century.

(A detailed account of the development and application of these gauge theory ideas to electroweak unification was published in our September 1977 issue, page 271.)

Abdus Salam, the oldest of the three laureates, was born in 1926 in Jhang, now in Pakistan. He received his doctorate from Cambridge University in 1952. In 1957, he became Professor of Theoretical Physics at Imperial College, London, a position which he still holds. He was also one of the main movers behind the establishment of the International Centre for Theoretical Physics in Trieste, which he directs.

Sheldon Glashow was born in New York in 1932, obtained his doctorate at Harvard in 1959, and is now Professor at the Lyman Laboratory, Harvard.

Steven Weinberg was born in New York in 1933, and attended the same Bronx high school as Glashow. He obtained his doctorate at Princeton in 1957, and now holds the post of Higgins Professor at Harvard.

As well as their formulation of the electroweak theory, the three men have also made numerous other important contributions to the theory of elementary particles.

Second ICFA Workshop

From 4–10 October a second Workshop on 'Possibilities and Limitations of Accelerators and Detectors' was held at Les Diablerets in Switzerland with review talks at CERN on the final day on the work of the different groups. It followed a Workshop at Fermilab in 1978 (see November 1978 issue, page 389) and was promoted by the International Committee for Future Accelerators in the context of its very long-term thinking about the future of high energy physics. ICFA, which was set up under the auspices of the International Union of Pure and Applied Physics, is at present chaired by John Adams and has representatives from the various regions of the world involved in high energy physics.

The Les Diablerets Workshop was organized by Ugo Amaldi and divided its work into several topics — Very high energy electron-positron colliders (reported by A.N. Skrinsky), Many TeV proton accelerators and proton-antiproton colliders (Lee Teng), Extraction and external beams from a many TeV accelerator (Bas de Raad), Electron-proton interaction regions and experiments (Gus Weber), Extrapolation of experiments at electron-positron and proton-antiproton colliders (Barry Barish), Deep inelastic experiments with lepton beams of a few TeV (Guido Barbiellini), Hadron and photon experiments at fixed target machines (Yuri Prokoshkin) and Possibilities and limitations of detectors and data handling (Dave Nygren).

In working on higher energy electron-positron machines it became even clearer that in the future this physics would have to be done with colliding beams from linacs. The largest storage ring system considered at the Workshop had 260 GeV per beam and such frightening parameters as 29 GeV

Seen here in discussion at the recent ICFA Workshop at Les Diablerets are, left to right, Ugo Amaldi (organizer of the Workshop), K. Lanius and T. Ekelöf.

synchrotron radiation loss and an r.f. frequency of 50 mHz. Beamstrahlung (the radiation effect due to high fields as bunches pass through one another at very high energies), which was uncovered at the previous Workshop, inhibits higher energies in rings.

Ideas on colliding beams from linacs have matured a lot in the past year as can be seen in the article on Novosibirsk and Stanford projects reported on page 403. One fascinating new idea is the production of positrons by passing a high energy electron beam through a wiggler (a periodically changing magnet structure). This gives synchrotron radiation of a particular frequency (several MeV photons) which can then be used on a thin target to produce electron-positron pairs. Spiral wigglers could give longitudinally polarized photons and hence polarized electrons and positrons. Careful handling of these emerging beams could give access to the extra information available from colliding polarized particles.

The future of proton machines looks like harder work but in essentially the same direction as has been followed up to now. Schemes up to 20 TeV with 10 T superconducting magnets and the possibility of antiproton injection and collision schemes were studied. Suitable extraction and external beam systems can be drawn up for such high energy machines but they are difficult and at present it looks possible to extract only a tenth of the protons which can be accelerated. It is perhaps particularly on the proton machines that new ideas are needed to make the future look exciting.

The experimental physics might change its nature dramatically at such high energies. There may no longer be a need for individual hadron identification. All the detection systems would need to be good at jet observation and lepton identification. The possible new physics looks fascinating but event rates might call for high luminosities (such as 10^{33} from electron-positron and 10^{32} from proton-antiproton colliders) which will not be easy to achieve. Present or foreseeable detection techniques look capable of handling the necessary information. Such modern devices as Cherenkov ring imagers, transition radiators with drift chambers, high pressure multiwire proportional chambers using scintillation light, wiggler radiators for particle identification, solid state detectors, etc. may come into their own.

Ugo Amaldi in his concluding remarks commented that taking long range looks into the distant future often reflects back on what we do now. There were many ideas emerging at the Workshop which could influence the progress of high energy physics in the fairly near future.

At a banquet on the last evening of the ICFA Workshop, Alvaro De Rújula (left), Chris Llewellyn-Smith (centre) and John Ellis presented their own idea of what a future ICFA Workshop might be like.

20th anniversary of CERN PS

On 24 November 1959 a beam was accelerated to 24 GeV in the CERN proton synchrotron. The machine became the first of its type (using the alternating gradient focusing principle) to accelerate protons and its early operation was a major achievement at CERN, the newly-born European collaboration in science.

The story of the start-up and of the first ten years of operation was recorded in the November 1969 issue of the CERN COURIER. For the second decade of the machine's operation, an 'improvement programme' came to full fruition, in particular with the completion of an 800 MeV four ring Booster synchrotron (to increase the injection energy and hence the intensity) and a new r.f. accelerating system.

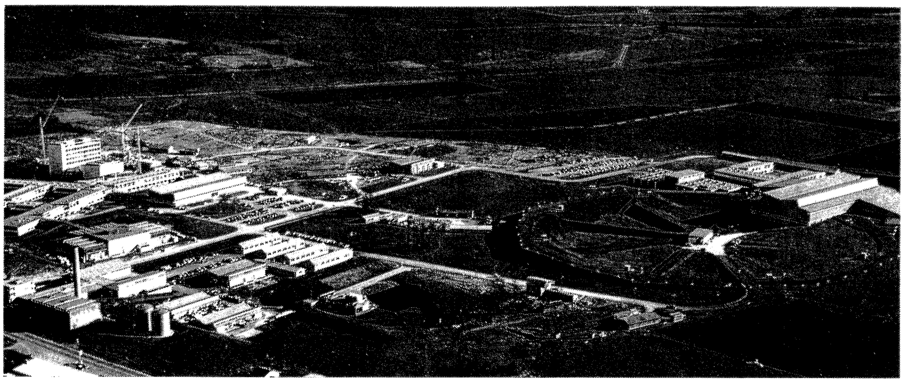
Later improvements included the building of a new 50 MeV Linac, new pole-face windings for the magnets and the replacement of mercury arc rectifiers by solid state ones. The control system is now being replaced by a modular computer system similar to the one which has been so successful at the SPS 400 GeV synchrotron.

This rejuvenation and continuous adaptation to the evolving needs of users now means that the PS serves as injector to the Intersecting Storage Rings and the SPS as well as providing protons for its own physics programme. It is now being prepared for further intricate manœuvres as part of the project to produce intense antiproton beams.

The machine provides per pulse over a thousand times the intensity in 1959 and works in complicated pulse cycles to feed its wide variety of users according to their individual requirements. There have been new problems to be overcome — such as intensity related effects on the beam, maintenance (induced radioactivity), the acceleration of new types of particle (deuterons, alphas) and in holding down the complex operation.

1. *The PS ring (right) in 1959. (Photo CERN 1257)*

2. *A recent shot of the PS complex. Between the PS ring (bottom left) and the Intersecting Storage Rings (top right) can be seen one half of the Booster ring, and the rectangular site being excavated for the new Antiproton Accumulator. (Photo CERN 198.1.79)*



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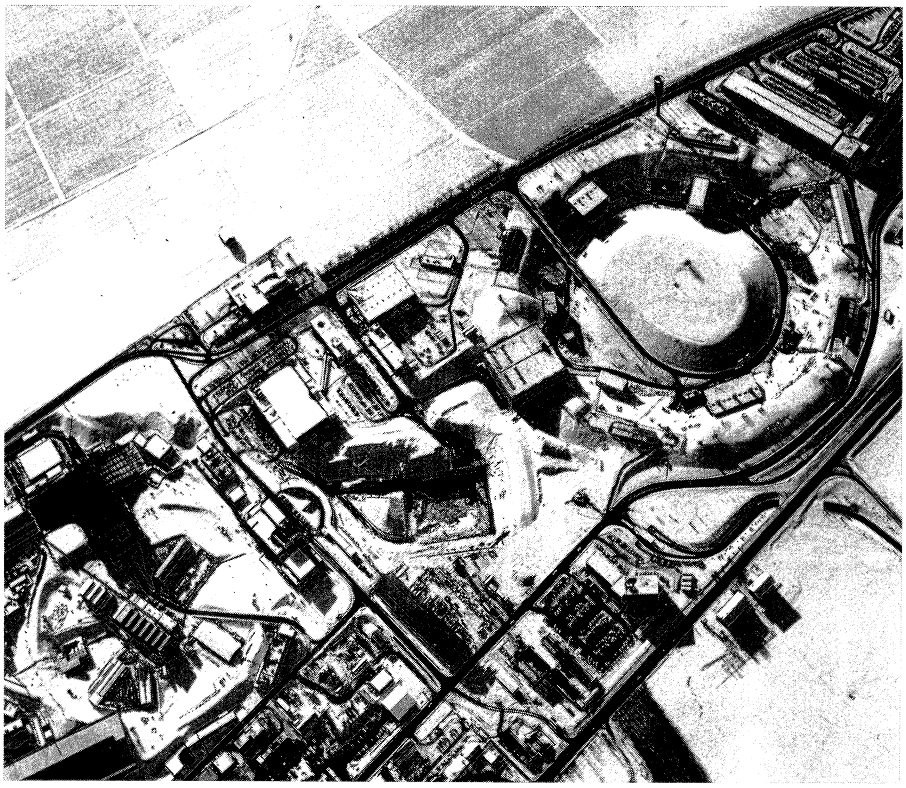

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Physics at the CERN 28 GeV Proton Synchrotron

The CERN 28 GeV Proton Synchrotron will always be remembered for the discovery in 1973 using neutrino beams and the Gargamelle bubble chamber of the neutral current of the weak interaction in both neutrino-electron and neutrino-nucleon processes. This was the first time for several decades that an entirely new kind of interaction had been found in Nature. It logically preceded the discovery of charm and the 'new physics' of the 1970s and pointed to a possible unification of weak and electromagnetic forces.

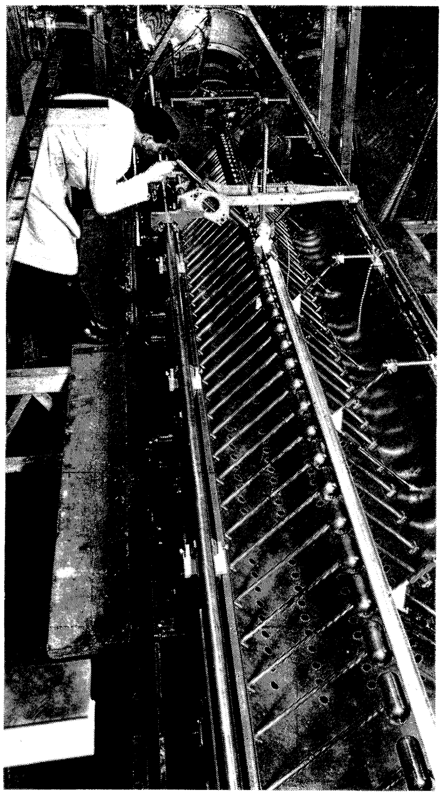
In addition to this milestone in physics, the PS has also been

Evolution of CERN Proton Synchrotron parameters

	1959	1979 (*under development)
Intensity	design 10^{10} p/p achieved 3×10^{10} p/p	1.6×10^{13} p/p
Pulse rate	1 per 3 to 5 s	1 per 1.2 (*0.65) to 2.4 s
Energy	design 25 GeV achieved 28 GeV	0.046 to 25 GeV
Injector	50 MeV Linac	800 MeV four-ring Booster (PSB) fed by new 50 MeV Linac
Linac ion source	radio-frequency	duoplasmatron
Preinjector voltage	500 keV	750 keV
Linac current	design 1 mA achieved 3 mA	130 mA
Linac pulse length	10 µs	100 µs
Number of turns injected	1(in PS)	15 (in PSB)
Booster intensity	—	1.8×10^{13} p/p
Accelerated particles	Protons	Protons, deuterons, alphas (*and antiprotons)
Magnet Power Supply	Motor generator set with one mercury arc rectifier	Motor generator set with two thyristor rectifiers
Voltage	5400 V	9000 V
Current	6000 A	6000 A
Cycle type	single cycle with 20 ms peak	Supercycle adapted to the user: 10 GeV for SPS, 26 for ISR, 24 with 600 ms flat top for PS decelerating cycles for antiprotons
Accelerating systems		
Accelerating cavities	16 units of 10 kV each tunable from 2.5 to 9.5 MHz	10 units of 20 kV each tunable from 2.5 to 9.5 MHz 8 units of 50 kV each tuned at 200 MHz
RF power	16 × 6 kW	10 × 100 kW (at 9.5 MHz) 8 × 20 kW (at 200 MHz)
Vacuum System		
Pumps	60 oil diffusion	139 ion and 14 turbomolecular
Average pressure	4.10^{-6} torr	2.10^{-8} torr
Volume under vacuum	9 m^3	16 m^3
Injection system		
50 MeV	single turn with 1 electrostatic inflector and 3 pulsed inflectors	multiturn with 1 electrostatic inflector and 3 orbit deformation dipoles
800 MeV		single turn with 1 septum, 4 module fast deflectors and 4 orbit deformation septums
Beam utilization systems	2 internal targets for South Hall (target 1) and North Hall (target 6)	1 internal target for South Hall Slow Extraction for East Hall Fast extraction for East Hall/ISR/SPS/ (*AA) and with decelerated particles for ICE/ (*LEAR) Continuous extraction for SPS
Experiments	1 main user plus parasite tests, emulsion exposures and irradiation chemistry	9 dedicated experiments in East Area with simultaneous use of all East Area beams and South Hall test facilities
	Exploratory counter experiments, 32 cm hydrogen bubble chamber	only counter experiments

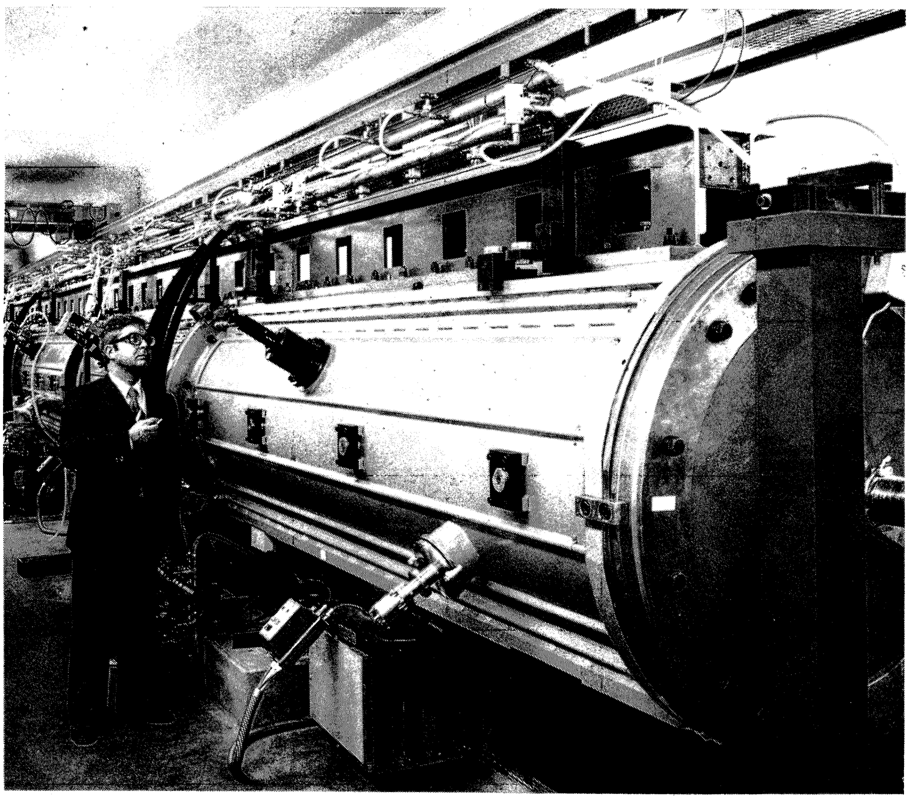
Construction of the original PS linac in 1957.

(Photo CERN K 31)



The new PS linac. Construction began in 1973, and the design energy was reached last year.

(Photo CERN 14.9.78)



instrumental in a whole series of important physics results, and new discoveries are still being made (see page 405).

The neutral current discovery was the result of a considerable investment at the PS in neutrino beams and detectors. This investment also paid dividends when experiments at the PS showed how the neutrino-nucleon cross-section rises linearly with energy, and that the constituent model of the nucleon which had been developed to describe high energy electron-nucleon scattering also holds good for neutrinos on nucleons. Experiments using Gargamelle showed for the first time that interactions involving the weak forces also behave as if there are three quarks in the nucleon.

The tradition of weak interaction physics at CERN had its roots in the early experiments at the 600 MeV synchro-cyclotron which, for example, saw the pion decay into an electron and a neutrino. One of the first weak interaction results to emerge from the PS was the measurement in 1964 of the polarization of the muons produced in the decay of the pion, showing that this too was in line with the left-right asymmetry (parity violation) seen elsewhere in weak interactions.

