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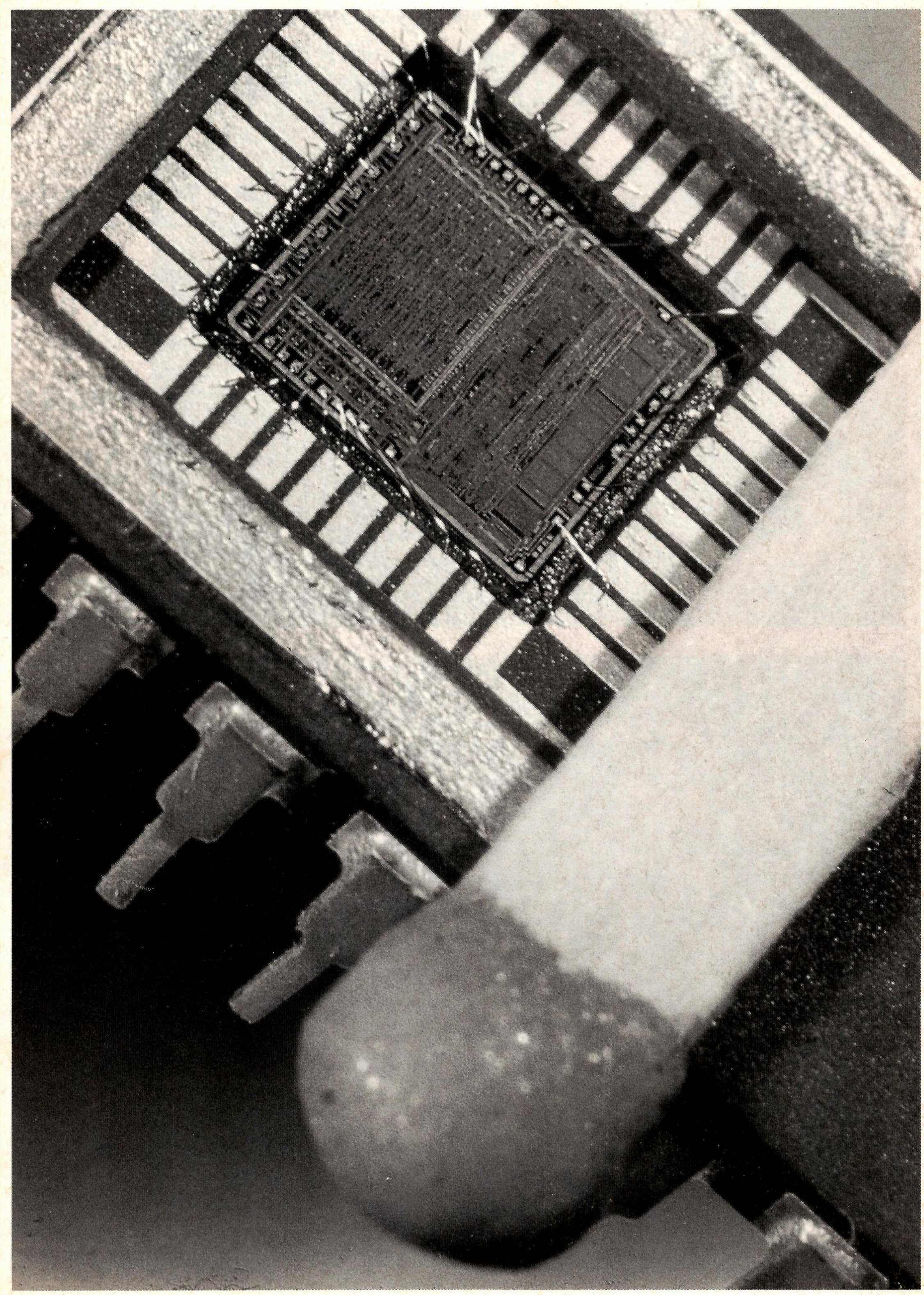

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Cover photograph: A microprocessor, seen here beside a match head. These tiny data handling units are now in widespread use in many different fields, and could soon make an impact on high energy physics — see the article on page 192. (Photo Motorola)

First beams in CESR

On Friday 13 April an electron beam was stored for the first time in the 8 GeV electron-positron ring, CESR, at Cornell. The storage ring was sufficiently complete by 1 April (the last of the ion pumps being turned on at midnight on 31 March) for electrons to be injected from the synchrotron. Thus the revised schedule, which called for injection six months earlier than the initial date of end-October, was respected with several seconds to spare!

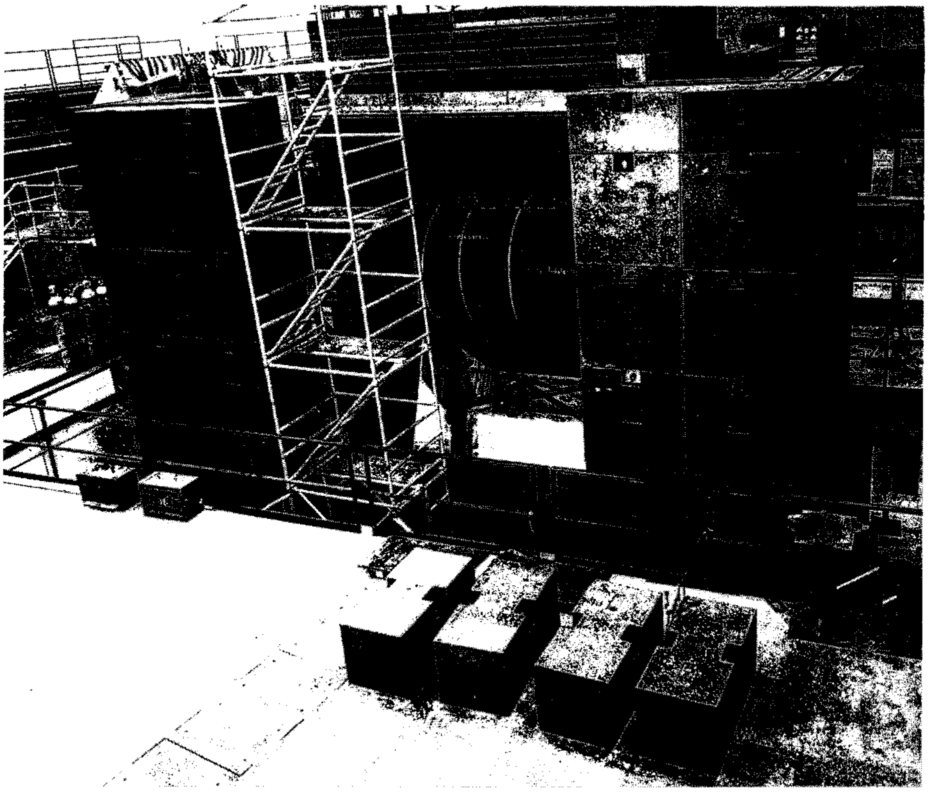
The first weekend run was limited to injection studies and coasting beams with the energy set at 5.5 GeV. On 13 April the electron beam was accelerated and stored. The tests are proceeding only at weekends to allow completion of the control and monitoring systems and of the CLEO detector, which sits at the main intersection point, and the CHESS beamline, which is to be used for synchrotron radiation research.

By the beginning of May beam was being stored with a lifetime of several minutes and intensity of a few milliamperes. The performance was limited by the pressure in the ring which was sustained by holding pumps only. The distributed ion pumps, built into the vacuum chambers, are being turned on progressively as power supplies become available.

The positron injection beamline is being completed and the crucial tests of the vernier compression scheme to build up positron beam intensity (see April issue 1976 page 129) will then begin. These tests will, of course, be much trickier than the electron injection.

It is hoped to have two stored beams and measurable luminosity in early summer so that physics in the upsilon energy region can begin.

1.

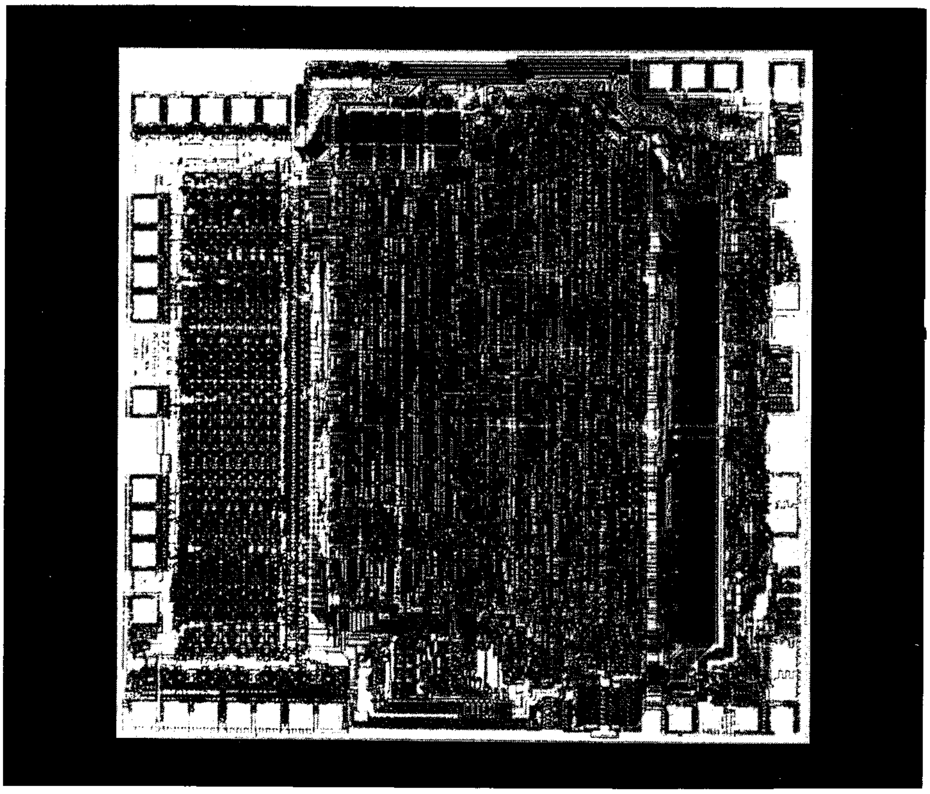


2.

1. Construction of the cylindrical drift chamber of the CLEO detector for the 8 GeV electron-positron storage ring, CESR, at Cornell. The chamber has 5304 sense wires arranged in seventeen layers.
2. CLEO being installed in the pit at the CESR intersection point. A conventional aluminium solenoid coil is in place (to be replaced later by a superconducting version) and has the assembly frame for one octant's worth of detectors below it. Mobile muon shielding doors are in the open position.

(Photos Cornell)

The microprocessor boom



Enlargement of a microprocessor (in real life just a few millimetres across). Units like these could soon make a big impact in data processing for high energy physics.

(Photo Motorola)

During the past few years, electronic circuitry techniques have been developed which enable complex logic units to be produced as tiny elements or 'chips'. These units are now mass-produced, and are available relatively cheaply to anyone building data processing equipment.

Just a few years ago, the first complete processing unit on a single chip was produced, and since then tremendous progress has been made. Now micro logic elements can be combined together to provide micro data processing systems whose capabilities in certain respects can rival those of more conventional computers. Commercially-available microcomputers are used widely in many fields.

Where an application requires special capabilities, it is preferable to take the individual micro logic units and wire them together on a printed circuit board to provide a tailor-made processing unit. If there is sufficient demand for the perfected design, the printed circuit board stage subsequently can be dispensed with and the processor can be mass-produced by large-scale integration (LSI) techniques as a single microprocessor.

With these processing units, there generally is a trade-off between speed and flexibility, the ultimate in speed being a hard-wired unit which is only capable of doing one thing. Flexibility can be achieved through programmable logic, but this affects the overall speed.

Programming micros is difficult, but one way of sidestepping these problems would be to design a unit which emulates a subset of an accessible mainframe computer. With such an emulator, programs could be developed on the main computer, and transferred to the micro after they have reached the required level of reliability. This could result in substantial savings in program development time. In addition, restricting the design to a subset of the mainframe architecture results in a dramatic reduction in cost.