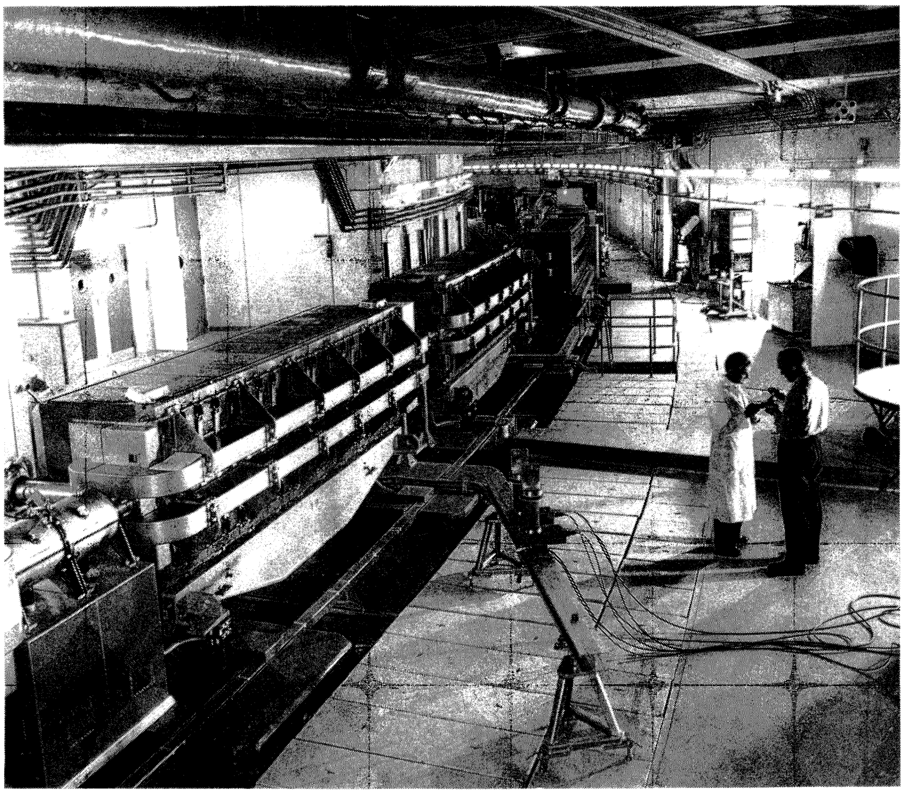
Experiments in the early 1960s studied the semileptonic decays of hyperons, and demonstrated how they fitted in with the Cabbibo description of strangeness conserving and strangeness non-conserving decays.

1964 saw the discovery at Brookhaven that a combined charge conjugation/parity (CP) symmetry is violated in the decays of the long-lived neutral kaon. This sparked off a flurry of activity to search for the origins of this unexplained effect.

Experiments at the PS showed that charge conjugation symmetry on its own is not to blame as it is good in the electromagnetic decays of the eta meson down to one per cent. A delicate experiment in 1970 showed that time reversal invariance was violated in the two pion decay modes of the long-lived kaon. This meant that the combined CPT (charge conjugation / parity / time reversal) symmetry, a cornerstone of modern field theory, was not violated. Other experiments on neutral kaons at the PS have measured the particle lifetimes and the tiny mass difference between the two types of neutral kaon with great precision.

Strong interactions and hadronic systems

One topic which has long been a speciality at CERN is the study of exotic atoms in which everyday orbital electrons are replaced by heavier negatively-charged particles.



The completed PS ring in 1959. On the tripod supports can be seen the first detectors — two scintillators lined up to look for particles produced by the orbiting proton beam.

(Photo CERN 1761)

Early experiments at the SC had studied exotic atoms containing orbital muons and pions, and the PS went on to make pioneer studies of exotic atoms containing kaons and sigmas. X-rays from protonium, the simplest antiproton atom of all, were seen for the first time only last year.

Another exotic hadronic species, hypernuclei, has also been extensively studied at the PS. Using the first separated negative kaon beam, a hypernucleus was seen which contained not one, but two nucleons replaced by hyperons.

Recent experiments on hypernuclei have shown that the angular momentum interactions of lambda particles in nuclei are much smaller than the corresponding effects between nucleons. Most recently of all, just this year hypernuclei containing sigma particles have been observed for the first time.

While the Gargamelle bubble chamber dominated the neutrino physics scene at the PS, other bubble chambers enabled important discoveries to be made in the hadronic sector.

In 1961, the French 80 cm chamber exposed to a PS kaon beam enabled the relative parity of the sigma and lambda particles to be measured in the decay of a sigma into a lambda and a photon. This was important for the subsequent successes of the SU(3) symmetry model.

The PS contributed in no mean way to the hadron resonance boom of the early and mid-sixties. In particular, the emphasis on the use of kaon beams produced many important results on strange particles. Many of the quantum numbers of strange baryons were determined or confirmed at the PS.

Examples were the experiment which showed that the K^* (890), which previously had been suspected as carrying no spin, did indeed carry intrinsic angular momentum, and the discovery of the K^* (1420) with spin two.

Results on the high energy behaviour of hadron collisions have largely been eclipsed by subsequent developments at the ISR and the big proton synchrotrons, but it is important to draw attention to the groundwork done at the PS.

The total cross-section for proton-proton collisions was found to fall gradually with energy in the PS range, and provided stimulus for further studies at higher energies. It was also at the PS that the well-known 'shrinking' of the diffraction peak in elastic proton-proton scattering was discovered.

These investigations developed our understanding of hadronic production mechanisms and the Regge pole picture of hadron dynamics, with the Pomeron describing diffractive phenomena. Especially important in this work was the detailed study in the mid-sixties of pion-nucleon scattering, including the use of polarized targets.

Tests of quantum electrodynamics

After an initial high precision experiment at the SC to measure the anomalous magnetic moment of the muon, second and third generation experiments were mounted at the PS. These painstaking studies are among the most accurate measurements ever made in physics and succeeded in showing that our understanding of the electromagnetic force is accurate down to nine parts per million.

The apparatus used in the muon magnetic moment experiments found another use in the recent experiments on cooling techniques for particle beams, which demonstrated the feasibility of ambitious projects to collide beams of protons and antiprotons. High intensity, low energy antiproton beams from the LEAR project will in a few years time open up a new range of investigations at the PS.

Finally, it should be remembered that the PS is the source of all the high energy beams used at CERN, so that the machine continues to contribute to physics, both directly and indirectly.

The future looks full of interest with the challenge of the antiproton project, and the low energy antiproton work with LEAR in the South Experimental Hall means that the PS will retain its own novel physics programme.

Around the Laboratories

NOVOSIBIRSK/ STANFORD

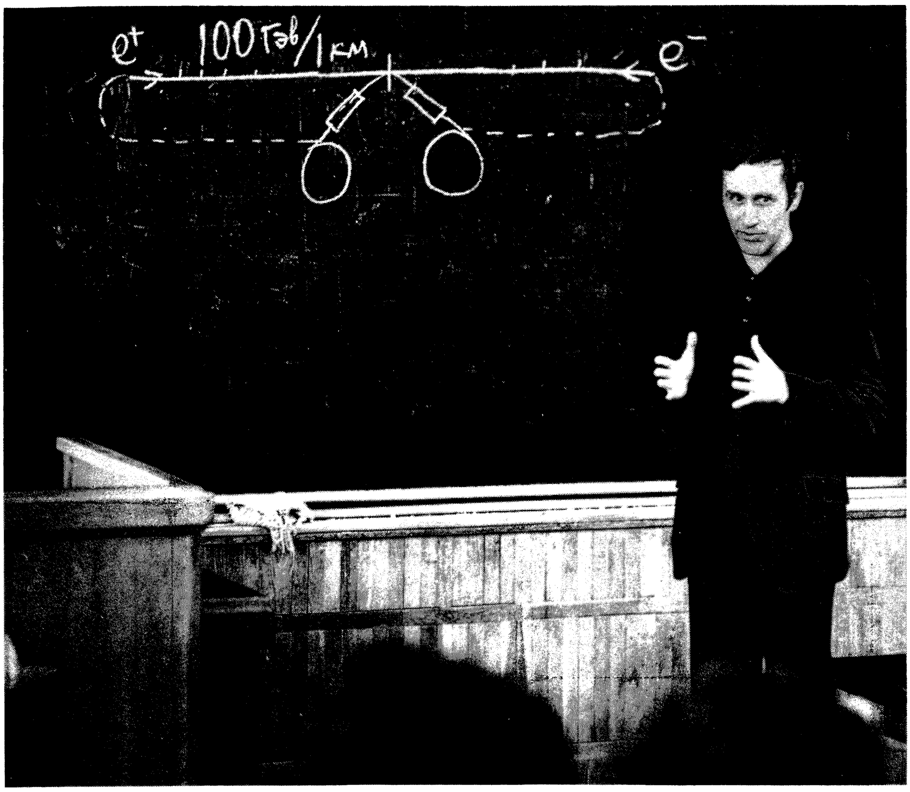
Colliding linac beams

The possibilities of colliding beams from linear accelerators have been investigated by several people in recent years and have recently become a focus of attention in accelerator physics following the realization in the course of the ICFA work (see page 397) that storage rings run into severe limitations at energies of a few hundred GeV. Two projects have emerged as a consequence of this attention. One is a multihundred GeV electron-positron colliding linac beam system being studied at Novosibirsk and the other is a 'single pass collider' using loops of magnets on the end of the Stanford linac.

The present thinking about the possibility of colliding electron and positron beams at the Nuclear Physics Institute in Novosibirsk first emerged at the international seminar in April 1978 organized to mark the 60th anniversary of Gersh Budker's birth. The paper was by V.E. Balakin, G.I. Budker and A.N. Skrinsky. It examined the feasibility of an electron-positron collider with beam energies of several hundred GeV based on linear accelerators.

The scheme is known as VLEPP and is at present envisaged as reaching peak energies of 300 GeV per beam probably beginning with 100 GeV linacs. There are several special features in the design. Very high accelerating gradients would be used (100 MeV/m) resulting in a smaller length for the whole system (linacs each about 3 km long for the peak energy). Such a high gradient will require power supplies capable of gigawatts of peak power in 1 μs pulses some ten times per second.

A possible location of VLEPP superimposed on a plan of Akademgorodok near Novosibirsk with the colliding beam region close to the existing buildings of the Institute of Nuclear Physics.



A.N. Skrinsky describing VLEPP, the Novosibirsk project to collide electrons and positrons from linear accelerators, at the International Seminar 'Problems of High Energy Physics and Controlled Nuclear Fusion' which was held at Novosibirsk to mark the 60th anniversary of the birth of Gersh Budker.

(Photos Novosibirsk)

Sources with similar parameters have been developed for plasma physics experiments and the power requirements may not therefore be too difficult to meet. The average power consumption of VLEPP is not frightening (about 40 MW).

To achieve the design luminosity of 10^{33} per cm per s requires the acceleration of 10^{12} particles per bunch in single bunches of very low emittance which are subsequently focused to a cross-section of 1 μm at the collision point. Even the passage of a single bunch through a linear accelerator structure produces an instability in the transverse direction and achieving the high quality bunches seems hard. However the work at Novosibirsk indicates that the instability can be suppressed. Also the emittance needs to be prevented from growing by ensuring precise alignment (1 μm) of the main focusing lenses.

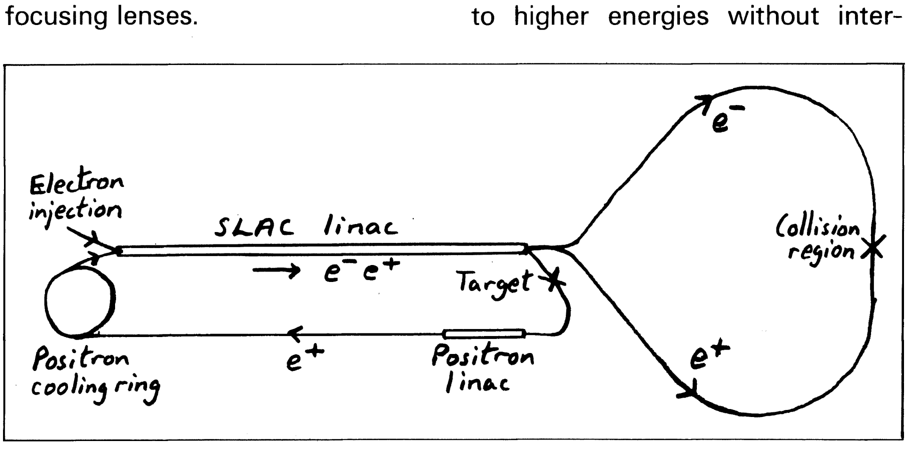
After collision of the particles the two beams can each be taken through a spiral magnetic wiggler where they will emit circularly polarized gammas of tens of MeV energy. These gammas can be used to regenerate electrons and positrons which will be polarized so that VLEPP could gain the additional information which will come from studying collisions of polarized particles with full luminosity. The regenerated electrons and positrons would be precooled to a very low emittance in a small storage ring (using the synchrotron radiation emission to do the cooling) at about 1 GeV before being injected again into the two linacs via 180° bending magnets at each end of the system.

The design has the convenient feature that the length of each linac could be increased in order to move to higher energies without interfering with experiments using the linac sections already built. Thus 100 GeV experiments could start while the extensions to reach 300 GeV were under way. The Novosibirsk Nuclear Physics Institute is optimistic that the project will be implemented sometime in the years to come.

At Stanford, Burt Richter presented a note in August entitled 'Conceptual design of a linear colliding beam system to reach 100 GeV in the centre of mass'. It resulted from the work of a subgroup of an 'Advanced Accelerator Task' comprising also Gregg Loew, Roger Miller, Dave Ritson and Rae Stiening. The aim is to build low cost facilities for the study of the Z, the neutral intermediate boson.

Major features of the operation sequence of the scheme are as follows: Electrons accelerated in the SLAC linac (using lengthened SLED pulses) emerge at an energy of 50 GeV to produce positrons from a target. These positrons are accelerated to about 1 GeV in a small linac and transported to the injection end of the main linac where they are 'cooled' by synchrotron radiation damping in a small storage ring. Several bunches each containing some 5×10^{10} positrons are stored, since the cooling time will exceed the foreseen 5 ms repetition rate for the collider, and the one which has cooled longest is pulled out for injection into the linac.

A single intense electron bunch is injected about 20 m behind the positron bunch so that each has about the same intensity and emittance. Further electron bunches are accelerated behind the intense electron



Sketch of the single pass collider system being studied at Stanford. The operating sequence, which might allow electron-positron collision to be studied at energies up to 50 GeV per beam, is described in the text.

bunch for the production of further positrons. The intense bunches emerge at 50 GeV and a magnet bends them around opposite arms of a ring (about 300 m radius) of alternating gradient focusing magnets so that they collide head-on after being focused to a radius around 1 μm. The particles are then rejected.

The anticipated luminosity with such a system is 10^{30} per cm^2 per s and the standard model then predicts a ratio of Z production to muon pair production of approximately 5000 with a total event rate of 150 per hour.

There are a host of accelerator physics questions to be answered before the construction of such a project could be confronted with confidence. The Department of Energy has been asked for money to finance preliminary engineering and design.

CERN
Hypernuclei with sigma particles

Experiments at the 28 GeV Proton Synchrotron have created artificial nuclei (hypernuclei) containing sigma particles.

Hypernuclei are formed when the usual nucleons in atomic nuclei are transformed into heavier particles (hyperons) by bombarding targets with low energy kaon beams.

The study of these artificial nuclei reveals useful new information about particle interactions and complements the knowledge gained from scattering experiments.

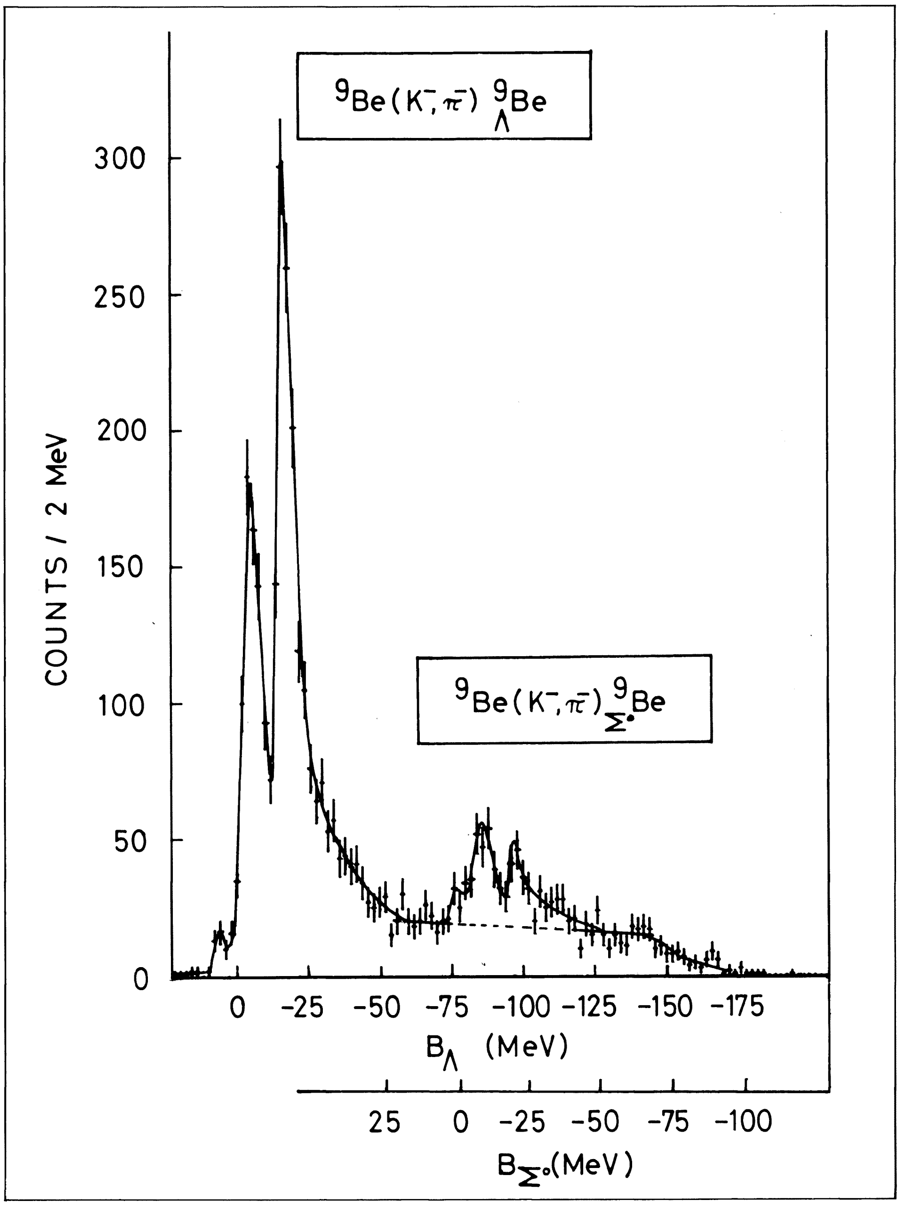
Previously, the only known hypernuclei were those containing the neutral lambda particle, which at 1115 MeV is the lightest hyperon. The lambda is thus only slightly heavier than the nucleon and cannot decay through strangeness conserving strong interactions into a nucleon and a kaon.

The heavier sigma is also stable as a single particle in strong interactions, however sigmas in nuclear matter should be able to decay through the strong reaction sigma + nucleon → lambda + nucleon. For this reason it was first thought that hypernuclei containing sigmas would not live long enough to make their study possible.

Recent experiments at CERN by a Heidelberg / Saclay / Strasbourg collaboration exposed beryllium-9 and carbon-12 targets to a 720 MeV separated beam of negative kaons.

The experimenters searched for strangeness exchange reactions where the kaons react with target nucleons and, after having transferred their strangeness to target

The first observation of hypernuclei containing sigma particles. Spectra from a Heidelberg/Saclay/Strasbourg collaboration at CERN using 720 MeV negative kaons on a beryllium target show two sharp peaks on the left due to the well-known hypernuclei containing lambda particles, while the smaller peaks in the centre are attributed to sigma hypernuclei. The two peaks in each case arise from different neutron spin states in the target nucleon. The bottom scale shows the respective binding energies.



nucleons to produce sigmas or lambdas, emerge as pions.

One spectrometer measured the momentum of the incident kaons, while the specially-designed SPES II spectrometer built by Saclay analysed the emergent pions. The large momentum acceptance of this instrument allowed pions coming from sigma and lambda production to be measured in the same spectrum.

In addition, a scintillation counter surrounding the target was used to detect the fragmentation of hypernuclei and the decay of lambdas.

The sigma hypernuclei signals were found 77 MeV above the usual lambda hyperon levels, corresponding to the mass difference between lambdas and neutral sigmas. The production of sigma hypernuclei was a quarter that of lambda hypernuclei, as expected from the relative probabilities of the different possible strangeness-exchange reactions.

Their width was measured at less than 8 MeV, a surprisingly narrow signal in view of the instability of sigma particles in nuclear matter.

Further studies will now have to establish whether this narrow signal is a peculiarity with light nuclei, or whether it is also found with heavier nuclei.

The results with beryllium–9 also show a small peak which might correspond to hypernuclei containing negatively-charged sigmas. The position of this candidate peak suggests that the interaction between sigma particles and nuclei differs from that between lambdas and nuclei, but that the sigma-nucleus interaction appears to be the same for neutral and negatively-charged sigmas.

Further experiments with higher levels of sigma hypernucleus production could require more intense low energy kaon beams than exist at present.

Aerial view of the Berkeley site with the location of the proposed relativistic heavy ion machine superimposed. The numbered buildings refer to existing facilities which could be used with the new machine.

(Photo LBL)

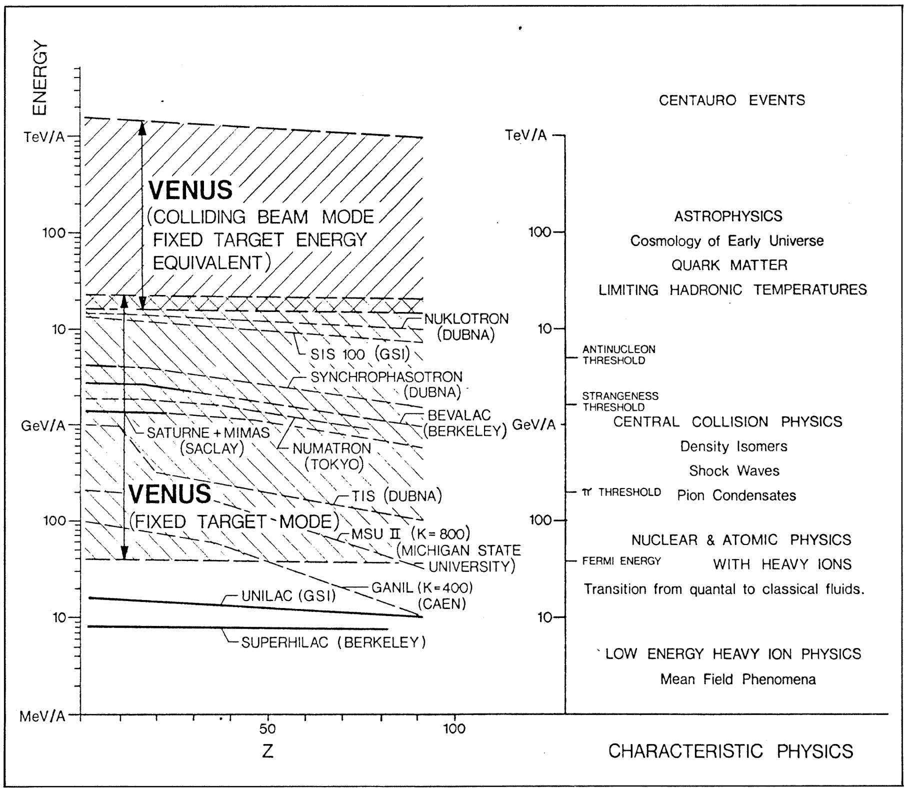
BERKELEY
The VENUS project

With several years of experience in operating the Bevalac complex for relativistic heavy ion physics behind them, the accelerator physicists and experimentalists at Berkeley have prepared a project which would enable them to pursue this field of research with increased vigour beyond the late 1980s. The project is known as VENUS, for Variable Energy Nuclear Synchrotron.

The aim has been to design a very versatile machine with the following major characteristics: intense ion beams from protons to uranium, low energy (40 MeV per nucleon) capability so as to 'overlap' with other machines, much higher intensities in the intermediate energy range than those currently available from the Bevalac, peak energies well above those available from the Bevalac (up to 20 GeV per nucleon for heavy ions), colliding ion beams of up to 20 GeV per nucleon in each beam.

The machine incorporates two superconducting accelerator/storage rings, about 200 m in diameter, in a tunnel on the Berkeley site. It will use the SuperHILAC as injector. Because of the slope of the site, half the tunnel would be bored into the hillside.

The operation sequence for the full energy beam would be to inject ions into one ring at about 8.5 MeV/A and accelerate to 1 GeV/A. Further stripping can then take place without loss and the ions would be transferred to the second ring for continued acceleration to 20 GeV/A. The beams could then be used for fixed target physics. However for beams of energy less than 8 GeV/A stripping is not necessary and the second ring can be used to 'stretch' the



Graph of the energies and ion species which could be covered by the VENUS project at Berkeley. Other existing and planned machines are also indicated. On the right is a list of the fields of physics which could be studied by the machine in its various operating modes.

beam for a better duty cycle. Colliding beam operation would be achieved by stacking many pulses in one ring and then transferring half of the beam back into the other ring (with its magnet field reversed) via an S-shaped reinjection line. The two rings cross in six locations and three would be available for colliding beam physics.

Many of the present facilities around the Bevalac complex could be used. The superconducting magnets are foreseen as improved versions of the ESCAR type, developed at Berkeley, to give peak fields of 4 T and a rate of change of field of about 1 T per s. Four separate r.f. systems are required to ensure all the various beam manipulations. Vacuum in the 10^{-11} torr range is needed to allow partially stripped heavy ions to be accelerated and stored.

The physics which would be accessible with VENUS spans the entire range from low energy nuclear and atomic physics (with ion beams available from energies of 40 MeV/A) through to the unexplored territory of very high energy heavy ion studies and 'quark matter' (with ion beams colliding at equivalent fixed target energies of up to 1 TeV/A).

The primary motivation is the possibility of creating dense, highly excited nuclear systems, far outside known nuclear physics. To pick just a couple of topics in particle physics where the machine may be used to investigate new phenomena – multiple quark scattering could be observed and the study could contribute to the understanding of quantum chromodynamics. The highest energy collisions could reach the region where the strong interaction appears to take on different characteristics such as have been seen in the 'Centauro events' with their dearth of neutral pions.

The estimated cost for construction of VENUS is around $ 100 million and it is believed that the machine would be in operation in 1987 if authorization comes through by 1983. A proposal to the Department of Energy will be prepared in the course of the next year and it is hoped that the necessary research and development work on the machine components could then begin in 1981.

VENUS would extend an area of physics in which Berkeley has played a pioneering role.

LOS ALAMOS
The future of medium energy physics

The usual arrangement of a Scientific Review Committee (by whatever name at a given accelerator) hearing research proposals from many separate groups, may sometimes appear formidable. In addition, coverage of the research field this way may be fragmentary. In an effort to circumvent these problems, LAMPF recently held a two-week Workshop on Program Options in Intermediate Energy Physics, involving broadly-based teams of both experimentalists and theoreticians. The Workshop was asked to raise critical questions in nuclear and particle physics and to recommend how they can best be addressed in the next few years by intermediate-energy accelerators.

The Workshop was organized by a steering committee, chaired by Earle Lomon (MIT), which outlined some topics to be discussed: fundamental interactions and symmetries, nuclear modes of motion, structure, and reaction mechanisms.

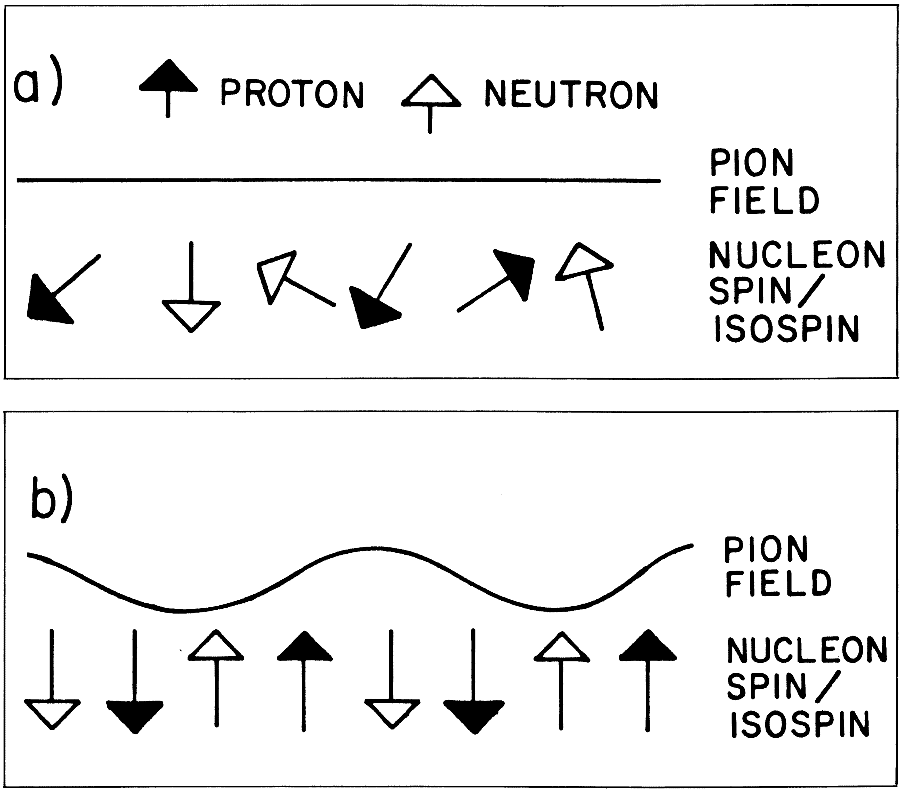
The Workshop was chaired by E.M. Henley (University of Washington) and was divided into eight nuclear panels and four particle panels. The panels were asked to outline experiments that would resolve critical questions in their areas, while considering the feasibility and requirements for the experiments (for example, requirements for new facilities such as larger-solid-angle spectrometers or special detectors, or even new accelerators such as Kaon Factories).

Keynote addresses were given by M. Jacob (CERN) on 'New Directions in Elementary Particle Physics' and on 'pp from Very Low to Very High Energies', and by G.E. Brown (Stony Brook) on 'New Directions in Intermediate-Energy Nuclear Physics'. P. Debevec reported on the Boulder 'Future Directions Workshop', held earlier this year and M. Gell-Mann delivered the J.R. Oppenheimer Memorial Lecture on 'Quarks and Other Fundamental Building Blocks of Matter'. Furthermore, there were talks on possible future facilities by D.E. Nagle (LAMPF), W. Turchinetz (MIT) and E.M. Henley, who reported on the TRIUMF Kaon Factory Workshop which followed the August Vancouver meeting.

A panel was organized to discuss major facilities, equipment and instrumentation needs at various intermediate-energy facilities. It was chaired by Maurice Goldhaber (BNL) and included John Domingo (SIN, Villigen), Vladimir Lobashov (INR, Moscow), Louis Rosen (LAMPF), Jack Sample (TRIUMF), and Jacques Thirion (CEN, Saclay). This panel presented and discussed plans at their own Laboratories and the recommendations made by the other panels.

Although overlaps occur, it is interesting to consider the panel recommendations under the topics of strong interactions, nuclear properties, and electroweak interactions.

A schematic illustration of (a) the lack of spin/isospin ordering in ordinary nuclear matter, and (b) the long-range spin/isospin ordering in a pion condensate. Nucleonic spin/isospin order permits an associated static pion field (because the pion has definite spin/isospin quantum numbers).



Panels headed by R. Silbar (Los Alamos), E. Moniz (MIT), and D. Koltun (Rochester, (New York)) addressed topics in strong interactions, not especially in the setting of nuclear matter. A typical topic was the incompleteness of the nucleon-nucleon phase shift data and a typical recommendation was for more intense variable energy polarized beams. A theoretician's slant was on quark and bag model connections to nucleon scattering.

Panels headed by G. Igo (UCLA), G. Garvey (ANL), I. Sick (Basel), J. Eisenberg (Tel-Aviv), and W. Van Oers (Manitoba) considered the broadest set of topics, loosely classified as nuclear properties. The fragmented nature of this field was often noted: there are many specialized descriptions for certain nuclear characteristics, but the broad goal is to produce a description of nuclei and nuclear matter which is independent of the probe. Recent advances in pion scattering and kaon strangeness-exchange generated interest. A common topic was comparison of electron, proton, pion, kaon, and nucleon probes. In this context the arsenal of accelerators and special beams was often discussed. The CERN antiproton project LEAR was eagerly anticipated. Improved pion and kaon facilities were recommended.

To continue development of the field at a useful pace, some panels saw the need for certain specialized facilities such as a 1 GeV electron accelerator with 100 per cent duty factor. This would make possible efficient coincidence experiments (detecting more than one emergent particle) which are difficult with short pulsed beams. A related consideration is the development of large solid-angle detector systems capable of recording several emergent particles, and the development of more powerful spectrometers and spectrometer pairs. Appropriate experiments for spectrometer pairs would be for example $e\ A \rightarrow e\ p\ X$, where A is some nucleus and X the residual nucleus with discrete states to be resolved.

An exciting idea often discussed was pion condensation. There may exist a new phase of nuclear matter at high density, characterized by an ordering of nucleon spin and isospin. Since the pion carries isotopic spin 1, angular momentum spin 0 and negative parity, a regular lattice of nucleon spin / isospin would have an associated static pion field. The only hope of seeing evidence for pion condensation is in transitory precursor phenomena such as enhancement of unnatural-parity states in nuclei.

Panels headed by K. Crowe (Berkeley), B. McKellar (Melbourne), F. Boehm (Caltech), and C.S. Wu (Columbia) reviewed topics in electromagnetic and weak interactions. Timely theoretical topics are the structure of the electroweak current and unified gauge theory models for the leptons. Relevant experiments may measure muon and pion decays, both rare and ordinary; in fact, it seems that almost any precise measurement gives a useful constraint. Thus the call was often heard for 'more' and 'better' beams and facilities. For example, to reach 10^{-13} sensitivity on muon decays, an experiment (even with perfect detectors) would be limited simply by the total muon flux available. Neutrino experiments have valuable contributions to make to electroweak physics, but because of the difficulties, neutrino research is only just opening up at intermediate energies. A useful new tool would be an intense pulsed neutrino source, such as proposed at the LAMPF-WNR storage ring.