High energy physics, which has already amply demonstrated its voracious appetite for computer power, could also soon cash in on this microcomputer boom and produce its own 'brand' of custom-built microprocessors.

According to Paolo Zanella, Head of CERN's Data Handling Division, now is the time to explore in depth the uses of microprocessors in high energy physics experiments. If initial projects now under way prove to be successful, the early 1980s could see microprocessors come into their own.

One of the biggest data processing tasks in any physics experiment is to sift through the collected signals from the various detecting units to reject spurious information and separate out events of interest. Therefore to increase the richness of the collected data, triggering techniques are used to activate the data collection system of an experiment only when certain criteria are met.

Even with the help of this 'hard-wired' selection, a large proportion of the accumulated data has to be thrown away, often after laborious calculations. With experiments reaching for higher energies where many more particles are produced, and at the same time searching for rarer types of interaction, physicists continually require more and more computing power.

Up till now, this demand has had to be met by bringing in more and bigger computers, both on-line at the experiments and off-line at Laboratory computer centres.

With the advent of microprocessors, a solution to this problem could be in sight. Micros could be incorporated into experimental set-ups to carry out a second level of data selection after the initial hard-wired triggering — an example of the so-called 'distributed processing' approach where computing power is placed as far upstream as possible in the data handling process. In this way the demand on the downstream central computer would be reduced, and the richness of the data sample increased.

The micros would filter the readout in the few microseconds before the data is transferred to the experimental data collection system. Zanella is convinced that this could significantly improve the quality of the data and reduce the subsequent off-line processing effort to eliminate bad triggers.

As well as being used in the data collection system, micros would also be useful for control and monitoring functions, where their use is already common wherever routine process control is important. The use of off-the-shelf microcomputers in accelerator control systems, for example, is already relatively widespread.

Some limited applications outside the control area are already being made in experiments, a notable example being the CERN/Copenhagen / Lund / Rutherford experiment now being assembled at the CERN Intersecting Storage Rings (see April issue, page 65).

Microcomputer projects are now being tackled at several Laboratories. At CERN three projects are under way in the Data Handling Division. Two of these are programmable emulators (one being based on the IBM 370/168 and the other on the Digital Equipment PDP-11), while the third is a very fast microprogrammable unit called ESOP.

High energy physics has still a lot to learn about microprocessor applications, and there is some way to go before their feasibility is demonstrated and practical problems, such as programming, are overcome.

However this year could see some of these initial projects come to fruition, and the early 1980s could live up to Zanella's expectations as the time when the microprocessor becomes a routine part of the high energy physicists' toolkit.

Around the Laboratories

CERN
First CHARM results

The second experiment lined up in the CERN neutrino beam (after the CERN / Dortmund / Heidelberg / Saclay detector) is the 'CHARM' experiment — the handy acronym coming from the CERN/Hamburg/ Amsterdam / Rome / Moscow collaboration with blatant disregard for alphabetical order.

The major design aim of the experiment is to study the structure of the nucleon as revealed by the weak neutral current. In these interactions the incoming neutrinos scatter elastically off the component quarks without changing their flavour. Unlike charged current interactions, the outgoing lepton cannot be detected, and additional information is required to fix momentum transfer.

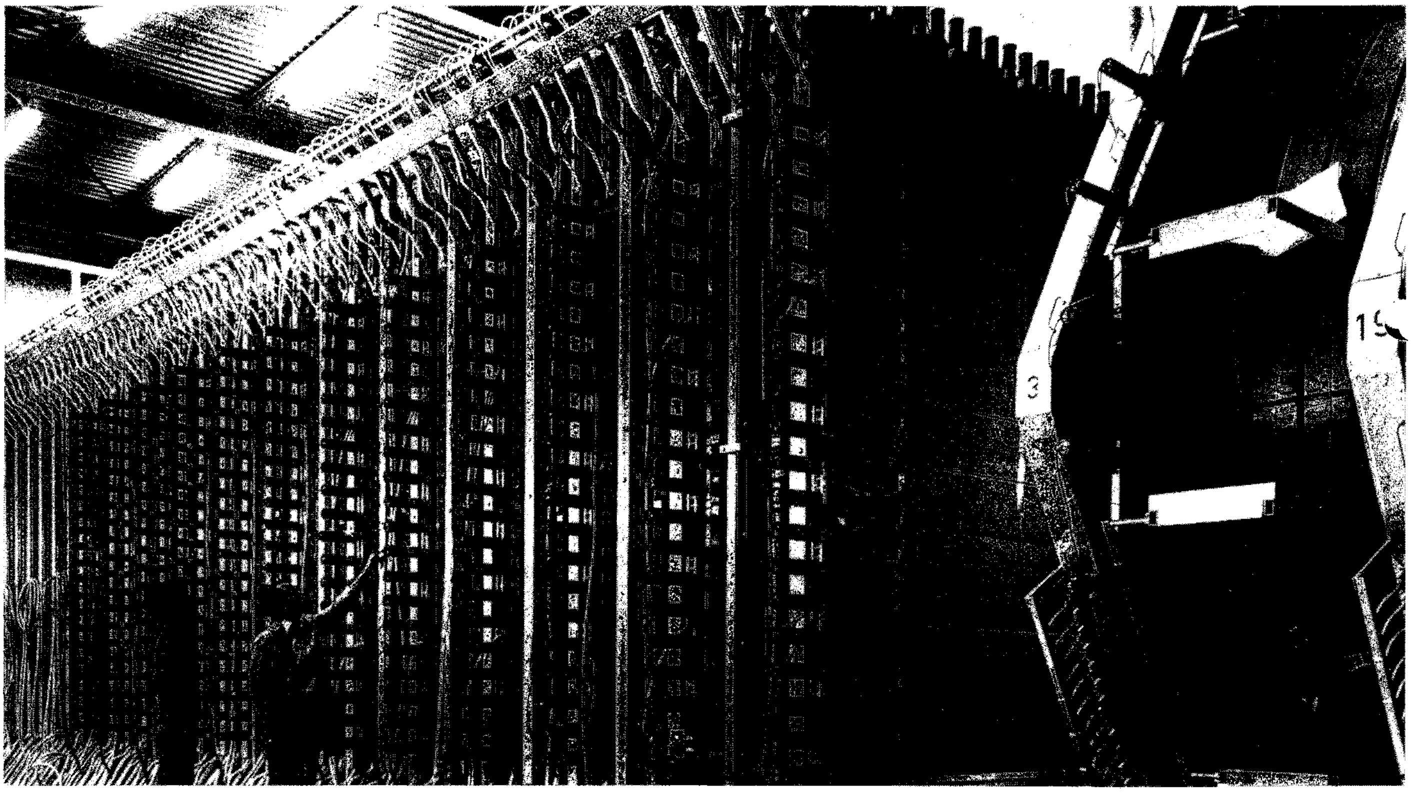
While in charged current interactions it is sufficient to measure just the energy of the produced hadron shower, neutral current studies also require the direction of the hadron shower to be determined.

The CHARM detector thus combines the features of traditional hadron calorimeter with a fine-grained matrix of scintillation counters and specially-developed drift tubes to enable the development of the hadron showers to be studied.

The 25 metre-long detector is built up of modules, each 4 m square and containing a 3 m square marble target slab of thickness 8 cm. Between these modules are 12 cm gaps filled with 20 scintillation counters and 3 cm square drift tubes. Each target plate is surrounded by a magnetized iron frame, and the whole assembly is backed by a magnetized iron calorimeter.

This arrangement enables the experimenters to follow the flow of hadronic energy, and in effect combines traditional calorimeter and visual detection techniques. As neutral hadronic particles can be detected, the technique has an advantage over bubble chamber experiments where normally only charged particles can be traced and the effect of neutrals has to be estimated.

In principle, the neutral current reacts differently with up (u) and



Apparatus of the 'CHARM' (CERN/Hamburg/Amsterdam/Rome/Moscow) collaboration in the neutrino beam at the CERN SPS, now producing the first in what promises to be a fruitful series of results. On the right can be seen the downstream end of the CERN/Dortmund/Heidelberg/Saclay detector. For measurements on muon polarization, these two mighty detectors join forces.

(Photo CERN 105.7.78)

down (d) type quarks, but this isospin dependence is not yet known. This problem is sidestepped in CHARM through the use of marble target slabs, which contain even-even nuclei and so have equal numbers of u and d quarks. Marble was selected as the cheapest such target material which would also allow muon polarization measurements.

First CHARM results, from a run last autumn, show that the nucleon structure functions as measured by neutral currents are similar to those measured in charged current interactions. More data should be available soon and should give the spectra which show how the neutral current transfers energy to the target quarks (the so-called y-distributions), and comparison of these spectra with those of the charged current could provide new information on the neutral current.

The CHARM techniques of energy flow measurement are also useful in muon studies as they allow the so-called 'leading muon' — the muon produced directly by the incident neutrino — to be readily separated from additional muons emerging subsequently from the hadron shower.

As well as studying the hadron showers produced in neutral current interactions, the apparatus can also be used to look at the purely leptonic process of neutrino-electron scattering, where the recoil electron produces an electromagnetic shower close to the direction of the incident neutrino.

Preliminary results on electron-neutrino scattering are in good agreement with the world average value for the 'Weinberg' mixing angle, and show well how this difficult experiment can be handled using an electronic calorimeter. Again further data will be available soon.

Another important result comes from the combined use of the CHARM detector and the 1200 ton iron target-calorimeter of the CERN/Dortmund / Heidelberg / Saclay (CDHS) experiment immediately upstream. This combined experiment with 36 metres of equipment installed in the neutrino beam must surely rate as one of the biggest assemblies of scientific equipment ever used in a single experiment.

The idea is to measure the polarization of the muons produced by high energy charged current interactions in the CDHS detector to ascertain whether the spin effects of weak interactions at GeV energies are the same as those known for twenty-five years in beta decay and other low energy weak phenomena where the emergent lepton carries the same 'handedness' as the incident neutrino.

First results are averaged over the angular and energy distributions of the emergent muons and show that the conventional picture of spin effects in weak interactions is still good — the first time that lepton polarizations have been studied at these energies.

Further progress lies in carrying out sensitive tests of the conservation of handedness in situations where kinematics alone says that the probability of conserved handedness is strongly suppressed and where on the contrary the probability of changing the handedness is enhanced. This occurs when the muon produced by an antineutrino comes off backwards and all energy is transferred to the target quark.

With this list of results already available from preliminary runs, the signs are that CHARM will go on to be a prolific experiment.

Polarized targets from ammonia

Ammonia contains some 18 per cent of hydrogen, more than that found in propanediol and butanol, the commonly used polarized target materials. This, together with its relatively high solid density, means that ammonia has considerable potential advantages for polarized target experiments, but previous attempts to prepare polarized ammonia samples have encountered problems.