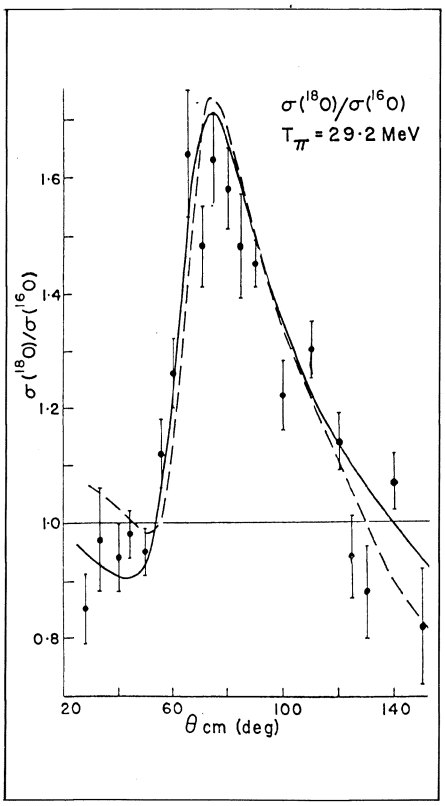
LAMPF was happy to bring together such a broadly-based and hard-working group of panelists. The resulting overview of the field is a useful framework for considering facility growth and the direction of the experimental programme.

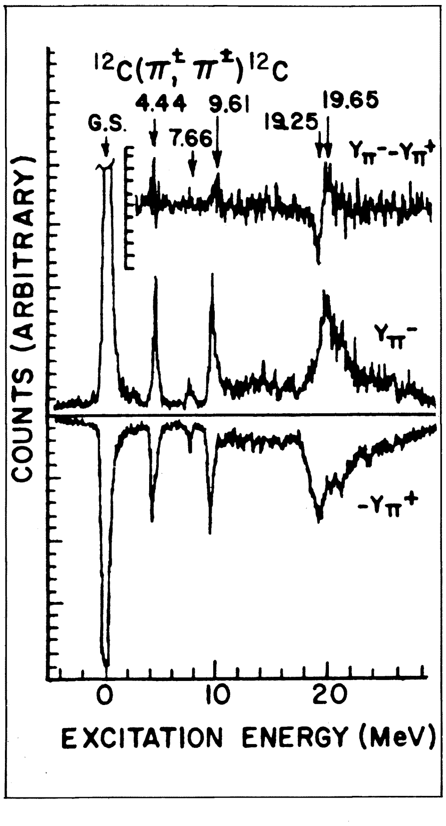
8–ICOHEPANS in Vancouver

The Eighth International Conference on High Energy Physics and Nuclear Structure was held in Vancouver from 13 to 17 August, with 540 delegates from 24 countries. This series, initiated at CERN in 1963 by Viki Weisskopf and the late Amos de Shalit, has become the natural home for research at the meson factories. These machines were constructed expressly to apply the techniques and the particle beams of the then 'High Energy Physics' to the study of nuclear structure. In fact the last few Conferences have all been held close to meson factories — 1975 in Santa Fe near LAMPF, 1977 in Zürich near SIN and now 1979 in Vancouver near TRIUMF. Although the title lends itself to misinterpretation, it was decided to retain it for the next conference, which will be held in France (probably in Paris) in 1981.

Throughout the week it became clear that the meson factories were now 'in production' and many beautiful experiments were described and discussed. The interface of particle and nuclear physics is clearly a place for creative talent. This year's Conference lacked a single high spot such as was the feature of the Zürich Conference (the muon decay into an electron and gamma) but there were important contributions on many topics including baryonium, nucleon-nucleon resonances, lepton conservation laws, matter radii of nuclei, isospin mixing in nuclei and finally a cluster of exotic ideas about the properties of nuclei including pion condensation and the quark soup model.

The social highlight was a cruise to the small town of Nanaimo on Vancouver Island. Someone had spread the rumour that the boat contained scientists who were looking for a site to build a 'nuclear structure' (i.e. reactor) to produce 'high energy'. The participants were therefore greeted by a fair-sized but peaceful demonstration, including some small boats bearing occasionally obscene slogans! The overseas delegates snapped photos of banners such as 'No nukes', or 'I'm too young to die'. Happily, after discussions on the dock, many of the demonstrating youngsters went away wiser than they came, and several delegates acquired placards as a momento of a short but intense discussion. In attempting to explain the delegates' essential harmlessness to the local press, Karl Erdman, *Adding to our knowledge of the neutron distribution in nuclei is this graph of the ratio of negative pion elastic scattering on oxygen 18 to that on oxygen 16 measured at the TRIUMF cyclotron at an energy of 29.2 MeV. This ratio is sensitive to the overall neutron radius and gives 2.81± 0.03 fm for oxygen 18 using 2.60 fm for oxygen 16. The curves are for two different optical models.*





Inelastic scattering spectra for positive and negative pions on carbon 12 near 70° at 162 MeV. The inset shows the difference between the yields and indicates isospin mixing of the nuclear levels.

Associate Director of TRIUMF, was memorably quoted as saying that 'Most of these physicists wouldn't know one end of a screwdriver from the other'.

Rare decay modes

One of the topics most closely connected with high energy physics to which the meson factories have turned their attention is the study of pion and muon rare decay modes. This came into prominence several years ago with rumours that the decay of a positive muon to a positron and a gamma had been observed.

The whole spectrum of lepton conservation laws was surveyed and it now seems that alternatives to simple additive conservation have finally been put to rest. The multiplicative law has been disproved by the new LAMPF result which puts a limit on the decay $\mu^+ \rightarrow e^+\bar{\nu}_e\nu_\mu$ of 7% of the normal $\mu^+ \rightarrow e^+\nu_e\bar{\nu}_\mu$. The Konopinski-Mahmoud scheme has difficulties with the new limit on muon to positron conversion of 9×10^{-10} set at SIN. With the discovery of the tau lepton these alternative schemes were less pleasing anyway. The focus of attention has switched to whether the additive law is absolute or whether it is broken at some minute level.

At present the upper limits from LAMPF on the branching ratio for the decay of the muon into an electron and gamma is 1.9×10^{-10}. The upper limits on other processes have also continued to improve, especially muon to electron conversion, now set at 7×10^{-11}. A new generation of detectors is being prepared to push even lower. One of the most ambitious is the Time Projection Chamber at TRIUMF, which will have an effective solid angle of more than 2π, and should permit a study of the muon to electron conversion at the level of about 10^{-12}.

Nuclear properties

At the other end of the spectrum of interests were reports on the understanding of nuclear ground state densities. Electron scattering has given a very good picture of the charge distribution, but there is no established probe for neutrons. Calculations for both protons and pions show a strong sensitivity to the neutron distribution, but as yet there is only one case where model and (limited) energy dependence have been established. This is for low energy negative pion scattering from neighbouring isotopes (such as oxygen-18 and 16 measured at TRIUMF), where all available theoretical models agree on a difference of 0.21± 0.03 fm for the neutron r.m.s. radii.

The high selectivity of negative pion (positive pion) for neutrons (protons) in the (3,3) resonance region has led to some beautiful evidence for isospin mixing in the three 4^- states of carbon-12 at about 19 MeV. This shows up most dramatically the difference in the pion inelastic cross-sections. It must be added that the precise electron scattering data for these same states was necessary too.

At Saclay, high precision coincidence measurements of electron scattering are extending our knowledge of nuclear single particle wave functions to high momentum. Interesting data were also reported for polarized proton reactions but it will be much more difficult to extract nuclear structure information there. In fact, at sufficiently high momentum transfer (about 500 MeV/c), even electron scattering is suspect — meson exchange currents, relativistic effects and isobar components in the nuclear wave function all conspire to confuse.

High density nuclear matter

There was excited discussion over the question of nuclear matter at higher density and particularly pion condensation. Unfortunately, no respectable model predicts this phase transition below twice the density of normal nuclear matter and thus the only place to find condensed matter seems to be in neutron stars. Indeed some evidence was presented from X-ray observations of SN1006 and Cas A for the existence of relatively young, cold neutron stars. The presence of a pion condensate is one mechanism by which this anomalous cooling could have occurred.

Back on earth the problem amounts to trying to prove that water will freeze at 0°C, given a sample at 30°C whose temperature cannot be varied! This is obviously difficult, but there are precursor phenomena to phase transitions which can provide clues.

Examples are the critical opalescence in liquids near the critical point or, more appropriately, the local spin ordering above the Curie temperature in ferromagnets. For pion condensation the theoretical expectation is for an enhancement of pion-like transitions in the momentum transfer range several times the mass of the pion. Inelastic electron scattering on carbon-12 seems to show some enhancement above the simple Cohen-Kurath predictions but more theoretical work, and experiments with different probes (such as possibly the muon neutrino producing a muon) will be necessary before this interpretation is widely accepted.

Of course, all the predictions of pion condensations are based on extrapolations far from the physical region of theories developed for real pions and normal nuclear densities. In this regime one of the pleasing features of the Conference was the attempt to unify different theoretical approaches — such as the optical model and the isobar-doorway pictures. Beautiful new pion reaction data were presented — for inelastic scattering from EPICS and SUSI, and for charge exchange from the LAMPF neutral pion spectrometer (see June issue, page 156). This should help to form a coherent picture from the best features of each model.

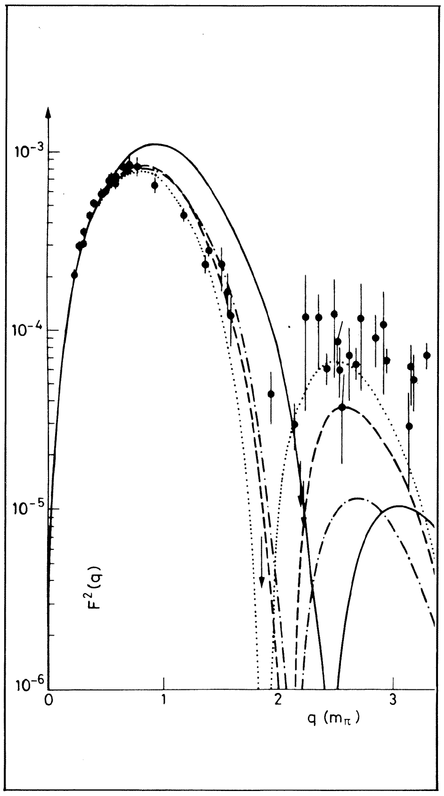
Baryonium, Nucleon-nucleon resonances and Quarks in nuclei

With many diverse theories now 'predicting' nucleon-antinucleon bound states and resonances, it was very disturbing to hear that the most recent Brookhaven experiment showed no evidence for the S (1932 MeV) in a proton-antiproton total cross-section measurement. This was probably the best established baryonium state and confirmation of its demise is anxiously awaited.

There is also continuing confusion over the nucleon-nucleon resonances which have been proposed to explain some proton-proton scattering results at the Argonne ZGS. It is difficult to distinguish between a resonance and a threshold effect without considerably more data at several energies through the region. New preliminary data from SIN were presented, which were somewhat different from the original ZGS data, and their complete analysis will be an important input.

Another aspect of high energy physics which received a good deal of attention was the interpretation of experimental data in terms of quark phenomenology. The MIT bag model has been shown to reproduce qualitatively the short range part of the phenomenological soft core potentials. It also makes interesting predictions concerning the repulsive, short-range three and four nucleon forces. Experimental tests of these, and the predictions of exotic (e.g. 6 quark) states, are eagerly awaited.

The square magnetic form-factor for electron scattering off the 1^+ 15.1 MeV level of carbon 12. The curves are for different values of a parameter which is proportional to the strength of the pion field in the nuclear medium. The theory of pion condensation expects enhancement at values of a few times the pion mass.



Fittingly, the final session was devoted to a discussion of quarks and nuclei. In particular, the radius of the MIT bag is so large that it is difficult to see how conventional understanding of nuclear physics could be correct, since nuclei should then act more like a quark soup. On the other hand, the little bag suggested recently at Stony Brook restores more of the conventional picture of nuclei, with small nucleon cores exchanging mesons.

However this model has its problems too. In particular, it is not clear whether many of the nice results of the MIT bag for hadronic properties will be lost. A great deal of challenging work lies ahead for both experimentalists and theorists. At question is the whole understanding of atomic nuclei at the microscopic level, but that is the sort of question that Weisskopf and de Shalit had in mind when they instituted this series of Conferences.

James Clerk Maxwell 1831–1879

Earlier this year saw the centenary of the birth of Albert Einstein. It is highly apt that 1979, which has been marked by further consolidation of the unified theory of weak and electromagnetic interactions and its recognition in the award of the Nobel Prize to Glashow, Salam and Weinberg, is also the centenary of the death of the great Scottish physicist who first formulated a unified theory of electric and magnetic fields. We are grateful to Abdus Salam for drawing our attention to the Maxwell anniversary.

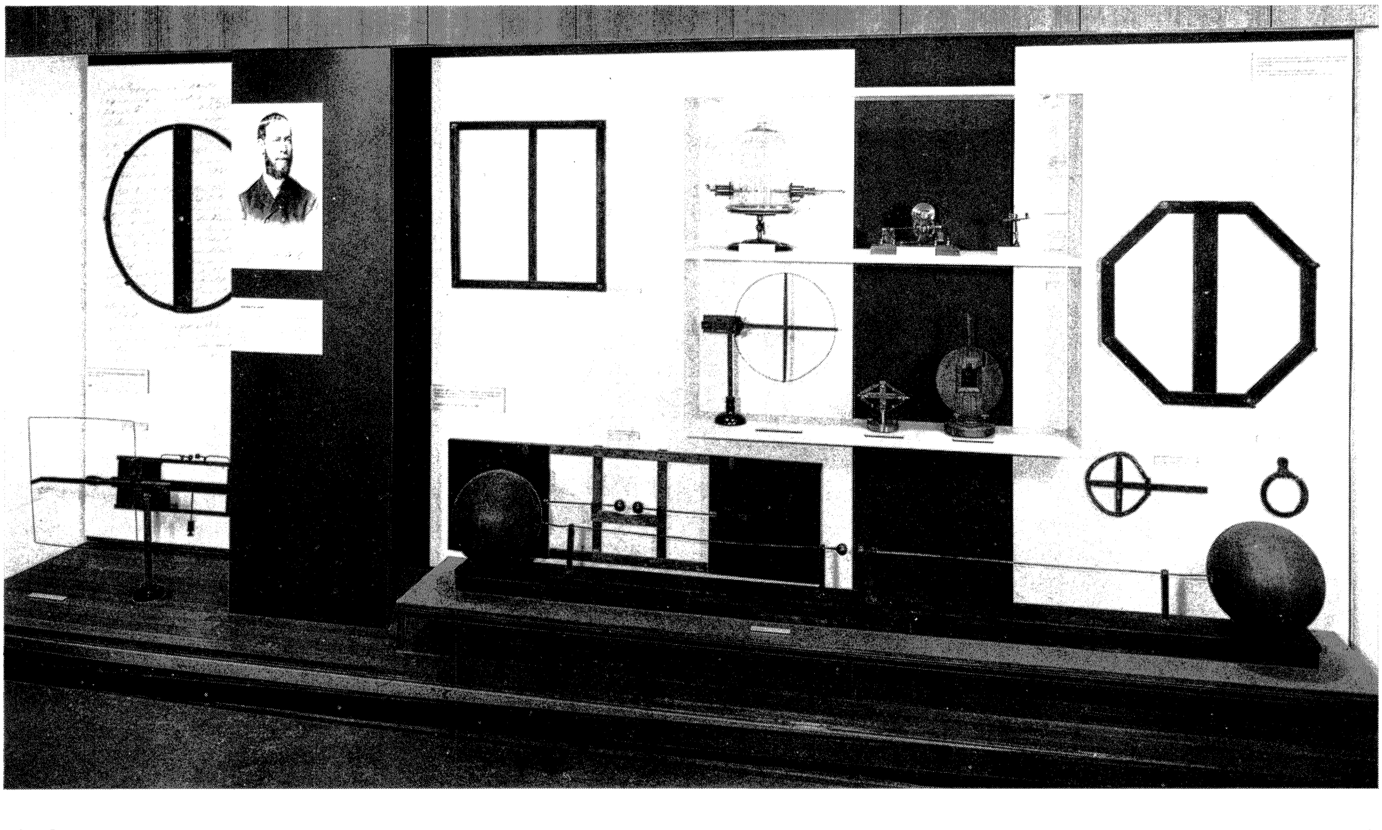
Maxwell's equations might have been called Clerk's equations instead. Maxwell's paternal ancestors had the family name of Clerk, and the name was only changed when the physicist's father inherited an estate, eventually named Glenlair, after marrying a Miss Maxwell.

Maxwell was born in Edinburgh on 13 June 1831, but soon went to live at Glenlair. At the age of ten, he returned to Edinburgh to begin his formal schooling, where his unfashionable clothes and rustic manner were mocked by his schoolfellows. The genius who was to shape much of physics apparently earned the name 'Dafty'.

By fourteen, he had developed a method for constructing geometrical figures which was read as a paper to the Royal Society of Edinburgh. His evident interest in physics led his uncle to introduce him to William Nicol, of prism fame.

Maxwell entered Edinburgh University when he was sixteen, and during this time he worked on the application of optical techniques to the study of elastic solids. This paper was presented to the Royal Society of Edinburgh in 1850.

He entered Trinity College, Cambridge, on the strength of his



Hertz corner at the Deutsches Museum, Munich. It was with this apparatus that Heinrich Hertz discovered the electromagnetic radiation predicted by Maxwell's equation.

(Photo Deutsches Museum, Munich)

And God said:

$$\nabla \cdot \mathrm{E} = \frac{\rho}{\varepsilon_0}$$

$$\nabla \cdot \mathrm{B} = 0$$

$$\nabla \times \mathrm{E} = -\frac{\partial B}{\partial t}$$

$$c^2 \nabla \times \mathrm{B} = \frac{j}{\varepsilon_0} + \frac{\partial E}{\partial t}$$

–and there was light

published papers. His tutors reported his knowledge as immense, but in an appalling state of disorder. In 1854 he came overall second in the final examinations, beaten only by E.J. Routh (of Routh's Rule for calculating moments of inertia).

He was immediately given a staff position at Cambridge. Released from the pressures of formal examinations, Maxwell threw himself into original work. Geometrical optics and colour vision first occupied his attention, but also at about this time, urged by William Thomson (later Lord Kelvin), he began to take an interest in electricity. In particular, he carefully studied the work of Faraday.

He remarked that while there were mathematical formulations of individual electric and magnetic phenomena, no general theory had been developed.

In 1856, Maxwell became Professor at Marischal College, Aberdeen. Here he made an epic study of the stability of the rings of Saturn, which led on to important contributions to the kinetic theory of gases.

In 1860, Marischal College was incorporated into the new University of Aberdeen. As there was room for only one Professor of 'Natural Philosophy', Maxwell lost his job. He was also passed over for the chair at Edinburgh, and went back to Glenlair, where he worked on his famous treatise on electricity and magnetism.

He soon found a post at King's College, London, where he came into contact with Faraday. At London, he published many of his most famous papers, including his Dynamical Theory of the Electromagnetic Field in 1864 which included the famous equations. The Dynamical Theory of Gases followed soon afterwards. Also during his five years at King's College Maxwell supervised an ambitious project for the standardization of electrical units, the forerunner of the system we now use.

Strain and illness began to take their toll, and in 1865 he resigned from King's College and went back to Scotland, there to continue work on his monumental treatise on electricity and magnetism.

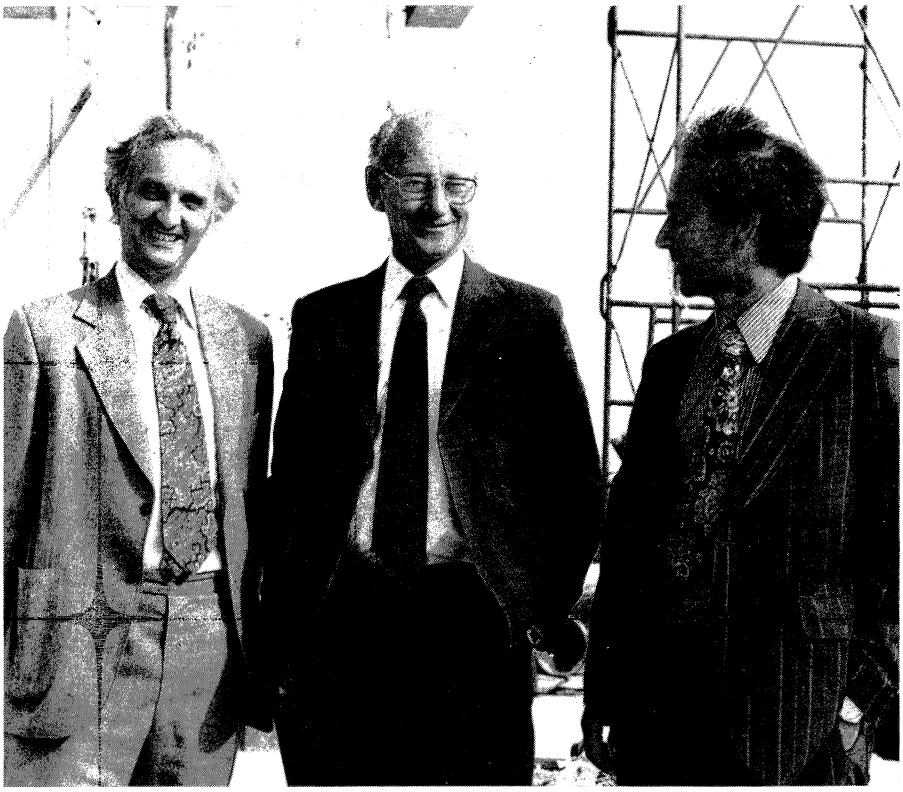
At this time, the Cavendish Laboratory was being established at Cambridge. Both William Thomson and Helmholtz were offered the new chair, but declined. It seems bizarre now that Maxwell was only third choice, but his great treatise on electricity and magnetism was not published until two years later.

At Cambridge, he put the finishing touches to his book. Subsequently, he wrote a whole series of short articles and reviews, and edited an account of the researches of Cavendish.

In the summer of 1879 he was working on a new edition of his book when his health gave way. He died of cancer on 5 November 1879, only 48 years old.

People and things

Godfrey Stafford (centre) Director General of the combined Rutherford and Appleton Laboratories flanked on his right by J.T. Houghton, Director Appleton, and Geoff Manning, Director Rutherford.



On people

Milton White died at Princeton on 16 October. He was a leading figure on the USA accelerator scene for many years and was Director of the Princeton Pennsylvania Accelerator Laboratory. It was his inspiration and optimism which kept the Laboratory vital until budget restrictions forced it to close in 1972. In March of this year he was elected President of the Universities Research Association which operates Fermilab.

The distinguished Soviet physicist Isaac Markovich Khalatnikov celebrated his 60th birthday on 18 October. He was a talented student and friend of Lev Landau and a founder and Director of the Landau Institute for Theoretical Physics. He is well known for his work with Landau and A.A. Abrikosov on quantum electrodynamics, particularly the charge normalization problem. His most significant contributions are in low temperature physics (the theory of liquid helium) general relativity and cosmology. The particle physics community owes him a debt for his organization of the particle and field theory group at the Institute which has been very fertile in ideas now occupying the minds of many theoreticians. The Institute has also played an important role in international collaboration stimulated by Khalatnikov. We join our good wishes to those of his many friends throughout the world.

I.M. Khalatnikov

Arthur M. Poskanzer, senior scientist at the Lawrence Berkeley Laboratory has been awarded the American Chemical Society's award for nuclear chemistry. Art has the identification of twenty-nine new isotopes at the limit of stability to his credit and in recent years has been a key figure in the research programme with relativistic heavy ion beams on the Bevalac. His team produced the first results on central collisions which led to the fireball and coalescence models of relativistic nuclear collisions. He is currently taking a year's leave of absence at CERN working on the ISOLDE Isotope On-line Separator.

On 30 October and 1 November Professor Weisskopf gave the first Bernard Gregory Memorial Lectures at CERN. He chose as his topics 'The beginning of field theory, a personal recollection' and 'Perspectives in particle physics'.

ISR new record intensity

The Intersecting Storage Rings at CERN achieved another record in October. The peak stored proton beam current in Ring 1 reached 50 A. This is two and a half times the design value (which was in any case regarded as very ambitious). It is another indication of the perfection of the machine, another stimulus for the experimentalists who use it and another encouragement to the heavy ion fusion optimists who plan for high intensity beams.

John Rutherfoord (left) and Frank Sciulli — incoming and retiring Chairmen, respectively, of the Fermilab Users Executive Committee.

Happy New Year for PEP

The turn-on date for the Berkeley-Stanford electron-positron storage ring, PEP, is now moved to end-January 1980 when the SLAC linac comes back into action after its Christmas shutdown. All the essential ring components are on site and have been tested. Installation is going reasonably well and the end-January date looks firm.

Space at Fermilab?

The Universities Research Association, which operates Fermi National Accelerator Laboratory, is preparing a proposal in collaboration with astronomers to locate a Space Telescope Science Institute at Fermilab. The Institute will manage the science operations of an orbiting telescope scheduled to be launched in 1983. The proposal will be presented to NASA and the decision is expected before the end of next year.

Argonne Users Support Center

A Users Support Center has been established by the Accelerator Research Facilities Division of Argonne National Laboratory. Its purpose is to continue to make available expertise and facilities which have been developed at Argonne during the lifetime of the Zero Gradient Synchrotron (ZGS) to high energy physics users (particularly University user groups) who do not normally have access to them. Some of the fields of possible interest to users are plastics, electrical and mechanical engineering, computer controls, polarized targets, magnet design and superconductivity. The Center will have a physicist as coordinator and will use the part-time efforts of personnel in the fields of interest. Further information concerning the Center may be obtained from Peter F. Schultz at Argonne.

Limits on the proton lifetime

With the Weinberg-Salam theory of unified electroweak interactions in such good shape, it is fashionable these days to propose 'grand unifications' which attempt to extend the synthesis of forces and merge the electroweak theory with strong interactions, and perhaps gravity as well.

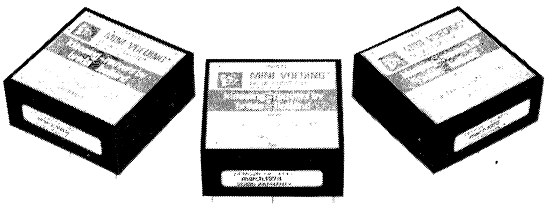
One spin-off from these more ambitious theories is the idea that the proton is unstable, so that baryon number is not an exact conservation law (see May issue, page 116). Calculations give a proton lifetime of the order of 10^{31}–10^{32} years.

Experiments are now being proposed to look for signs of proton decay, but meanwhile a Case Western Reserve/Witwatersrand/Irvine collaboration has analysed existing data collected over many years in experiments installed over 3000 m underground in a South African mine.

The results, interpreted in terms of the grand unified theories, give a limit for the proton lifetime of 10^{30} years, already not far from the predicted value.

The negative result from the South African experiment means that any 'hyperweak' interactions responsible for proton decay are mediated by particles heavier than 10^{14}GeV.

Meanwhile in Europe the feasibility of an underground low-background laboratory is to be investigated by a Frascati/Milan collaboration in the Mont Blanc tunnel.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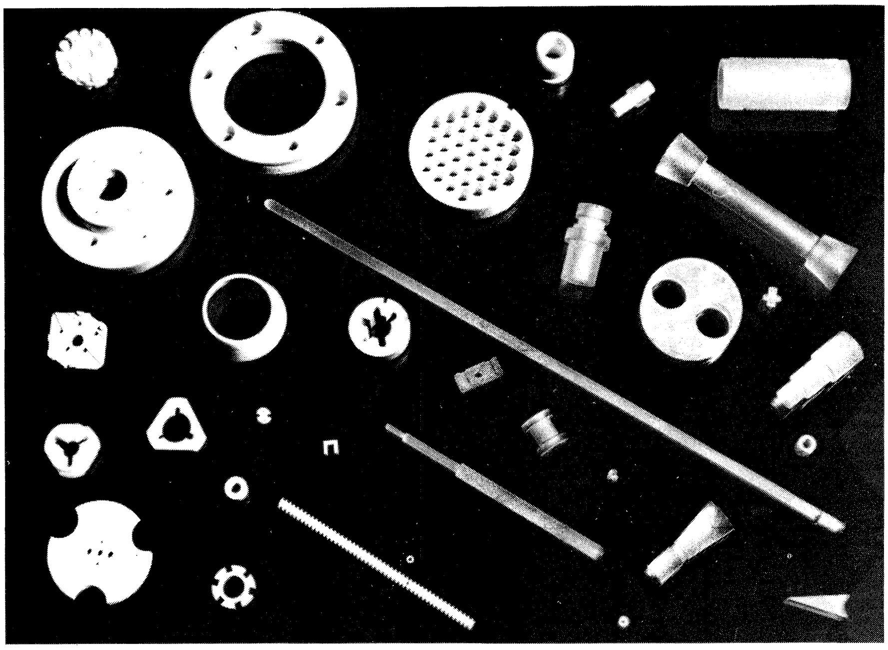

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The appointment is for a maximum period of two years and the initial salary will be within the range £5,777 – £7,521 per annum according to the age, qualifications and experience of the successful candidate.

Applications, together with the names of three referees, should be received not later than 17th January, 1980, by The Registrar, The University, P. O. Box 147, Liverpool, L69 3BX, England, from whom further particulars may be obtained. Quote Ref. RV/831/CC.

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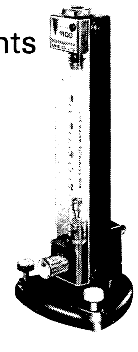

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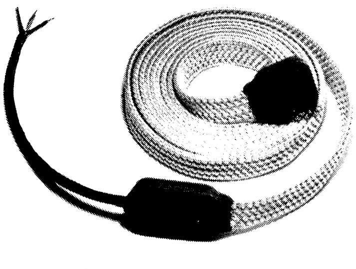

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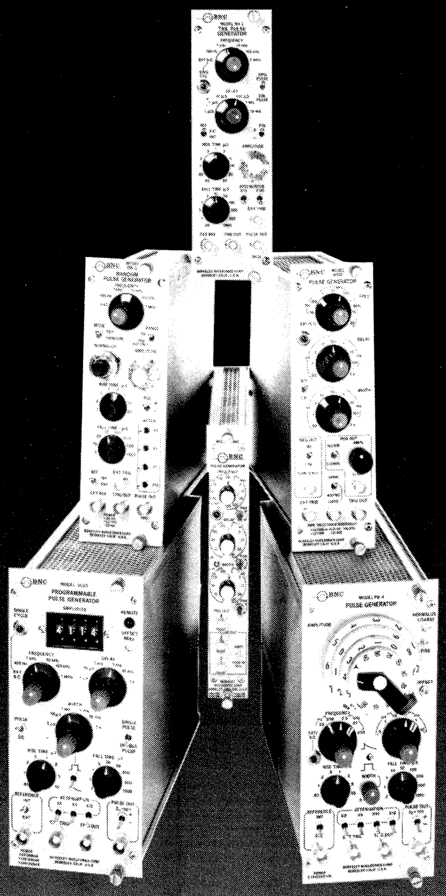

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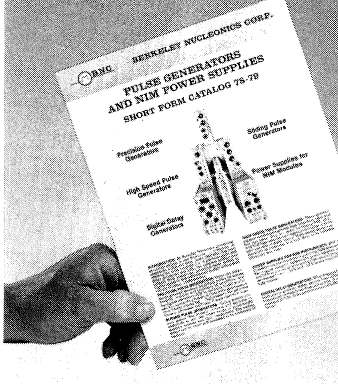

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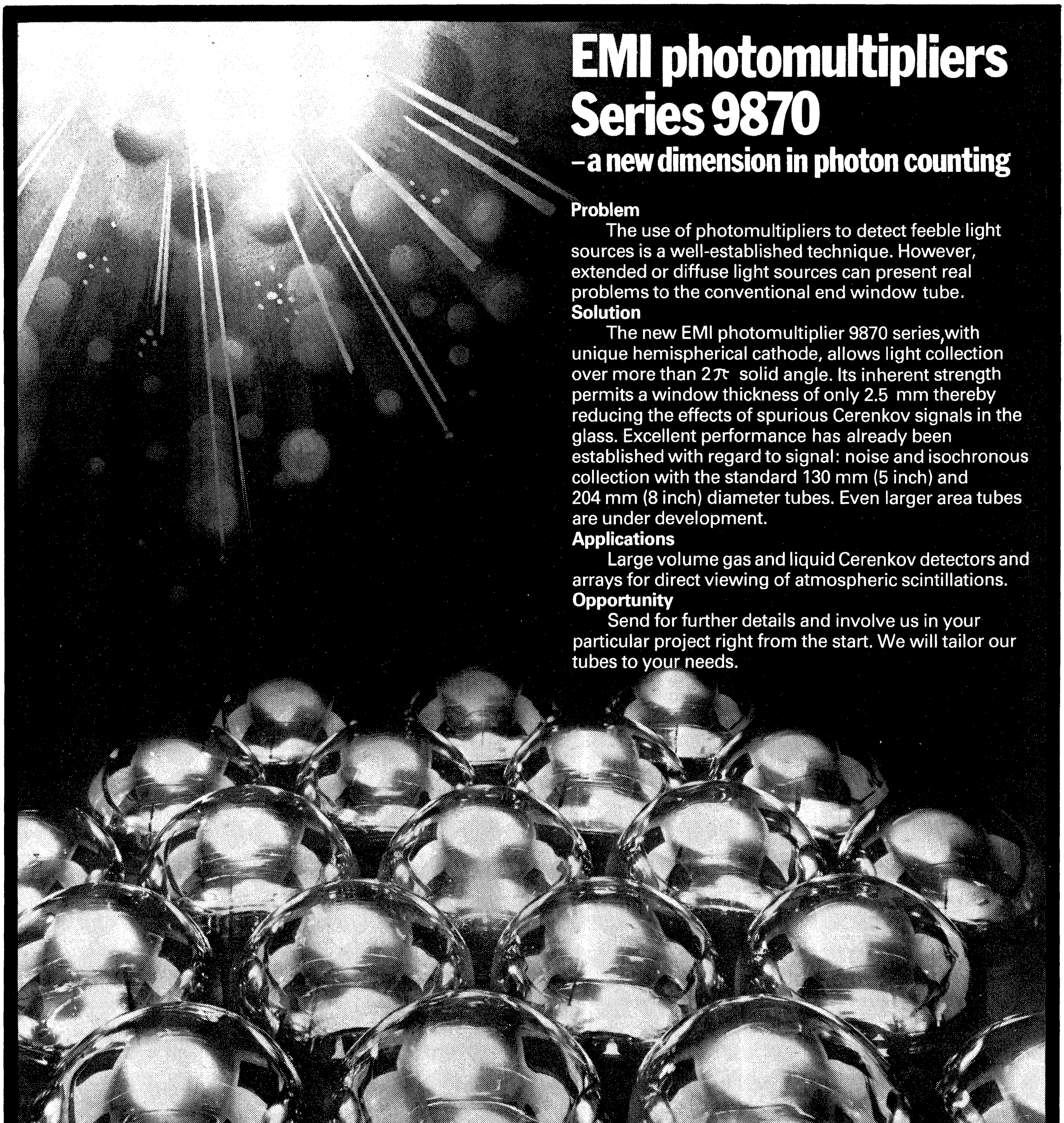