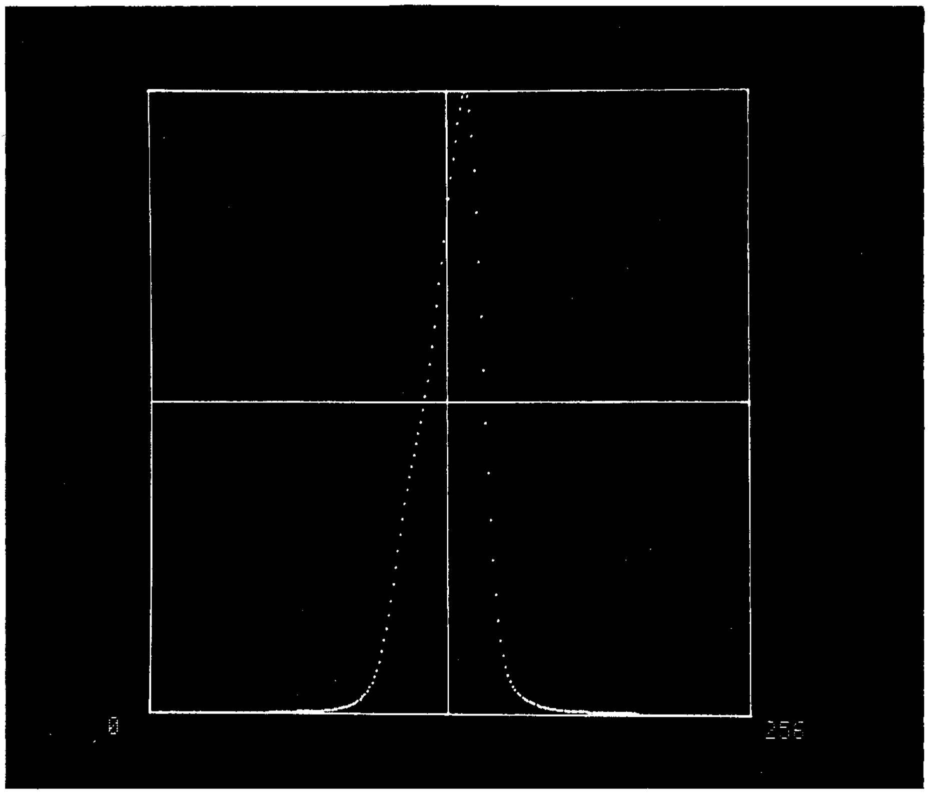
Now a new technique developed at CERN has shown that the chemical radicals produced by intense irradiation can produce proton polarizations in ammonia of over 90 per cent, comparable to those obtained with propanediol. This, together with the intrinsic advantages of solid ammonia as a polarized target material and its resistance to radiation damage, could provide target materials considerably more effective than those in common use.

At CERN, 2 mm diameter solid ammonia beads were exposed to a 580 MeV proton beam from the synchro-cyclotron (SC) with 10^{15} protons per cm^2, considerably in excess of what any polarized target has been exposed to so far.

The beads were held in liquid nitrogen both during the irradiation and during their transfer to the dilution refrigerator of the target. Normally radicals react very quickly, but at these temperatures the new radicals produced by the irradiation are relatively inert, and their physical properties can be exploited for dynamic polarization.

Analysis of the samples by electron spin resonance shows the presence of these radicals, and it seems feasible that the radical concentration could be increased significantly before unwanted chemical destruction occurs.

If this can be achieved, the homogeneity of the sample and its increased resistance to radiation could result in polarized targets many times more effective than those now in use. Further progress lies in finding the optimum method of irradiation and subsequent treatment of the ammonia to produce the best polarization results.



A new technique developed at CERN has shown how significant proton polarizations can be produced in solid ammonia. Shown here is the NMR absorbtion line corresponding to a polarization level of 90 per cent. The asymmetry, observed for the first time, shows that the polarization is indeed produced in the solid ammonia, and confirms that in previous work, the observed polarization was mainly due to the doping material.

Recent aerial view of the Brookhaven site with Long Island Sound in the background. Beyond the AGS ring and experimental areas can be seen the freshly cleared hexagon in the forest where the 400 GeV proton storage rings ISABELLE will be built.

(Photo Brookhaven)

TRIUMF
Single turns extracted at 200 MeV

A demonstration that single turns can be extracted from the cyclotron at 200 MeV with less than 200 keV energy spread marks a major milestone in TRIUMF's programme to provide proton beams of improved energy resolution.

Ordinarily the internal beam diameter is larger than the turn separation at extraction energies, so protons are extracted from several adjoining turns. With an energy gain of about 0.3 MeV per turn the 'unimproved' energy spread is typically 1 MeV. During the past year the commissioning of the internal slit system, together with improvements in r.f. and magnet stability, have enabled individual turns to be kept separate out to energies high enough for extraction (over 180 MeV). In January clear evidence was obtained that proton beams were being extracted from single turns at 200 MeV. Their energy spread has now been measured as 173 ± 12 keV in agreement with expectations.

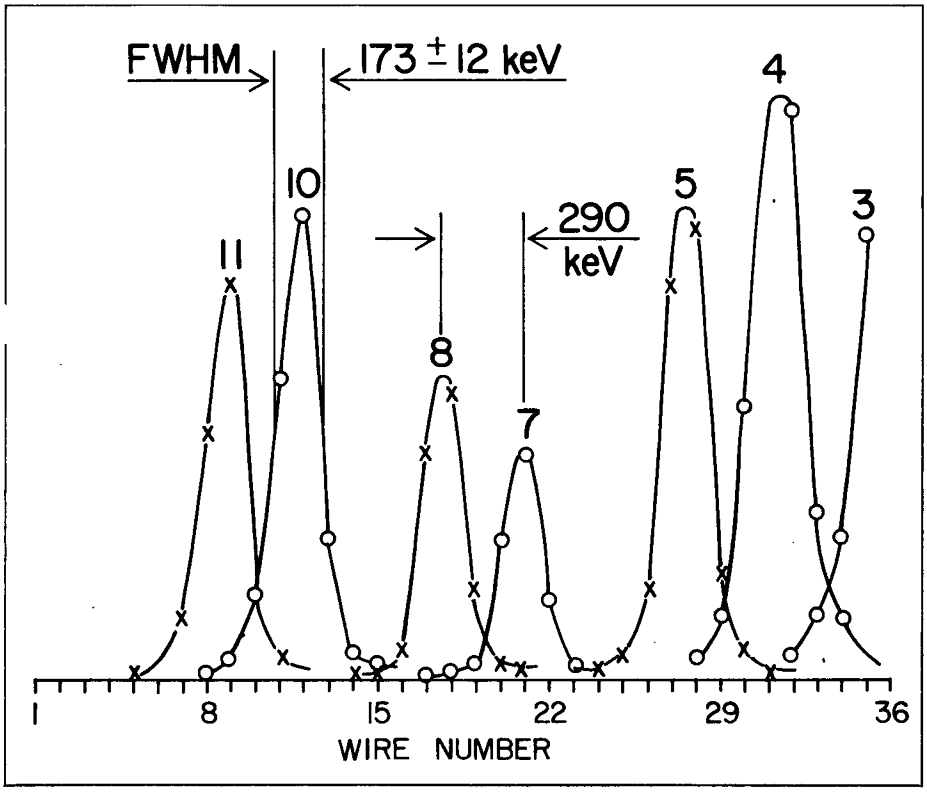
The drive towards high energy resolution proton beams is in support of TRIUMF's role as a variable energy proton factory (as well as a meson factory). At present it is the only accelerator producing protons directly over the energy range 180 to 520 MeV (without degradation over all but the lowest end of the range). The eventual aim is to provide beams with an energy spread below 100 keV throughout this range.

In the study of proton-induced nuclear reactions, improvements in energy resolution will make it possible to identify reaction products from many more individual excited states. The first customers for a 200 keV (polarized) beam at 200 MeV will be a British Columbia group studying pion production from light nucl near threshold (see March issue 1978, page 66).

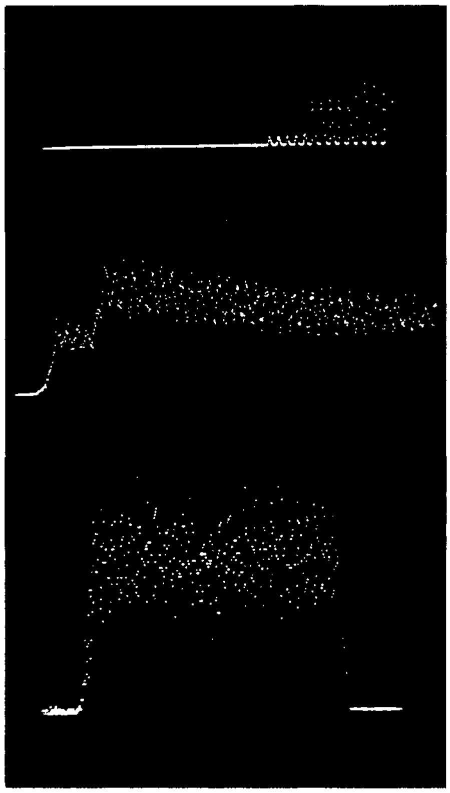
To achieve separated turns at high energies requires small radial emittance of the beam and also small energy spread; there must therefore be phase selection and good energy stability. The radial emittance is selected by 1.5 mm slits separated by a quarter of a radial betatron oscillation (about eight turns); they are positioned near 30 MeV, beyond the region where a resonance can induce radial oscillations. The regular phase acceptance (about 40°) is cut down successively by a radial flag on the first turn (about 15°), an inner slit at 3 MeV (about 10°), and the outer slits at 30 MeV (about 4°).

To keep the energy (and therefore

Energy spectra of seven single turns extracted individually from the TRIUMF cyclotron at 200 MeV. The spectrum was taken using a multiwire profile monitor located at a dispersed focus. Note the excellent energy resolution of 173 keV.



Time spectra showing the leading edges of the pulse trains at 200 MeV extracted from one turn (bottom), two turns (middle) and three turns (top). Each step in the spectra is one orbital period long and consists of five bunches separated by the 43 ns r.f. period.



radius) of each turn stable requires high stability both in the r.f. and in the magnetic field. The field is stable to × 10^{-6} but fluctuations in dee voltage have been harder to control. Because the accelerating gap is 15 m long, the dees were constructed from eighty separate quarter wave cavities (0.75 m by 3 m), rather loosely coupled mechanically. As a result, vibrations induced in each cavity by the flow of cooling water produced rather independent voltage fluctuations. With the help of mechanical dampers and feedback from a number of strategically placed r.f. probes, an effective dee voltage stability of 6×10^{-4} had been achieved by 1978. This, plus the commissioning of the slit system, made it possible to observe marginally separated turns at 200 MeV in July 1978.

During a six week shutdown at the end of the last year, the mechanical coupling between the individual accelerating cavities was strengthened. This gave a four-fold improvement in r.f. stability and in January it was possible to produce clearly separated turns at 200 MeV and the first firm evidence of the extraction of single turns.

The energy spread of the extracted single turns has now also been measured by setting up a dispersed tune and observing the beam on a multiwire profile monitor. Spots from seven neighbouring turns were observed and showed an energy spread of 173 ± 12 keV. The raw width at 90% maximum was about 360 keV; corrections for imperfections in the focus amount to about 50 keV, bringing the base width into line with the measured energy gain per turn, 290 keV.

To achieve the aim of separated turns and 100 keV energy spread at 500 MeV, stability in magnetic field fluctuations must be improved by a factor of three. The plan is to make the r.f. frequency follow the field, which will be monitored by an NMR system with better than 1 ppm resolution. To obtain good intensity (about 1 µA) for this highly selected beam at 500 MeV, it is also planned to install third harmonic r.f. flat-topping.

The instensity of the present 200 MeV high resolution beam is about 1 % of that of unselected beam (and quite usable) but at 500 MeV the selection is much more severe. Tests at signal level were carried out in 1978 and showed that the accelerating cavities will accept power efficiently at the fundamental and at three times higher frequency simultaneously. Work on the full-power system is progressing and third harmonic tests are planned for the end of 1979.