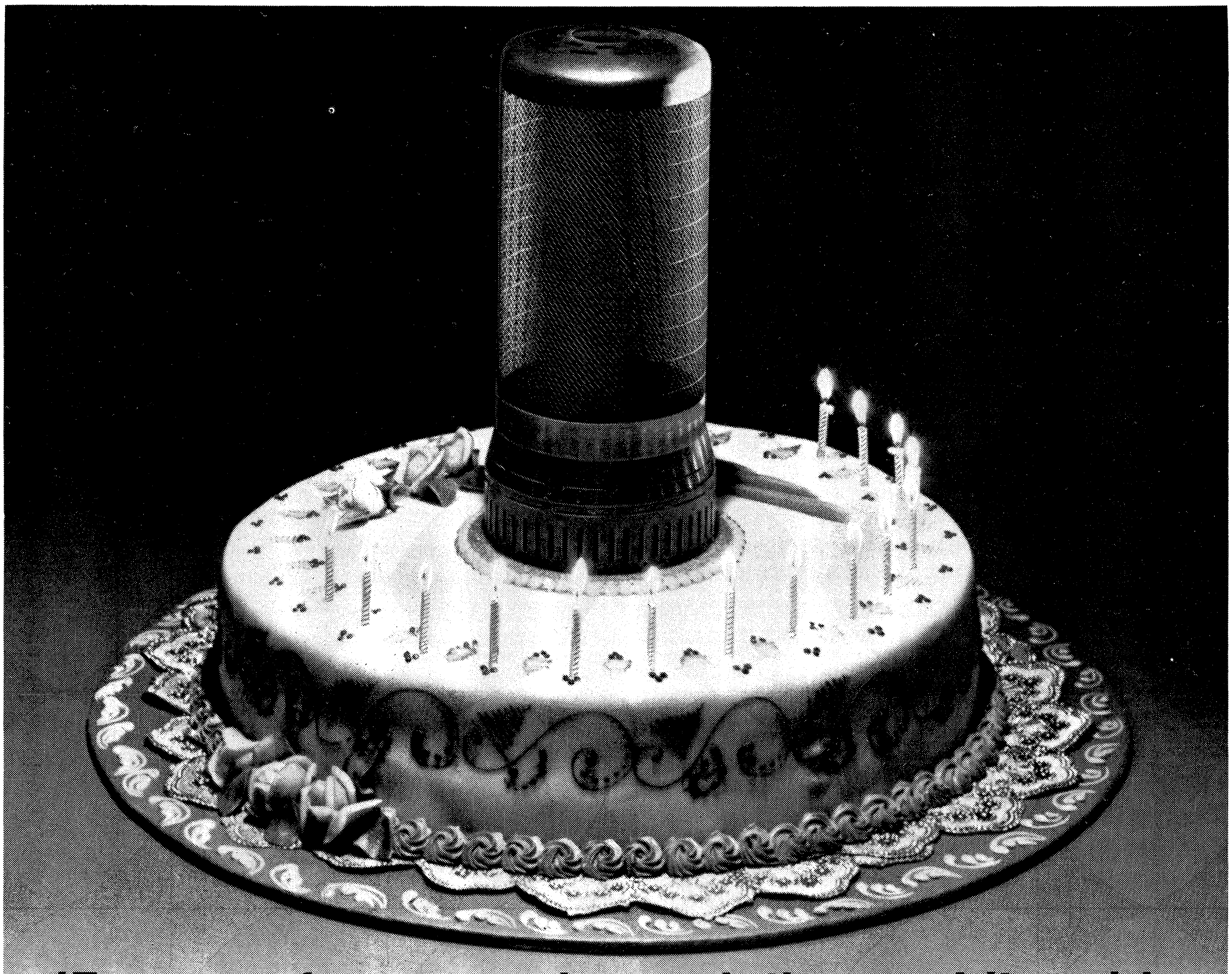

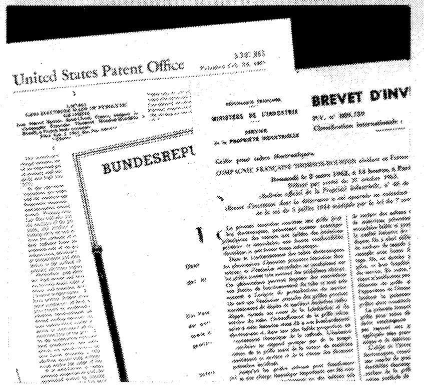
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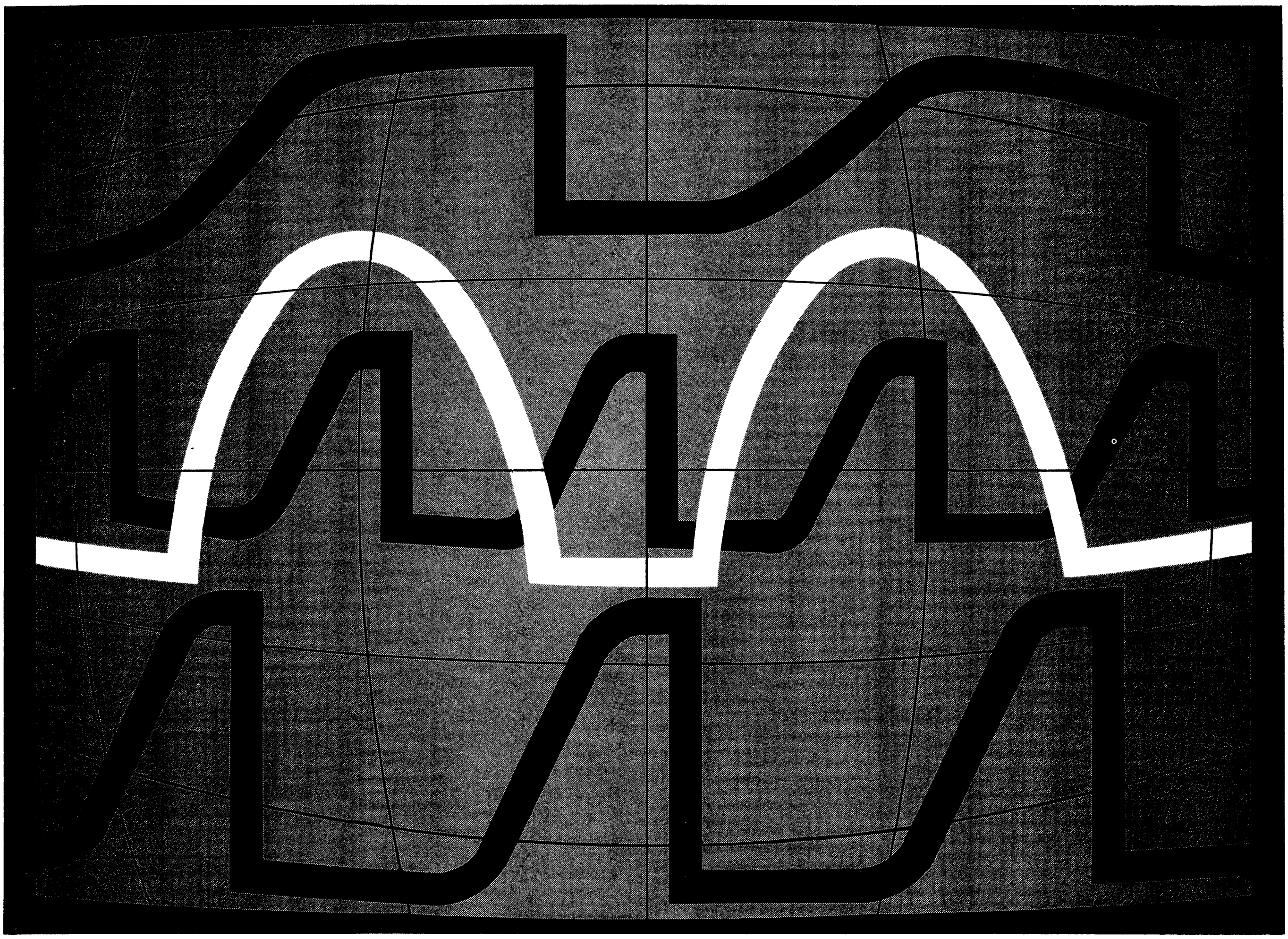

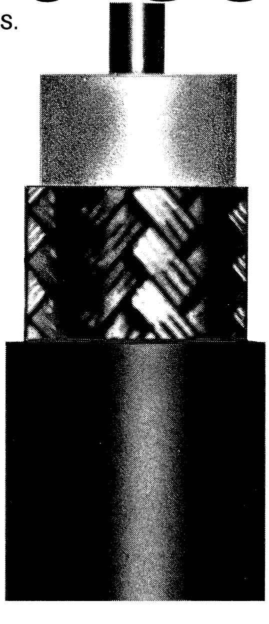

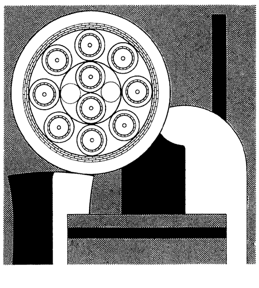

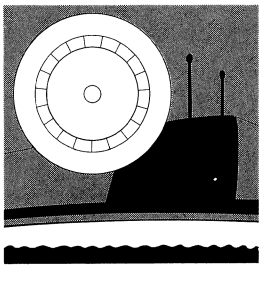

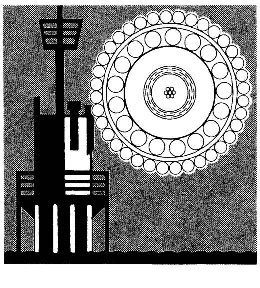

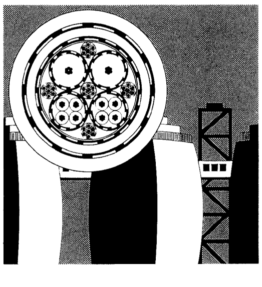

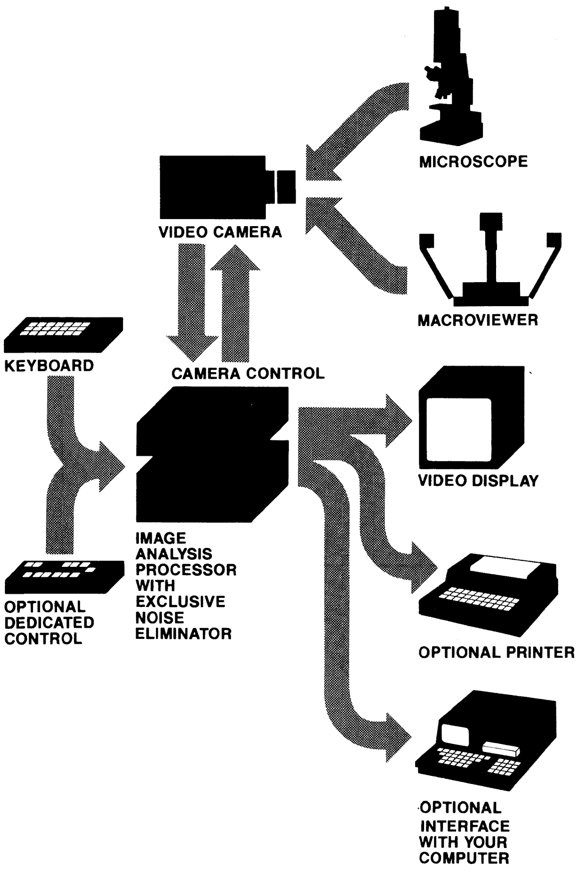
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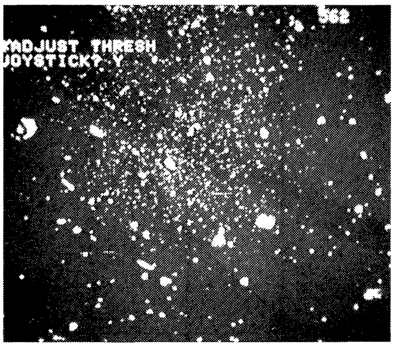
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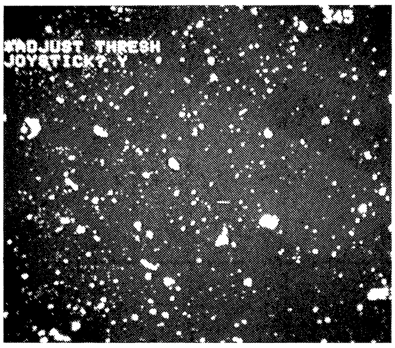
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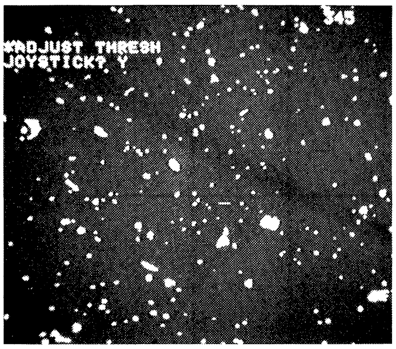
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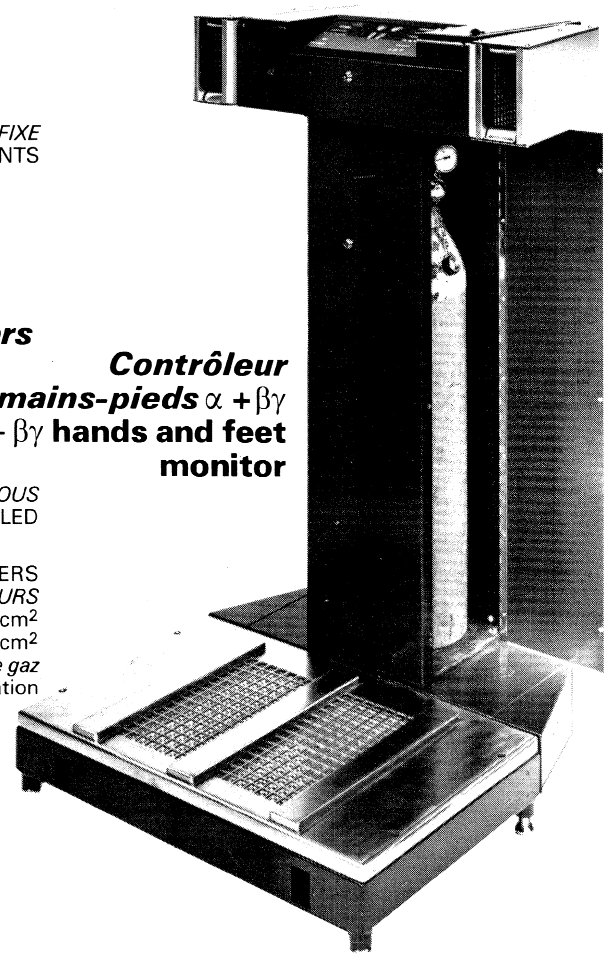

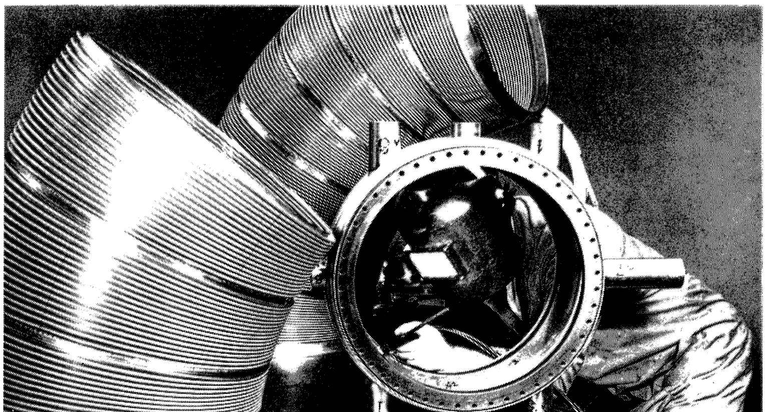

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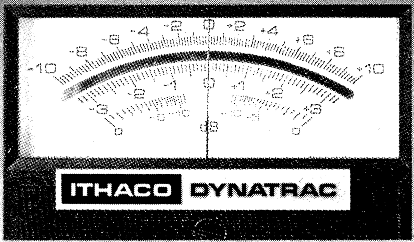

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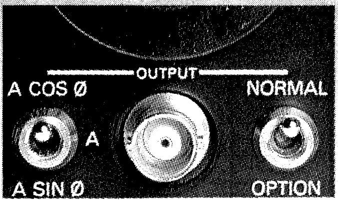

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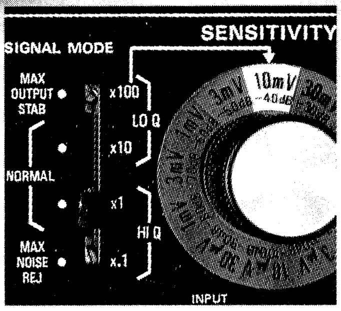

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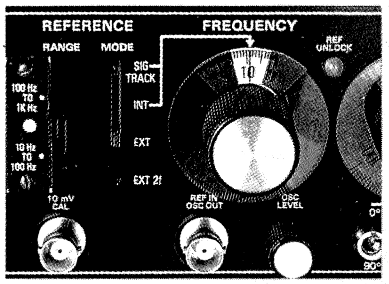

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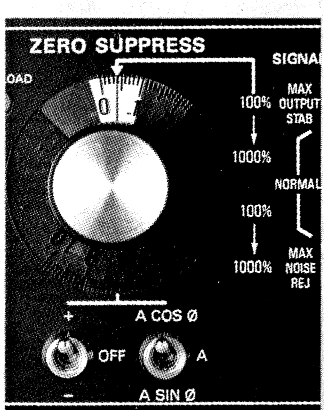

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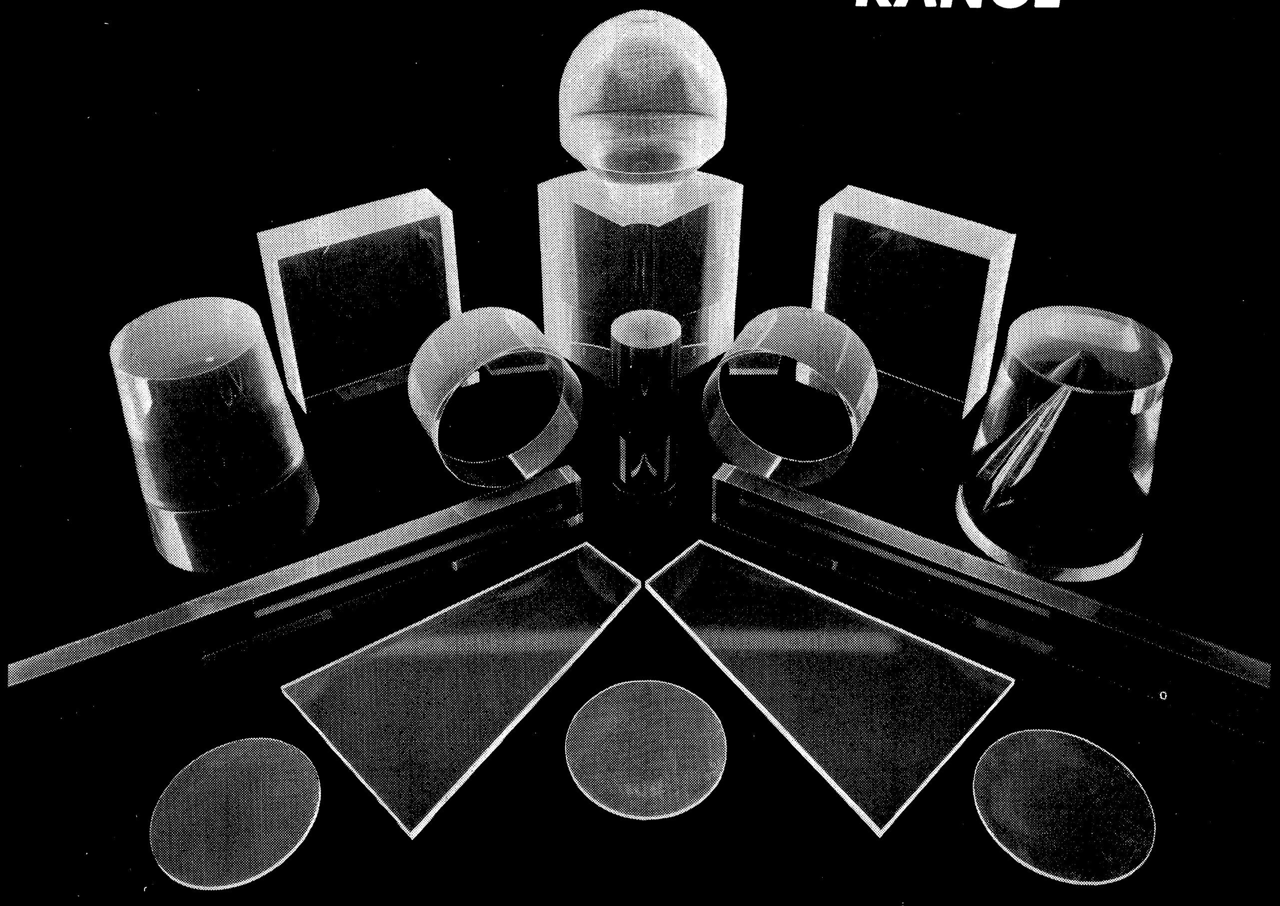

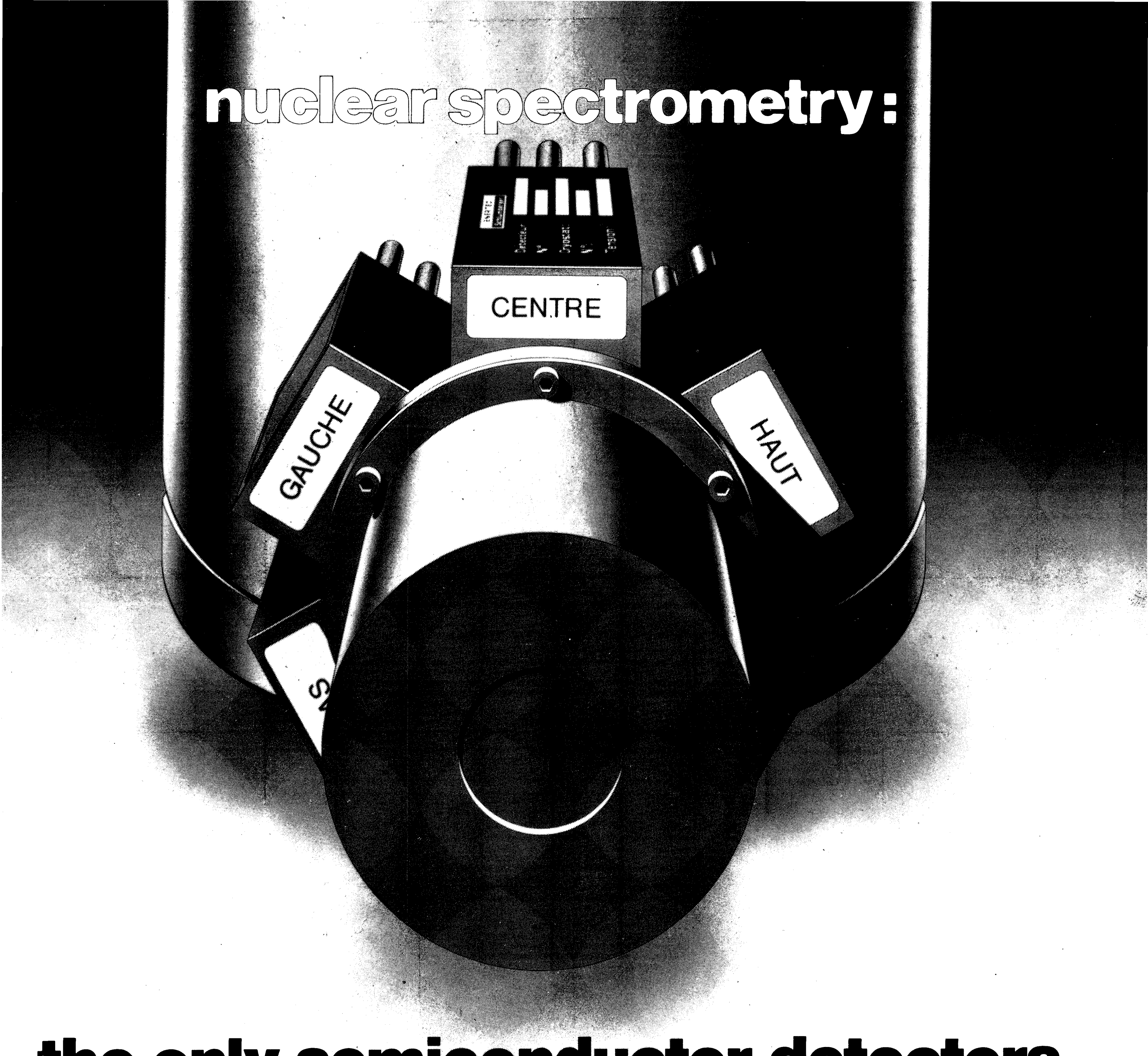
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description

During the past few months we have introduced the various elements of the new SEN Controller system: in this issue we wish to describe the software and typical applications.

The heart of the system is a powerful ***16-bit microprocessor*** (TMS 9900) associated with 16K-RAM, 2K-EPROM and TTY interface, located on a single CAMAC PC-board which is found in each of the intelligent units of the system (ACC 2099, ACC 2103 and STACC 2107).

Front-end processing in a typical problem of large CAMAC process – control and data collection systems. The ACC provides the best solution to this problem due to its processing power and easy implementation in the system – ***both hardware and software.***

On the hardware level, the ACC 2099 or ACC 2103 is compatible with all commonly used controllers – the A2 parallel controller, the L2 serial controller and the NORD 10 dedicated controller. Due to its very high density, a minimum of CAMAC space is lost to achieve front-end processing as fast as the main computer.

Software implementation is achieved by simply adding-on the front-end programs to your existing software. The front-end programs can be either assembly programs or high level programs loaded down-line through the crate controller into the ACC RAM memory, or resident in the ACC EPROM memory. Assembly programs are normally written on the host computer using cross assemblers: high-level programs in NODAL – an interpretive language with a built-in editor and assembly-written subroutine linkage – are written, either on the NORD 10 main computer using a cross-compiler*, or locally at the ACC level using an EPROM resident NODAL interpreter. Debugging facilities are available at the ACC level.

Test and stand-alone systems have the common problem of simulating the exact environment of the under-test device. Our new CAMAC controller system is able to test the device through the same controller used in the experiment and under the same software. The front-end system can be converted into a stand alone system simply by placing the CAMAC branch off-line. Test programs are loaded from a floppy disc connected directly to the ACC (ACC 2103 only). For permanent stand-alone systems, the STACC 2107 (Stand-Alone CAMAC Computer) combines the functions of a microprocessor and a controller. A floppy disc resident software is also available.

* available from CERN, div. SPS

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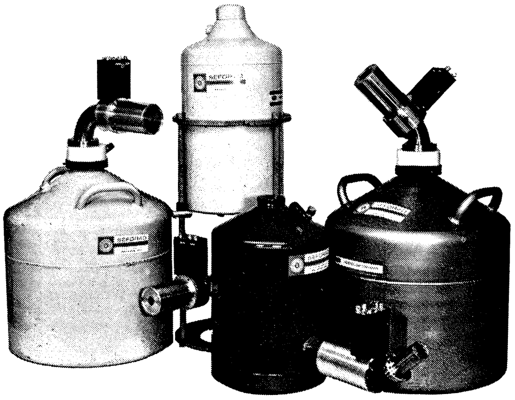

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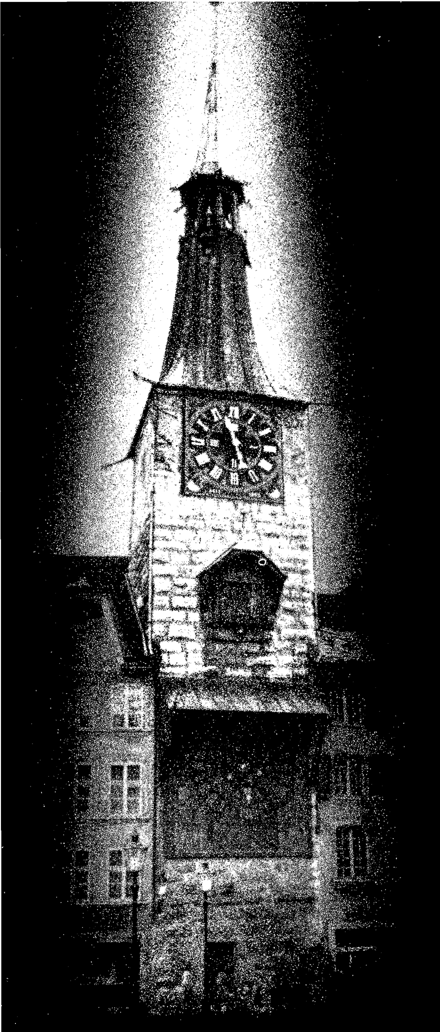


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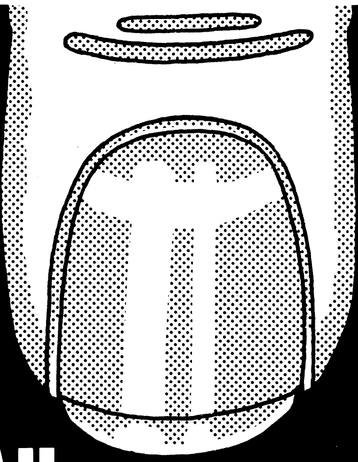

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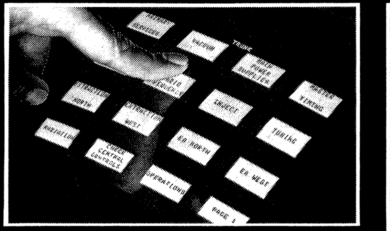
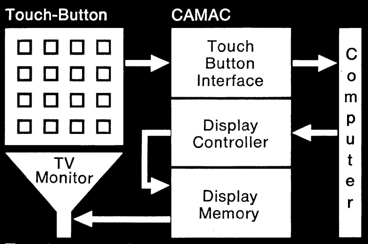
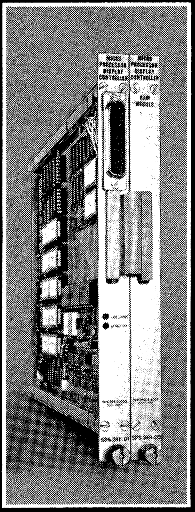


The Touch-Panel used for central control of the SPS-accelerator at CERN.



Touch-Button Control System, diagram.



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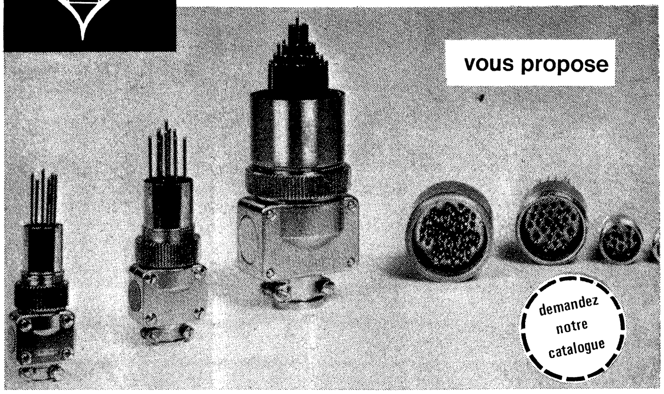

PASSAGES BASSE TENSION connecteurs JAEGER 1,5 KV/5A

hublots d'observation NIVEAU ZÉRO STANDARD AMAGNÉTIQUES

passages de thermocouples **passages de courant**

raccords tubulaires RIGIDES SOUPLES

En outre, notre activité ne se limite pas au matériel présenté ici, une équipe de techniciens se tient à votre entière disposition pour étudier toute réalisation sur plan ou toute modification du matériel standard.

The latest techniches are used.
Also we guarantee a perfect nightness.
All our production is tested with helium.
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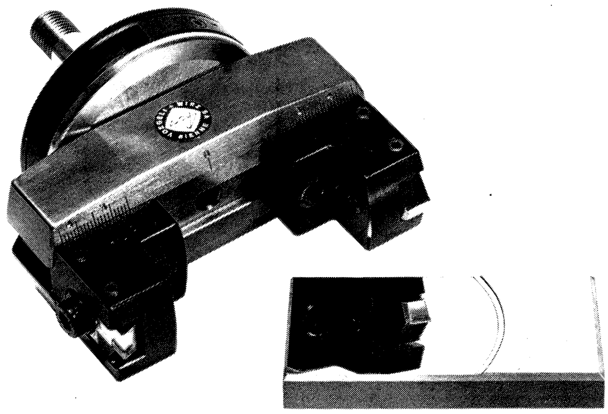

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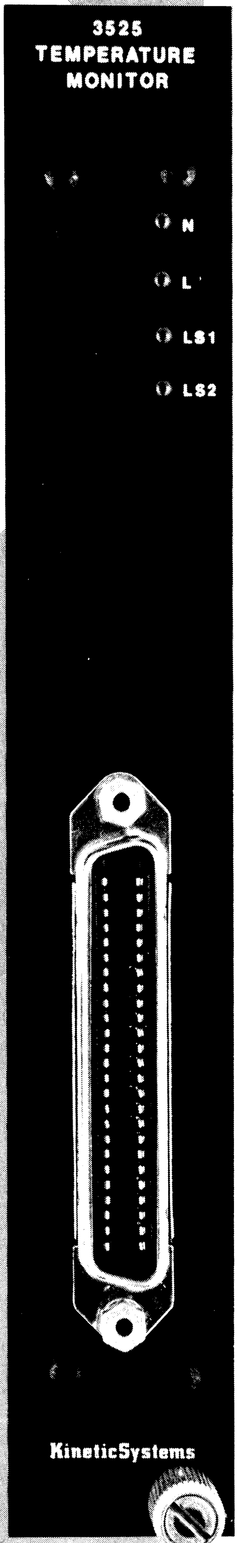
Temperature Monitoring

comes to CAMAC



OUR 3525 16-channel Temperature Monitor module is an exciting new development at KineticSystems. This module provides the interface to thermocouples without any external amplification or signal conditioning; temperatures are read on the Dataway in degrees Celsius or Fahrenheit.