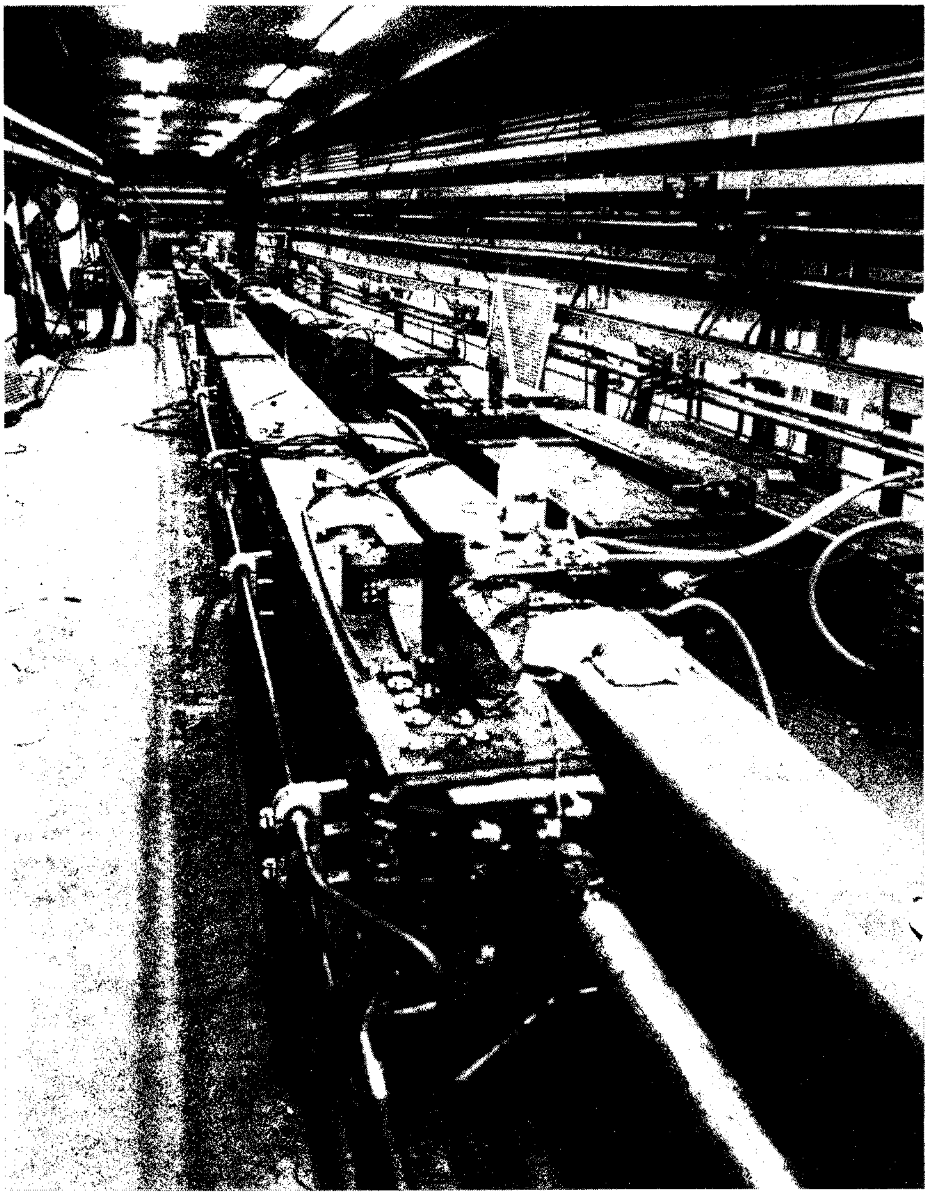
FERMILAB
Operation resumes in Meson Area

In late May the Meson Area at Fermilab came out of an eight month pause during which major improvements were carried out and preparations made for future 1000 GeV Tevatron beams.

The target train was completely rebuilt to accommodate independent targetting for the M1/2/3/4 and M5/6 complexes. Provisions were made to raise the momentum of the M6 beam to 400 GeV using a superconducting front end. Extensive alterations were made on the M1 tunnel for high intensity operation. M2 is coming into action first for a lambda beta-decay experiment, followed by M3 for the study of pi-mu atoms. M1 follows and by late June M6 should be superconducting.

The new projects grew out of user workshops held early in 1978. They were further developed to maximize both short term goals in the Meson Department as well as future Tevatron plans, and work over the next few years will make 1000 GeV Tevatron operation possible. These efforts have been led by Ernie Malamud and Tim Toohig.

Flexibility has always been high in the Meson Area. Originally designed for 200 GeV operation, it has been upgraded to match the accelerator performance, reaching 300 GeV in 1973 and 400 GeV in 1975. Intensity increases have been achieved in all beamlines and energy increases in most. One beamline, M4, has been converted from neutral to charged operation. In the past this flexibility of the area has allowed small and medium sized experiments to be mounted rapidly. A great deal of physics, involving many user groups, has been done.



The Fermilab Meson Front End Hall looking upstream towards the production target. The M1 beam is on the left.

(Photo Fermilab)

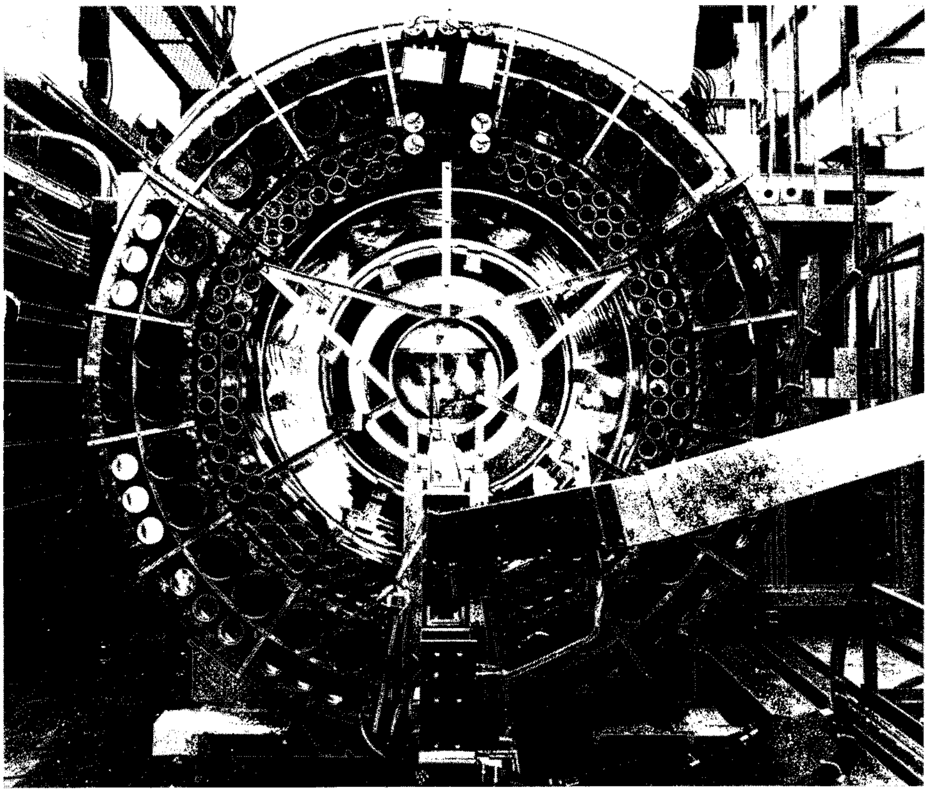
There continues to be a demand for higher intensity in the Meson Laboratory beams. One of the most direct ways to achieve this is to collect the secondary beam particles at very small angles relative to the proton beam. The original Meson Laboratory design employed one primary proton beam to illuminate a single production target. Characteristic angles for the secondary beams relative to the primary beam were two or three milliradians.

Present state of the art of beam targetting technology permits operation at much smaller angles. In the last year, it has been possible to vary the angle of the incident beam on the production target. However, this arrangement tended to favour one or the other of the secondary beams.

Under the new arrangement, the Meson Laboratory primary proton beam is split 1500 feet upstream of

The recoil calorimeter for the new Tagged Photon Spectrometer is shown during assembly in the Fermilab Tagged Proton Laboratory. The device was built at the University of Toronto and consists of four concentric layers of segmented scintillation counters. The outer two rings seen here are filled with liquid scintillator and are about 6 feet in diameter. Three cylindrical proportional wire chambers and a liquid hydrogen target will fill the inner volume of the calorimeter. The detector will be used to measure the energy and angle of recoiling protons in photon-proton interactions. In association with a new trigger processing system, it will allow triggering of the spectrometer based on the forward-going 'missing mass' which will be computed in real time for the recoil proton parameters.

(Photo Fermilab)



the target with electrostatic septa. Lambertsons following this septa separate the two beams by 14 inches at the production targets.

The switchyard group in the Accelerator Division at Fermilab and the Meson Department have teamed together to provide this splitting system. Five hundred feet of special, pre-cast four-foot diameter concrete pipe had to be installed just upstream of the target station to house the diverging beams. In addition, a new target train for the Meson Laboratory was built to accommodate two independent primary beams and targets, and new lines for the secondary particle beams diverging from them. Each of the two primary beams is now equipped with independent focussing and steering elements as well as angle varying systems capable of three milliradian swings horizontally. Both target systems will handle up to 10^{13} protons per pulse. Provision has been made for a third independent primary proton beam to be installed in the future.

One of the significant improvements is an M6 beam with double its original energy. The new beam makes it to 400 GeV by incorporating three energy doubler dipoles in the first major bend. These twenty-two foot dipoles are now installed in the beamline and have been cooled down. Four hundred GeV operation requires that these magnets run at 39 kilogauss.

To accommodate the 400 GeV optics, it has been necessary to more tightly couple the quadrupoles so that they are now in doublet clusters rather than the original stretched out triplet geometry. This new optical arrangement maintains the acceptance of the beam at some loss in momentum resolution. This loss is not particularly significant since the precision single arm spectrometer is no longer being used in M6 east.

The 200 GeV M6 beam had been designed for high resolution. The beamline contains an extended parallel section for differential Cherenkov counters. When M1 is converted to very high intensity pion operation, M6 may be the only tagged beam available in the Laboratory. Thus, designs have been devised for 400 GeV operation to preserve these properties.

The development of the three magnet string of Energy Doubler magnets and the accompanying pair of CTI 1400 liquefiers has shed a great deal of light on what is needed for operation of superconducting magnets in the experimental areas. This system can now be reproduced and installed at other major bend points throughout the Meson area as necessary. While the superconducting operation provides a major boost in beam energy, it also should substantially reduce the power usage for the beam.

For the present, only the West branch of M6 will be able to operate to 400 GeV. More superconducting installations will be required to bring the East branch up to that energy. The large multiparticle spectrometer at the end of the West branch of the M6 beam has also been extensively upgraded in anticipation of high transverse momentum jet studies at high energy and searches for other spectrometer applications.

During the Pause, work in M1 concentrated on opening out the beamline passage so that it could accommodate future installations. It is anticipated that the development of the M1 beam will proceed in stages. One stage would be to permit the transport of the primary beam directly to experiments in the Detector Building. Another stage would be to produce a high intensity pion beam using a target station about 500 feet from the present primary target point along with highly corrected optics to achieve an extremely small spot size at a final focus in the Detector Building. A third stage would be to convert all bend points and possibly the quadrupoles to superconducting magnets and thereby raise the energy to Tevatron levels. Some designs for an upgraded M1 have fifty microsteradian percent in acceptance.

The aperture for the M3 neutral beamline has been increased for two hundred and sixty feet in the downstream portion to 36 inch diameter. This has permitted the development of an improved intense neutral beam to be used principally for kaon studies. Extensive civil excavation in the Meson Laboratory berm was required to open up the beam pipe.

The Meson Department has been very successful in pushing this large improvement program in the face of financial problems. In the face of these difficulties the Meson Department has been able to turn a problem into a remarkably successful improvement opportunity.

Fast neutron therapy

Work on fast neutron radiation therapy at Fermilab began in 1974 with clinical research going on in parallel to the basic physics programme. In the facility, a pulsed bending magnet extracts a 66 MeV proton beam from the linac between tanks 4 and 5 using protons not needed to fill the accelerator. Two years of construction followed by radiobiology studies gave sufficient information on the neutron beam to allow patient treatment to begin in September 1976.

A total of 424 patients have been referred to the facility either for pilot studies, or for critical evaluations in cooperative clinical studies, involving several centres which are investigating fast neutron therapy. The pilot studies confirmed the efficacy and safety of the beam for relatively advanced cancer cases where the prospect of cure was considered remote.

More recently, pilot studies have included potentially curable radioresistant tumours. For the advanced cases, information on normal tissue reactions was obtained and found to be essentially as expected. For the potentially curable cases the response of a variety of uncommon radioresistant tumours has been studied.

The facility provides the first isocentric capability with high LET (linear energy transfer); the centre of the target volume is on the centre line of the neutron beam and the patient is rotated around the intersection point. Although the facility is constrained to a fixed horizontal beam the intensity is high enough to allow the patient to be placed at an adequate distance for the necessary rotational and translational movements. At present, a source to target distance of 153 cm is used and this will be increased to 190 cm in the near future to give greater flexibility.

Tumour doses, when neutrons are used alone, range between 2000 and 2400 neutron rads over a six week period. In all other respects, treatments are designed to match those which would be used in conventional isocentric photon therapy.

A wide range of collimators permit 'tailoring' of the treatment. X-ray and laser beams are used to position the patient in a special chair usually so that the tumour is at the axis of rotation of the chair.

Treatment planning is done on a PDP-10 computer which calculates and plots equal dose distribution for fast neutrons and photons. The latter is especially important when patients are being treated with a mixed beam (photons and neutrons on consecutive days) or photon treatment followed by a neutron boost.

Early reactions were recorded on all patients and several interesting statements can be made. First, no excessively severe early reactions were observed in any patient. Skin and mucosal reactions were, in general, relatively mild and in only a few cases were significantly painful reactions produced. Second, the broad range of fractionation schemes all lead to similar early reactions, confirming the expected weak dependence of radiosensitivity on fractionation per se with high LET particles.

Late effects are being followed up for a number of specific tissues traversed by the beam. It is too early to draw conclusions from Fermilab experience alone but the technique can be evaluated in conjunction with observations at other centres.

In summary, results with locally advanced epidermoid carcinomas were consistently superior using neutrons. Many reputedly radioresistant adenocarcinomas and sarcomas respond dramatically to neutron irradiation, although long-term control and survival remains to be evaluated. On the other hand, the results of trials without the use of drugs for brain tumours were uniformly discouraging.

Physics monitor

A quark mass dilemma

Theoreticians grappling with the dynamics of quark interactions have a job on their hands. A technique (quantum chromodynamics) is emerging which enables calculations to be made for small interaction volumes, like those which occur in deep inelastic scattering, but this has yet to be related to the larger-scale problem where quarks appear to be permanently confined inside hadrons.

It could turn out that the description of quark matter has to take different forms according to the scale of things. This could be compared to our picture of the large scale structure of matter where calculations can be made using mechanics which makes little if any reference to the atoms of which the matter is built up.

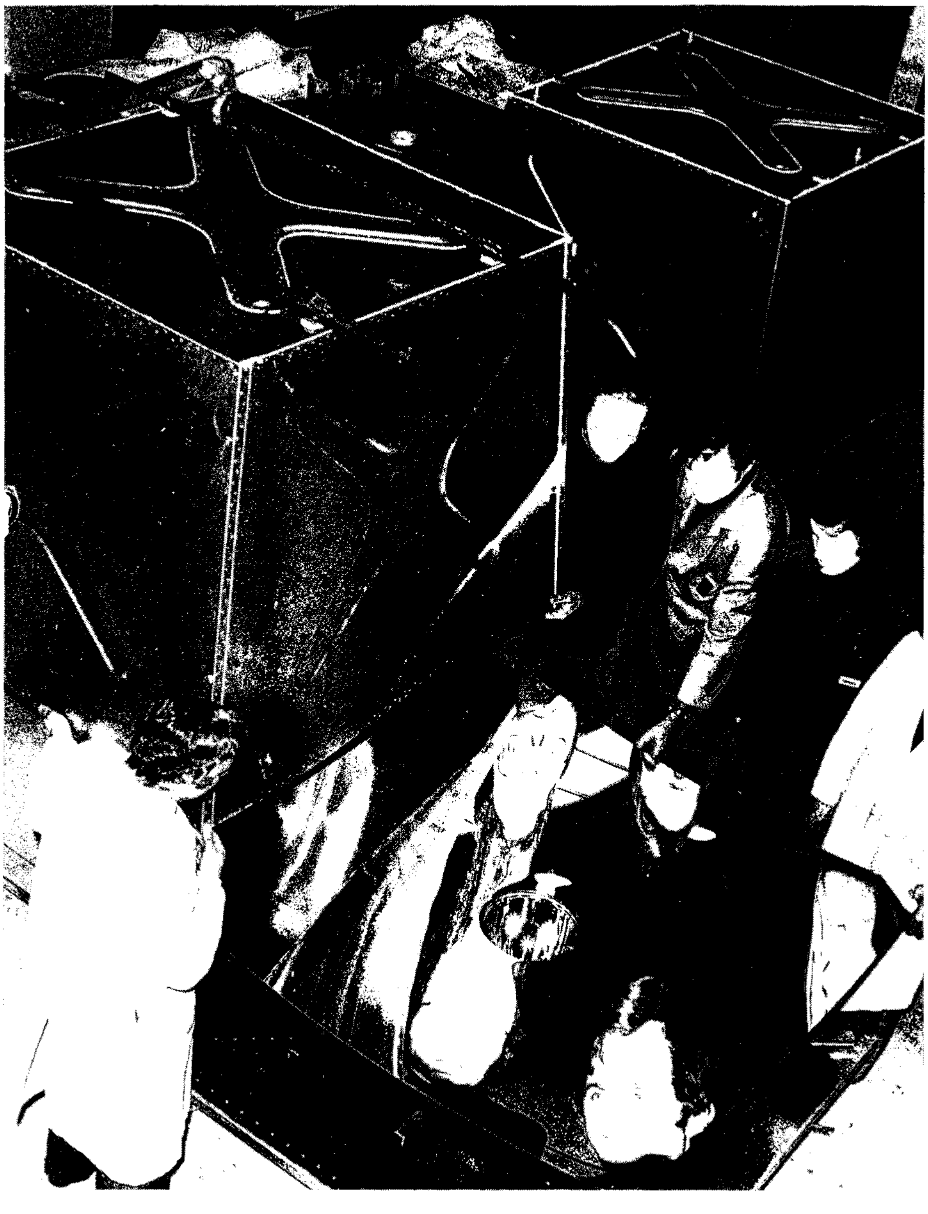
In preparation for theories which describe quark behaviour on different scales, some possibilities can be explored now. In particular, the effective masses of the quarks might be different according to the circumstances. There is a school of thought which says that calculations on the most microscopic form of quark behaviour (such as that seen in deep inelastic scattering) require one effective mass, called the 'current' quark mass, while the mathematics of constituent quarks, confined in hadrons, needs another mass value.

According to this renormalization prescription, the constituent quarks which make up the observed hadronic masses are heavier than the (same) quarks interacting with pointlike leptons at high energy.

This discontinuity in behaviour is implicit in the use of spontaneous symmetry breaking in which there is a change in the 'phase' of quark matter, analogous to a phase change of matter from liquid to solid, for example.

Although constituent quark masses are on the same scale as hadronic masses (from a hundred MeV into the GeV range), the current quark masses used in calculations on deep dynamics could be of the order of just a few MeV.

This could have implications, for example in parity violation effects in nuclear physics through neutral current interactions. Now that the parity violating component of the neutral current has been established in the



Assembly of one of the Cherenkov modules for the forthcoming experiment by a CERN / Copenhagen / Lund / Rutherford at Intersection 8 of the Intersecting Storage Rings to study large transverse momentum phenomena.

(Photo CERN 421.2.79)

clean conditions of electron-nucleon scattering (see June 1978 issue, page 245), and indications have also been seen in atomic physics experiments (see May 1978 issue, page 200), a search can be made for similar effects in nuclear physics.

Because of the small effective mass of quarks on the smallest scale, this parity violation might be larger than expected.

Quantum effects from the Earth's rotation

An unusual experiment at the University of Missouri Research Reactor has shown how the rotation of the Earth produces quantum mechanical effects in neutron beams.

The experiment involves splitting a primary neutron beam in a crystal and passing the two emergent beams through the two halves of a vertically-aligned rectangular interferometer. Because of gravity, the kinematics of the beams are different in the horizontal and vertical directions of the interferometer, and this results in a phase difference when the two beams are recombined.

This phase difference due to gravity was measured by interferometry in a previous experiment in 1975 at the University of Michigan, and the results agreed with the predicted value, obtained from an unusual calculation involving both Planck's constant and the acceleration of gravity.

The latest experiment attempted to detect the additional effect due to the rotation of the Earth when the interferometer is turned about a vertical axis.

This additional effect is only about two per cent of the gravitational phase shift, but the measured value is in excellent agreement with the predicted value.

The experiment is the quantum mechanical analogue of a 1925 investigation by Michelson which succeeded in detecting the effect of the Earth's rotation on the propagation of light. Michelson used an interferometer measuring 2010 feet by 1113, but the new neutron beam measurements relied on an interferometer with an area less than 9 cm^2.

People and things

Eastern visit

From 7 to 17 May John Adams and Owen Lock visited high energy physics centres in China and Japan. In China they were welcomed by Vice-Premier Fang Yi, who has special responsibility for science and technology, and had discussions at the Institute of High Energy Physics at Peking.

The staff there has now grown to 1300 people with some 200 in the Accelerator Division concerned with the construction of the 50 GeV proton synchrotron (see April issue, page 59). Huge workshops, well equipped, are already built and there are many signs that our Chinese colleagues are rapidly developing the necessary technologies for accelerator construction. Some machine components have been built but the construction programme may extend beyond the 1982 completion date initially hoped for.

At the site itself, 40 kilometers from Peking, some thirty people are engaged in survey work and preparations are being made for the construction of a science town to take some 10 000 inhabitants.

In Japan, they visited the impressively well organized KEK Laboratory (see June issue, page 160). Attention is concentrated at present on the construction of the Photon Factory, a 2.5 GeV electron storage ring for synchrotron radiation research, and it seems unlikely that a start could be made on the ambitious high energy storage ring complex, TRISTAN, until the Photon Factory is completed in 1982.

Bubbles in the classroom

In the November issue 1975 (page 352) we reported an experiment in physics teaching in France

John and Renie Adams with Chinese scientists on the site of the new high energy physics Laboratory near Peking.

(Photo E.R. Lock)

using bubble chamber film taken in the CERN 2 m chamber to communicate several physics ideas, particularly in the field of relativity. The work was led by Jean Duboc and has been so successful that it is to be intended to be taken into the national education programme (1100 lycées) as from 1980–81. A description of the work can be found in the 'Bulletin de l'Union des Physiciens' No. 612 under the title 'Un enseignement expérimental de la relativité et de la physique des particules'.

Electron cooling in ICE

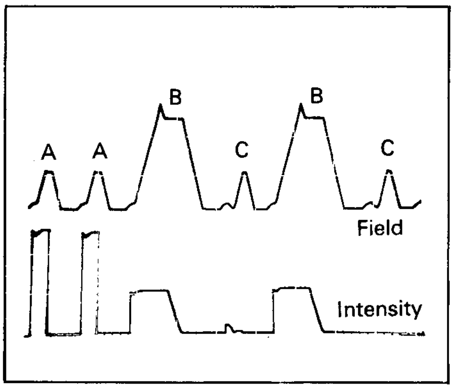
In two short runs during May, electron cooling was tried in the ICE ring at CERN. A substantial effect on a low momentum proton beam was seen without refinement of the cooling system, thus confirming the phenomenon first investigated at Novosibirsk. We will have more news in the coming months when the electronic cooling has been studied in some detail.

Polarized Target Material Workshop

A five day 'Polarized Target Material Workshop' will be held at Abingdon near Oxford U.K. from 1 to 5 October, 1979. This Workshop will be concerned with the chemical and physical processes involved in the preparation and use of polarized target materials with particular reference to the possibility of developing new materials with both a higher hydrogen content and a greater resistance to radiation damage than those currently available. Further information can be obtained from G.R. Court, Oliver Lodge Laboratory, University of Liverpool, P.O. Box 147, Liverpool L69 3BX, U.K.