Thermocouple linearization and alarm limits are provided on all channels. An on-board microprocessor controls the scanning of the inputs, calculates the temperature from the thermocouple linearization equation, and compares the current temperature to preset limits. A LAM interrupt can be set whenever any temperature is out-of-limits.

Now Available in a 16-channel Module

Features of the 3525 Module

- On-board microprocessor control
- 16 channels of differential inputs with guard per channel
- Readout via Dataway directly in degrees Celsius or Fahrenheit
- Resolution of 0.1° C.
- Accuracy of ±0.5° C. (excluding thermocouple)
- Reference junction input with optional on-board isothermal panel for direct connection of thermocouples to module
- Range of -200°C. to +760°C. with Type J thermocouple
- Optional linearization for various thermocouple types
- Can be used as general-purpose low-level monitor without linearization
- Upper and lower alarm limits for each channel written and read from Dataway
- LAM interrupt on out-of-limit temperature

Please contact us for additional information

Kinetic Systems International S.A.

the CAMAC people

Dept. CC129 * 6 Chemin de Tavernay * 1218 Geneva, Switzerland * Tel. (022) 98 44 45 * Telex 28 9622
KineticSystems Corporation * 11 Maryknoll Drive * Lockport, Illinois 60441 * Tel. 815 838 0005 * TWX 910 638 2831

Announcing...

LeCroy's new ECLine of high-density trigger logic in CAMAC

featuring...

- * Remote event simulation via CAMAC programmability
- * High-speed ECL operation
- * Reliable, simple system interconnection via inexpensive twisted pairs or flat cables
- * Low cost—ideal for large system applications
- * An expanding variety of fast logic and data acquisition units

SYSTEM MODULES

Model 4415*
16-Channel, 40 MHz Non-Updating Discriminator

Model 4416
16-Channel, 200 MHz Updating Discriminator

Model 4417
16-Channel, 200 MHz Updating Shaper/Line Repeater

Model 4504*
4-Channel, 4-Input Lookup Memory Logic Unit

Model 4508*
2-Channel, 8-Input Lookup Memory Logic Unit

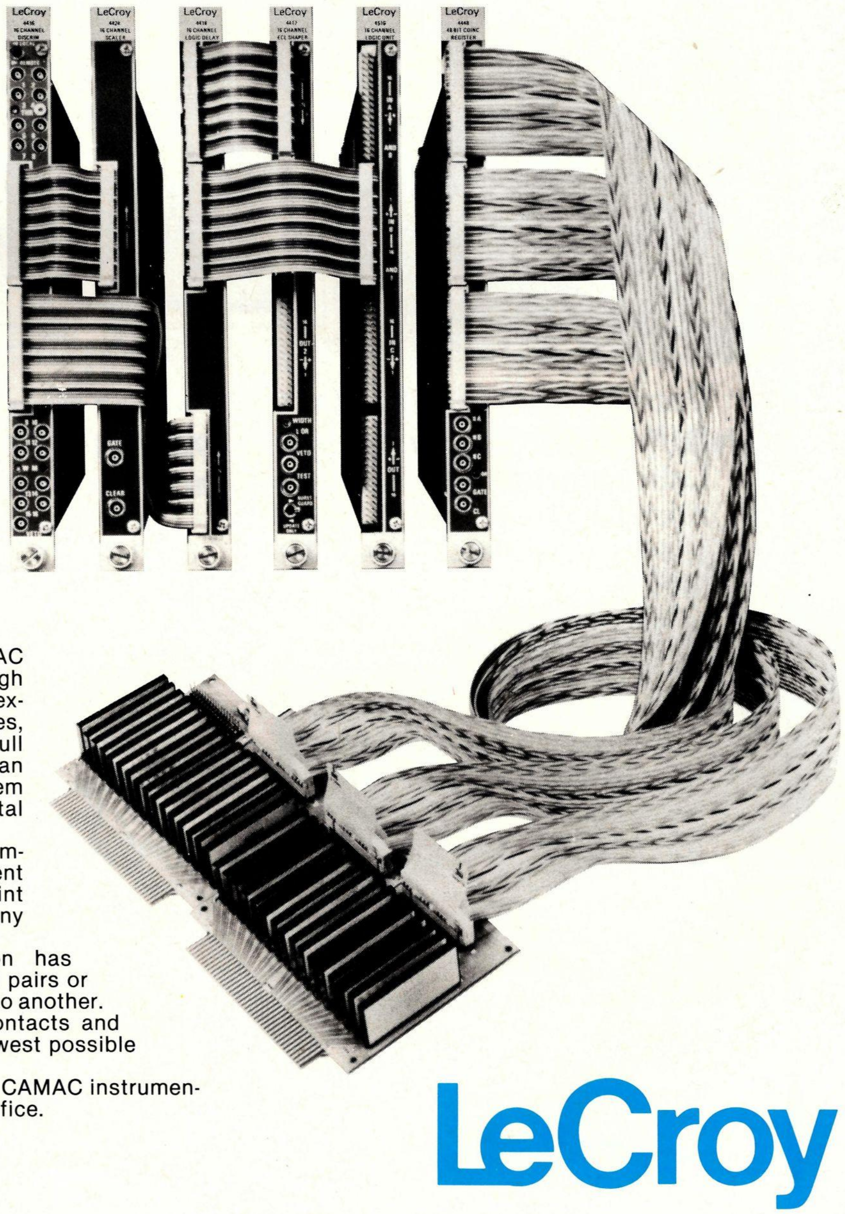
Model 4516
16-Channel, 3-Fold Logic Unit

Model 4418
16-Channel Programmble Logic Delay

Model 4424
16-Channel, 200 MHz, 24-Bit Scaler

Model 4448
48-Bit Coincidence Register/Pattern Unit

*Preview



LeCroy's new 4000 Series ECLine of CAMAC instrumentation is designed to meet the high density requirements of today's large-scale experiments. Using this new range of modules, the experimenter can not only achieve full computer control of his experiment, but can also store the complete status of his system logic on tape along with other experimental data.

ECLine offers the advantage of programmable test features, permitting convenient event simulation as well as easy point-to-point system check without the need to remove any cables.

The front-panel connector organization has been designed so that either single twisted pairs or flat cables may be used to connect one unit to another. This new technique offers very reliable contacts and minimal interconnection difficulty at the lowest possible cost.

For details on this unique new ECLine of CAMAC instrumentation contact your nearest LeCroy sales office.

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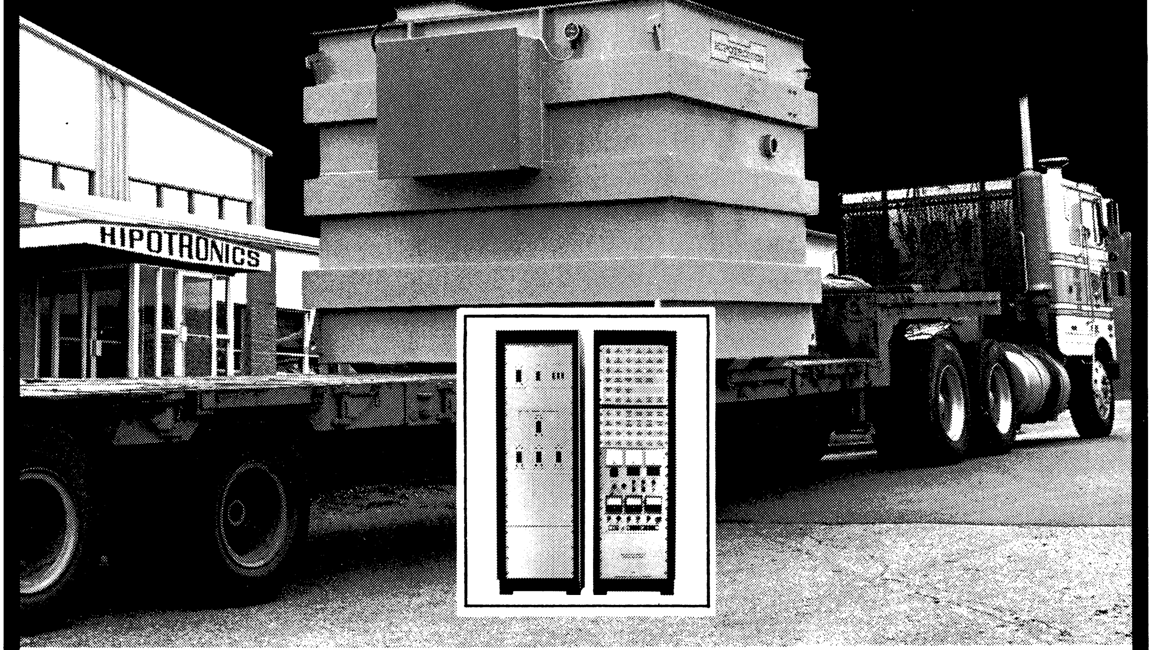
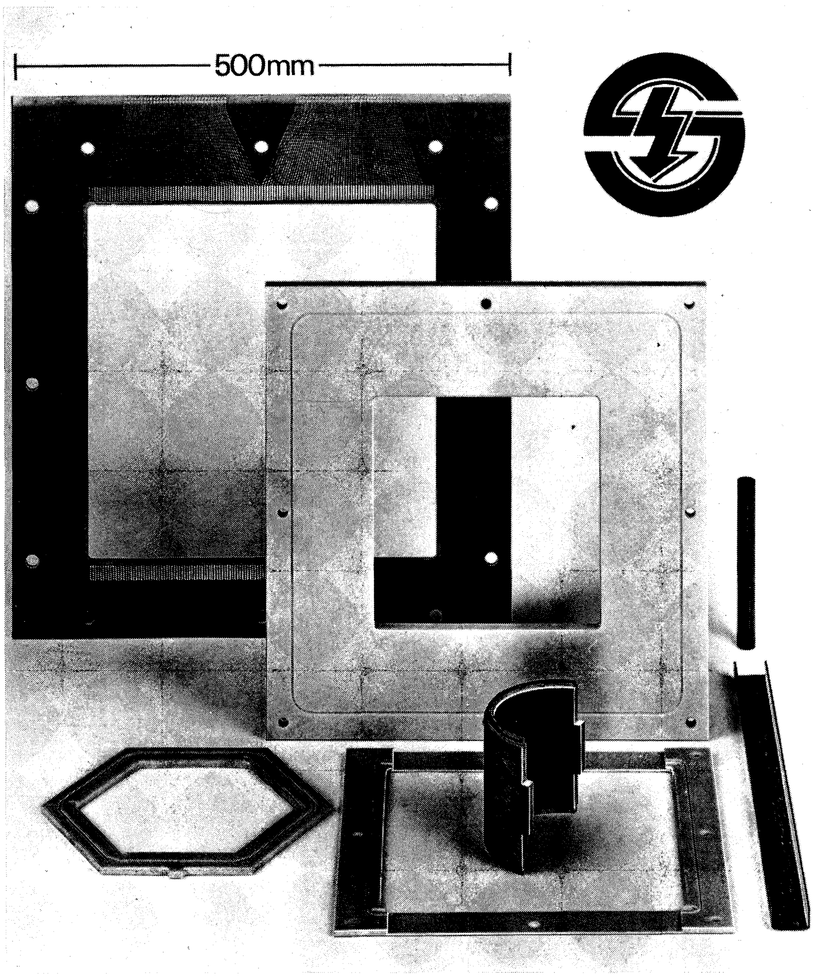
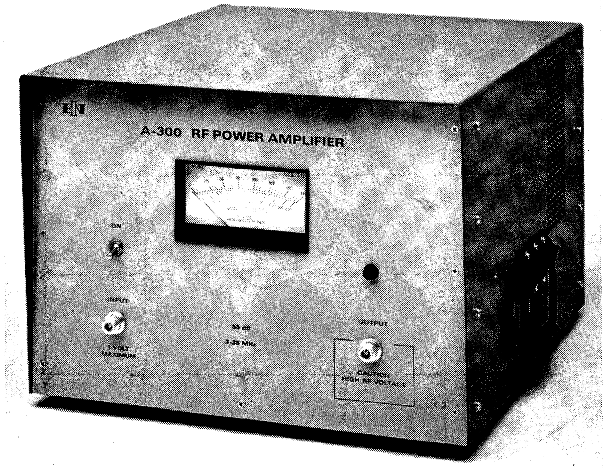

HIPOTRONICS


500mm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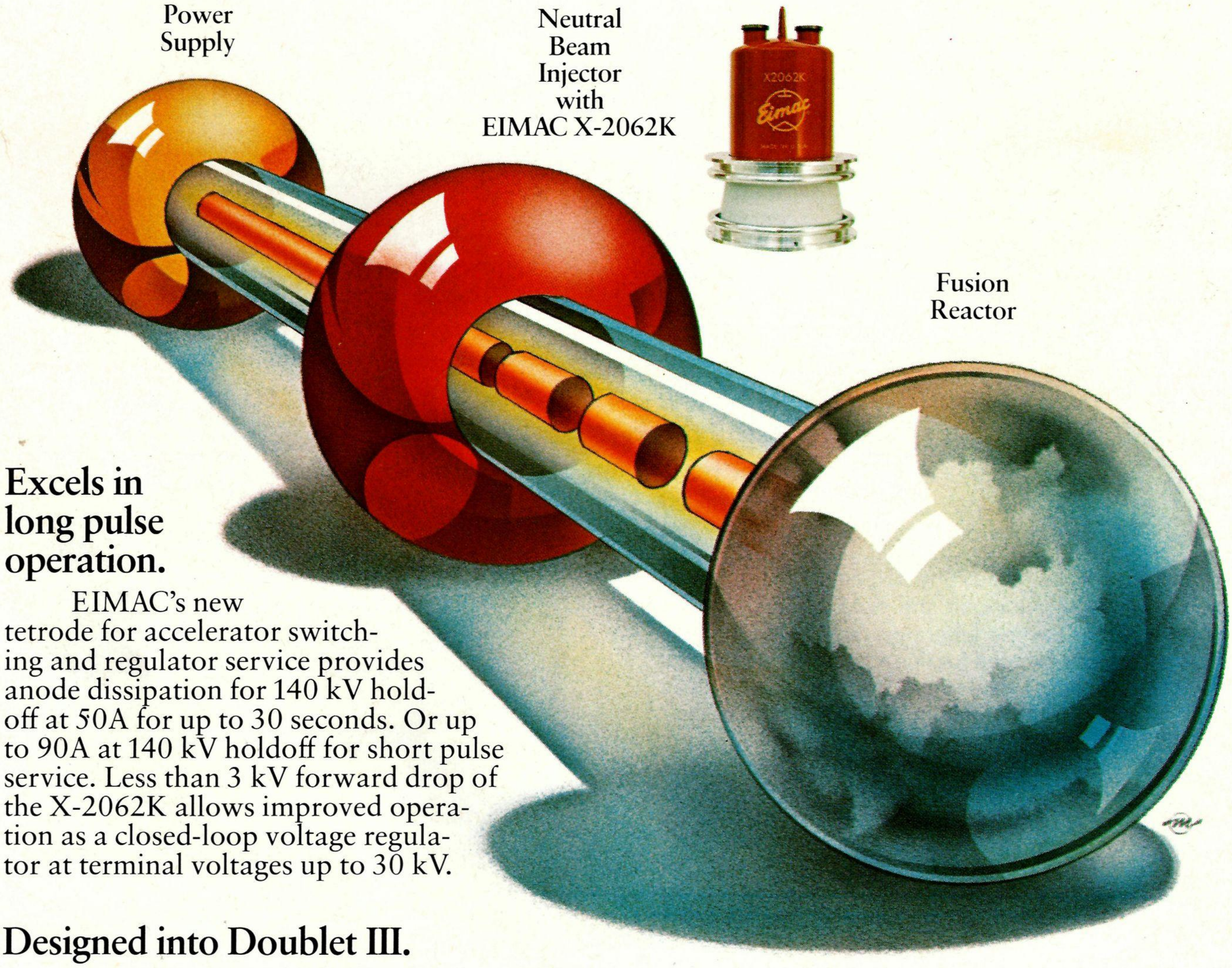
Control tomorrow's neutral beam guns with today's EIMAC X-2062K.



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Get full details on the X-2062K from Varian, EIMAC division, 301 Industrial Way, San Carlos, CA 94070. Telephone (415) 592-1221. Or contact any of the more than 30 Varian Electron Device Group Offices worldwide.