After its success last year with stochastic cooling, the ICE experiment at CERN has successfully turned its attention to electron cooling, where a low energy electron beam concentrates a beam of protons. This proton beam is supplied by the '28 GeV' proton synchrotron (PS) after some complicated gymnastics where the 800 MeV beam from the Booster is first taken to 1 GeV and then decelerated to 46 MeV, with the PS magnet field only about one per cent of its usual value. This has been achieved while the machine continues to supply beam to PS experiments and to provide the particles for the ISR and the SPS.

1. A 9.6 s supercycle in the PS. The A cycles fill the SPS (1.4×10^{13} protons per pulse) and the Bs are used for the ISR and for PS physics ($3\text{-}6 \times 10^{12}$ ppp), while the new C cycles with two peaks, the first at 1 GeV and the second at 10 GeV, are for the injection of single low energy pulses into the ICE ring (2×10^{10} ppp).
2. Detail of a C cycle. The energy trace (lower curve on the left) shows the 800 MeV beam from the Booster being taken to 1 GeV before it is decelerated in the PS to produce a record low energy of 46 MeV. The beam is subsequently reaccelerated to 10 GeV. The other curve shows intensities.



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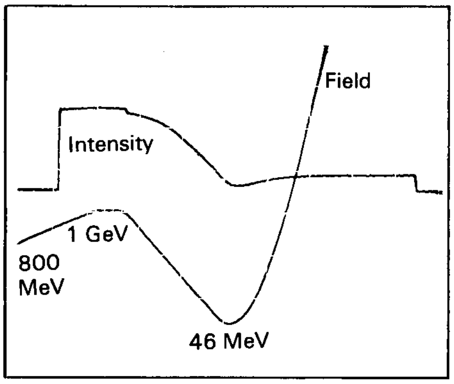
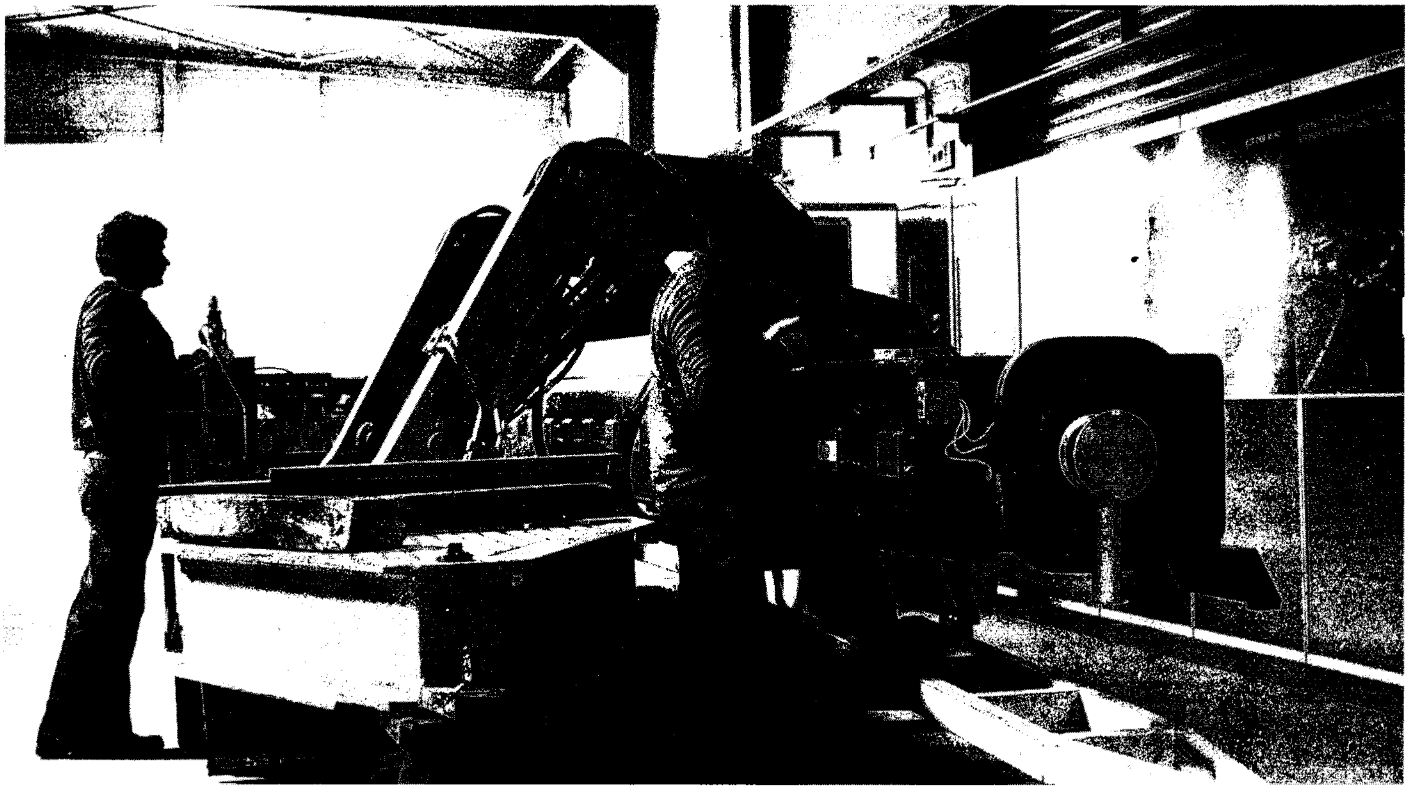


2.

One of the highlights of CERN's 25th Anniversary celebrations is the Technology Exhibition, on view during the summer months. An SPS magnet is seen here being swung into position during the preparations for this exhibition, which illustrates the technological advances made as part of CERN's work.

(Photo CERN 356.4.1979)



CERN's 25th Anniversary Celebrations

CERN came formally into being on 29 September 1954 when sufficient ratifications of the Convention establishing the European Organization for Nuclear Research were obtained from Member States. Several events are being arranged to mark the 25th anniversary.

On 23 June an Anniversary Ceremony took place on the CERN site in the presence of Ministers and other important personalities from the Member States, representatives of local authorities and distinguished friends of CERN. Jean Teillac, President of CERN Council, presided over the Ceremony and Viki Weisskopf and H.B.G. Casimir were invited speakers.

On 29 June a concert, offered in honour of CERN by the Swiss Confederation and the Municipality and Canton of Geneva, took place in Geneva. Given by the Orchestre de la Suisse Romande conducted by Horst Stein, it featured a new work 'Lux et Pax' dedicated to CERN by Mathieu Vibert.

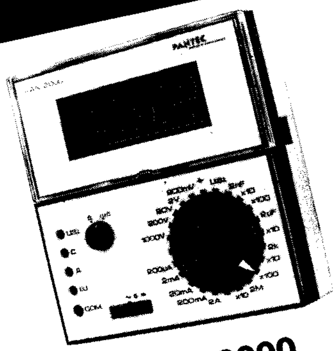
30 June was a 'CERN Day' at the European Physical Society's International Conference on High Energy Physics held in Geneva. Talks in the morning were from Leon Van Hove ('Highlights of 25 years of physics at CERN') and Bjorn Wiik ('Prospects in high energy physics') in a special session chaired by Viki Weisskopf. In the afternoon, visits to the CERN site were organized.

A fete will be held at the site for CERN staff and their families on the actual day of the anniversary — 29 September — with a ceremony in the evening particularly to honour those staff who have worked at CERN for 25 years. Later in the year, a 'journée d'accueil' will be held on the French part of the site.

Throughout the summer months a large exhibition of many of CERN's technological achievements will be open on the site and from 5 to 22 September a popular exhibition on CERN will be on view in Geneva.

On the 8–9 October, a Symposium is being organized for scientific and technical Press.

CERN COURIER will itself be marking the anniversary with a special issue in September which will review CERN's history, highlighting the achievements in science, technology and international collaboration, together with the usual coverage of the latest news and developments in high energy physics.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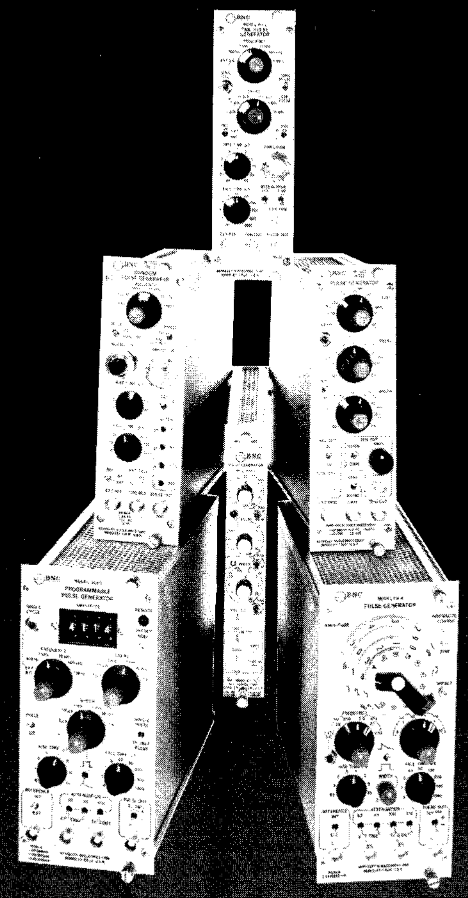

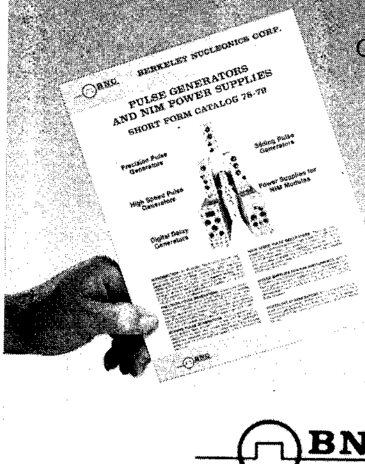
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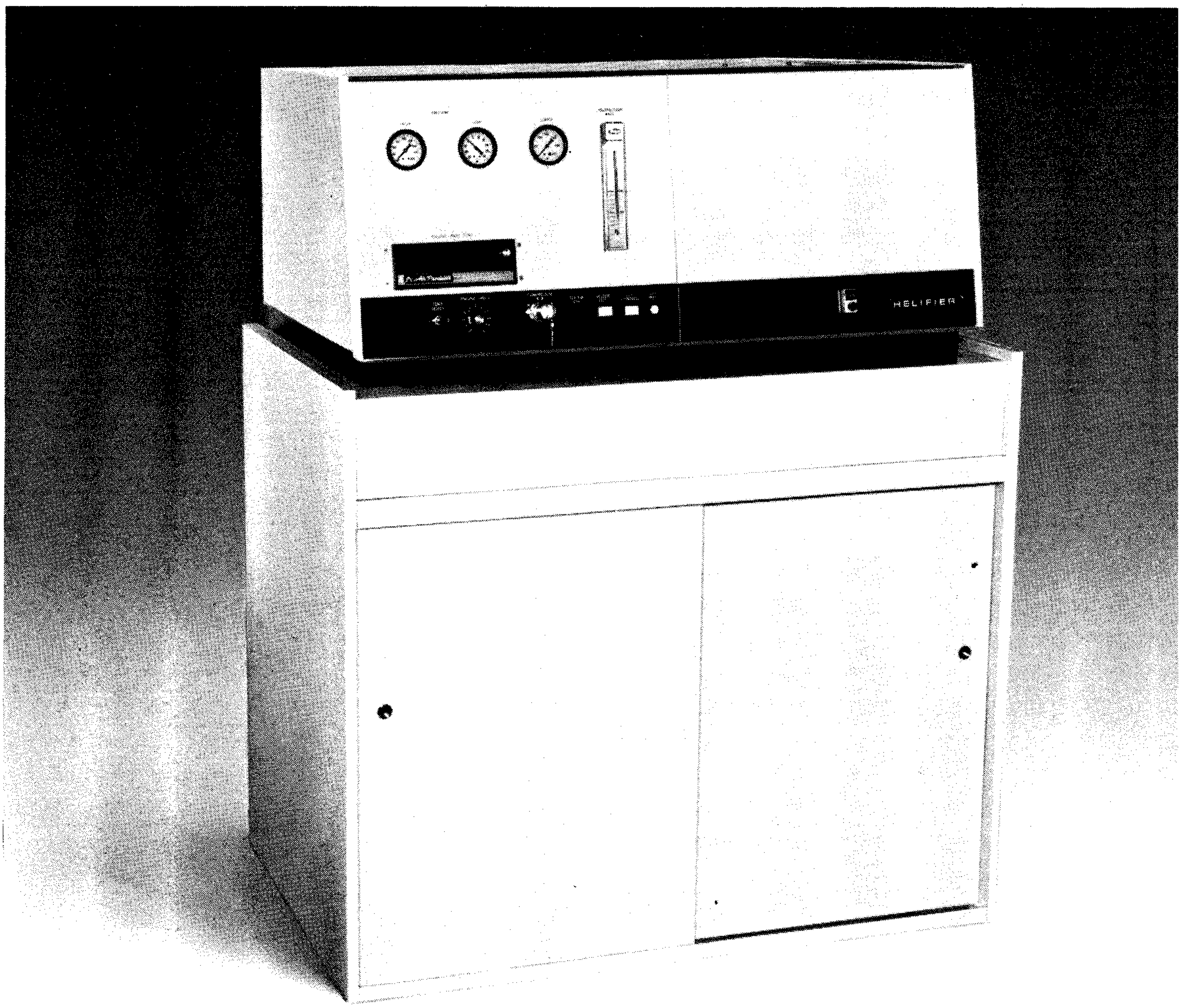
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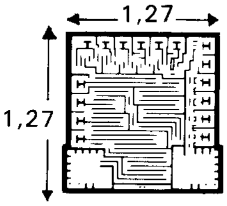

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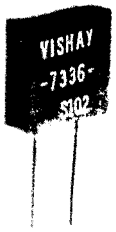

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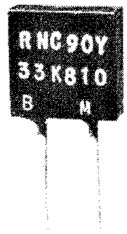

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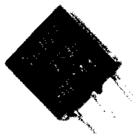

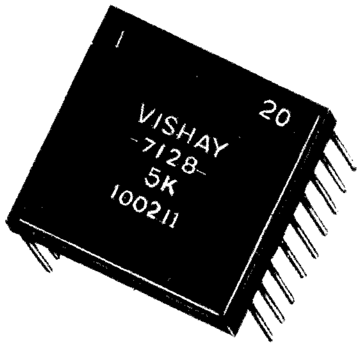

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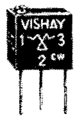

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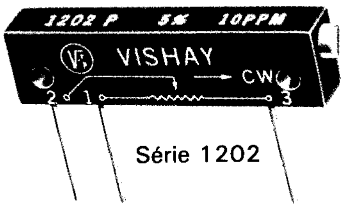

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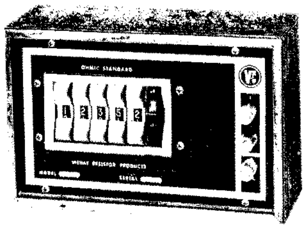

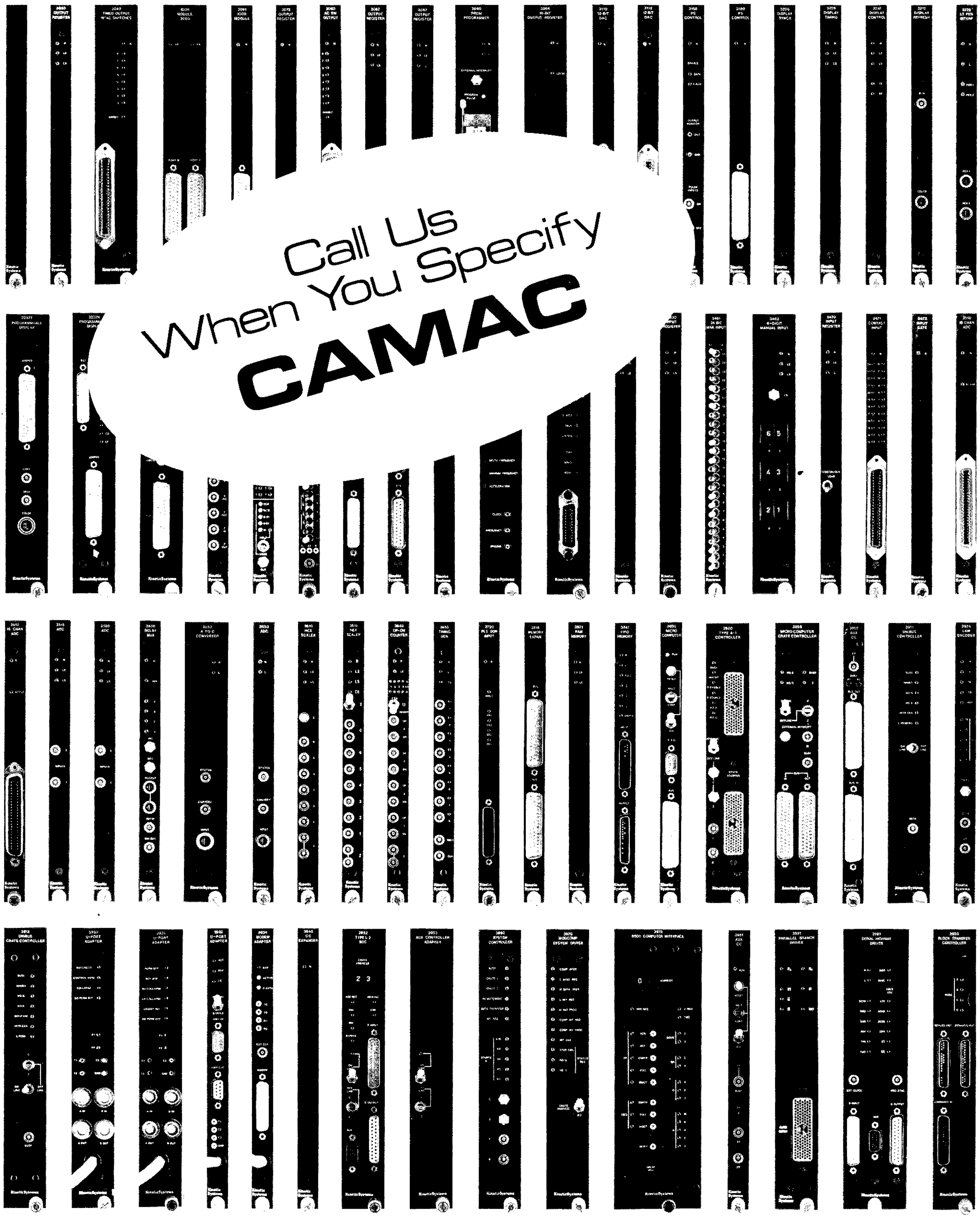
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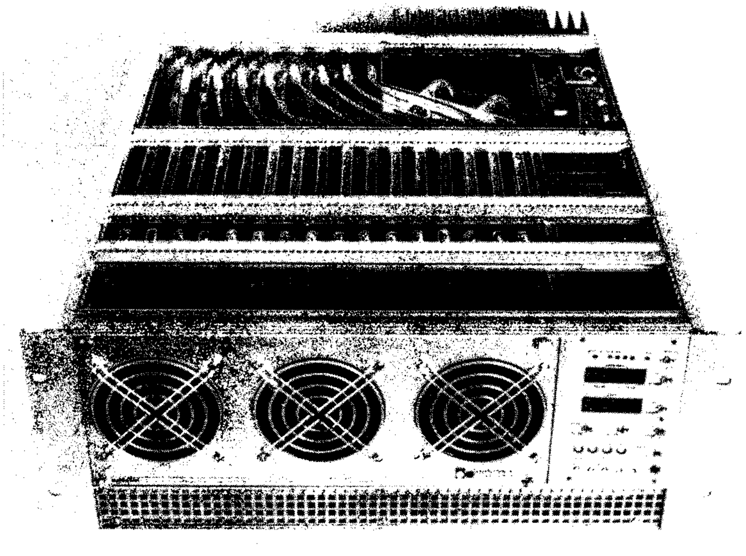

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[1] The N1130 is manufactured under licence by Wenzel Elektronik, Munich, West Germany.

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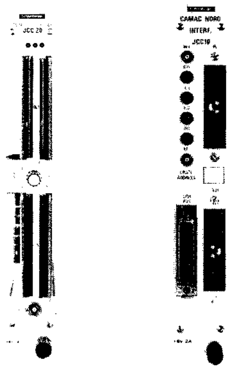

• CONTROLLERS INTERFACES

JCAM 10	Autonomous CAMAC controller system with built-in microprocessor
JLSI-10	Dedicated crate controller for microprocessor LSI 11 (PDP 11.03) *
JCC-20	Dedicated crate controller for PDP 11 *
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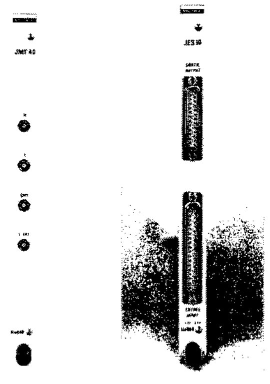
JCRC-60	Crate controller type A2 and dedicated crate controller for MITRA 115

* CASIC/RT 11 compiler available



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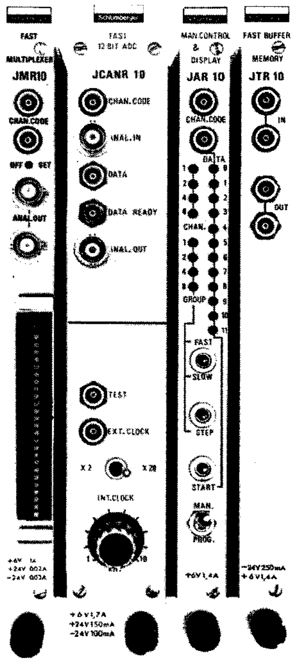
JMT-30	Buffer memory 256 × 16 bit
JMT-40	Buffer memory 1 K × 24 bit
JIR-10	16 bit interrupt alarm register
JES-10	24 bit input register, 16 bit output register easy coupling to digital voltmeters



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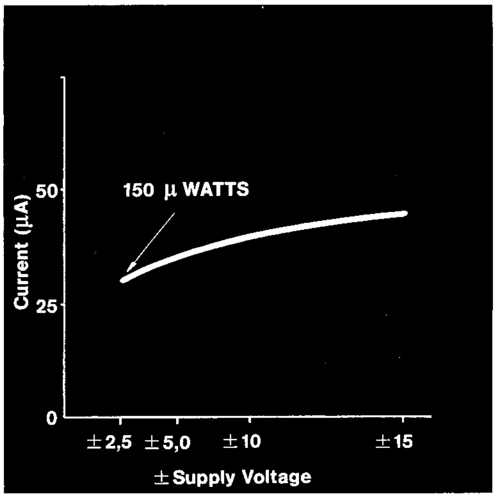

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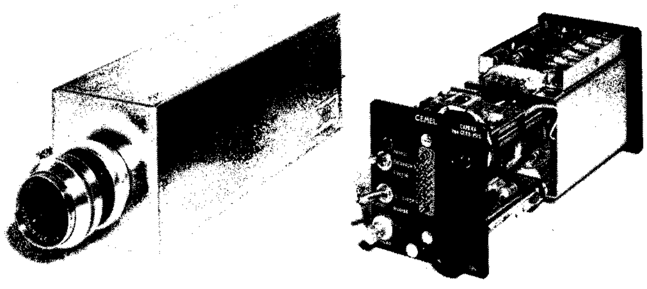

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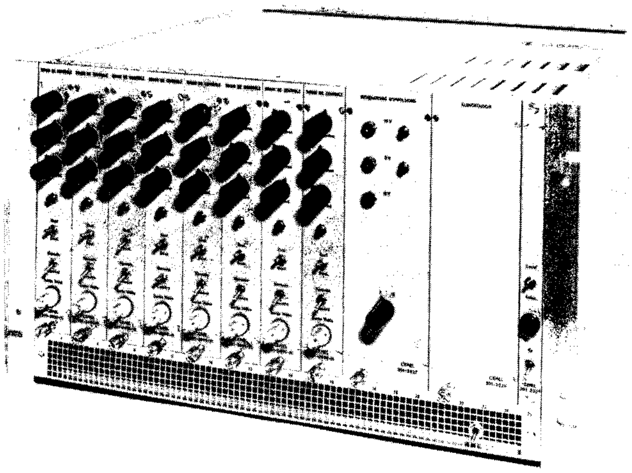

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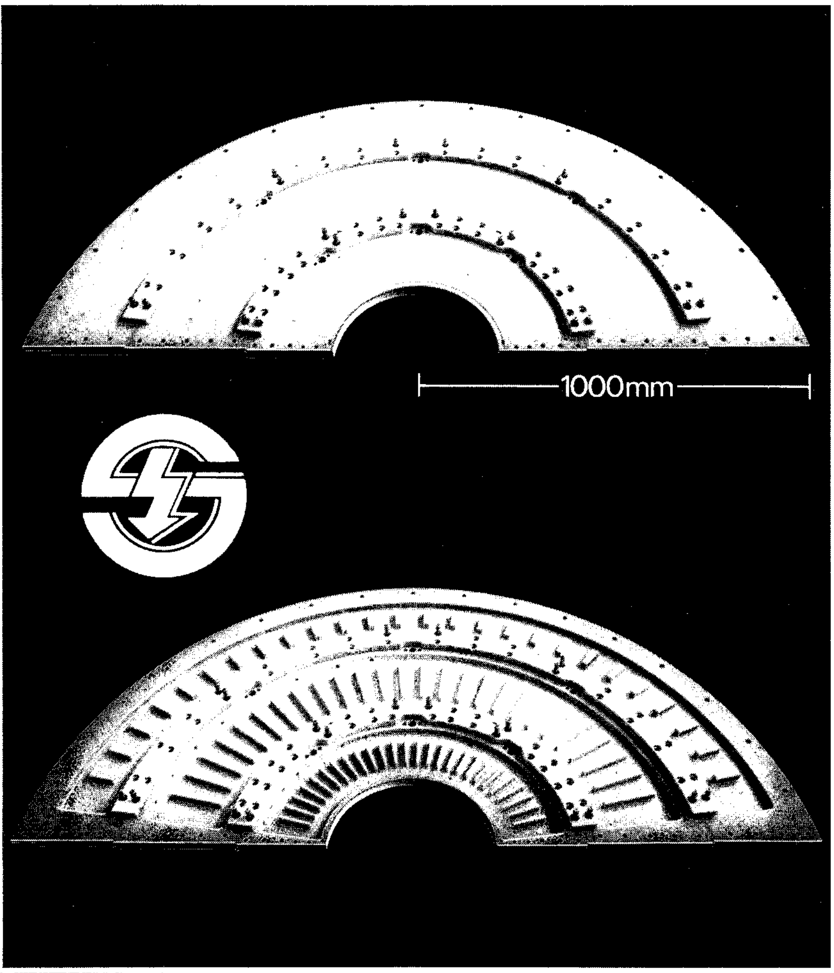
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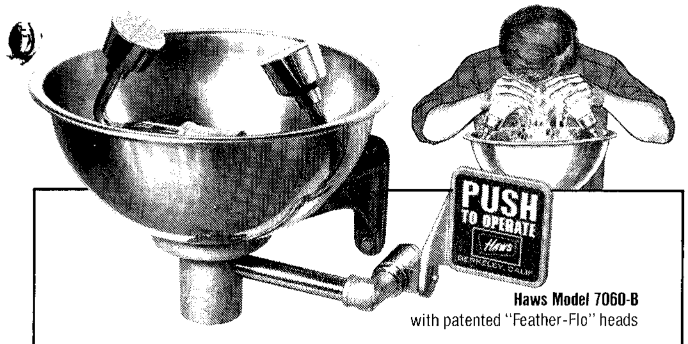
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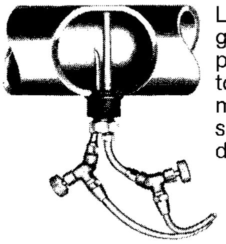

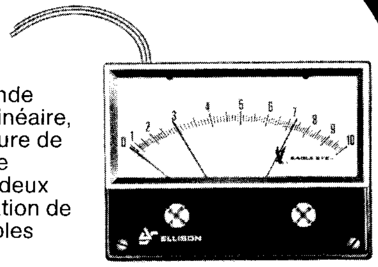
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CCA2 2089 A2 Parallel Crate Controller

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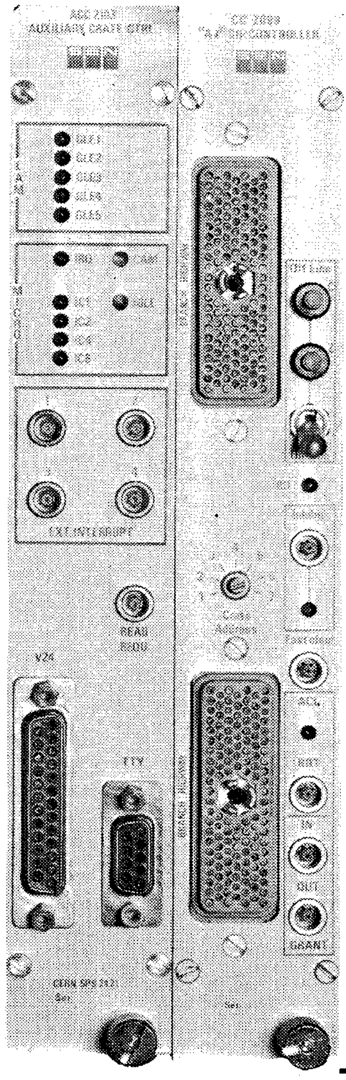

SYSTEM OPERATION

The A2 Crate Controller is a parallel Crate Controller and includes all the same functions plus new control logic for local data handling using a microprocessor module (as ex. ACC 2103). The A2 provides access to the N and L lines via a rear panel connector for the Auxiliary Crate Controller placed in any normal station. It also handles the remote/local access request conflicts. Front-end data processing is governed by the ACC 2103 just as long as the man computer does not require access to this particular crate: However, when this occurs, the local processor is released, its status saved and the Branch Demand processed. Once the Branch Demand has been filled, control returns to the ACC 2103.

Brief configuration guide

- For systems not requiring permanently available high-level languages the ACC 2099 (single width) is normally sufficient.
- to improve input/output and intersystem communication, the SEN CI 2092 communications interface (high speed, multi-channel, buffered, micro-processor controlled) may be added.
- for fully autonomous systems, a version combining the features of the ACC 2103 and of a Crate Controller will be available shortly (Type STACC 2107 – Stand Alone CAMAC Computer).

France: **ORTEC Sarl**; 7, rue des Solets; Tel. (1) 687 25 71 - Tlx 202553F, F-94 RUNGIS – **Germany:** **SEN ELEKTRONIK GmbH**; Brandstücken 11; Tel. 041 80 20 46 - Tlx 2163705d, D-2000 HAMBURG 53 – **DIDAS Digital System**; Radspielstrasse 8; Tel. 089 91 67 10 - Tlx 529167d - D-8000 MÜNCHEN 81 – **Switzerland:** **SEN ELECTRONIQUE SA**; CP 39; Tel. (022) 44 29 40 - Tlx 23359ch - CH-1211 GENÈVE 13 – **SEN ELEKTRONIK AG**; Austrasse 4; Tel. (01) 945 51 03; Tlx 58257ch - CH-8604 VOLKETSWIL – **United Kingdom:** **SEN ELECTRONICS LTD**; London Street; Chertsey; Tel. 9328.66744 - GB - KT168AP SURREY – **OFFICES THROUGHOUT THE WORLD.**

Headquarters:
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SEN
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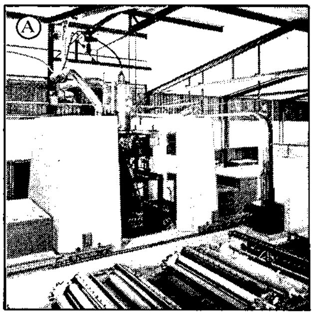
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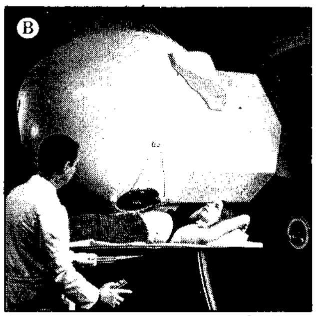
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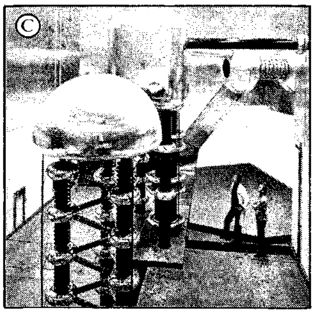
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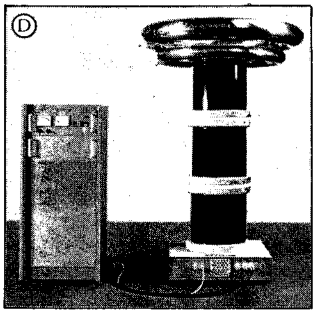
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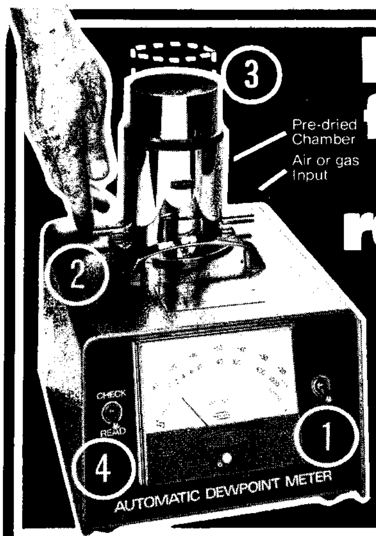
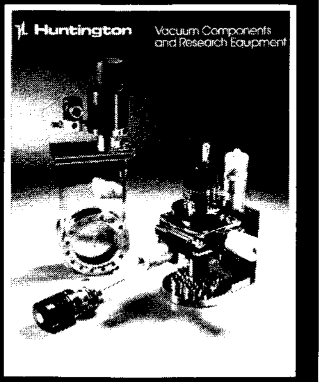
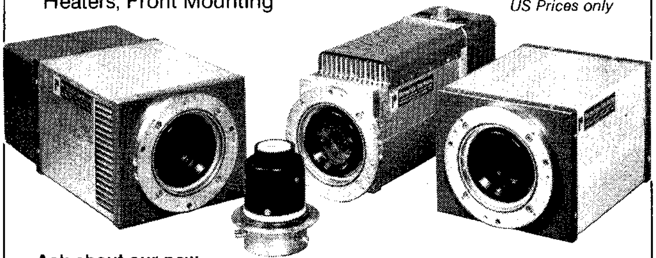
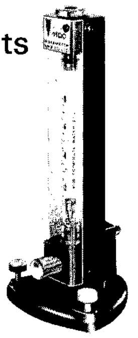

3
Pre-dried Chamber
Air or gas Input
2
CHECK
READ
4
1
AUTOMATIC DEWPOINT METER


Huntington
Vacuum Components and Research Equipment





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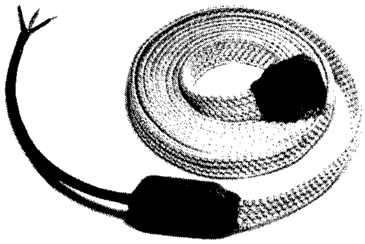
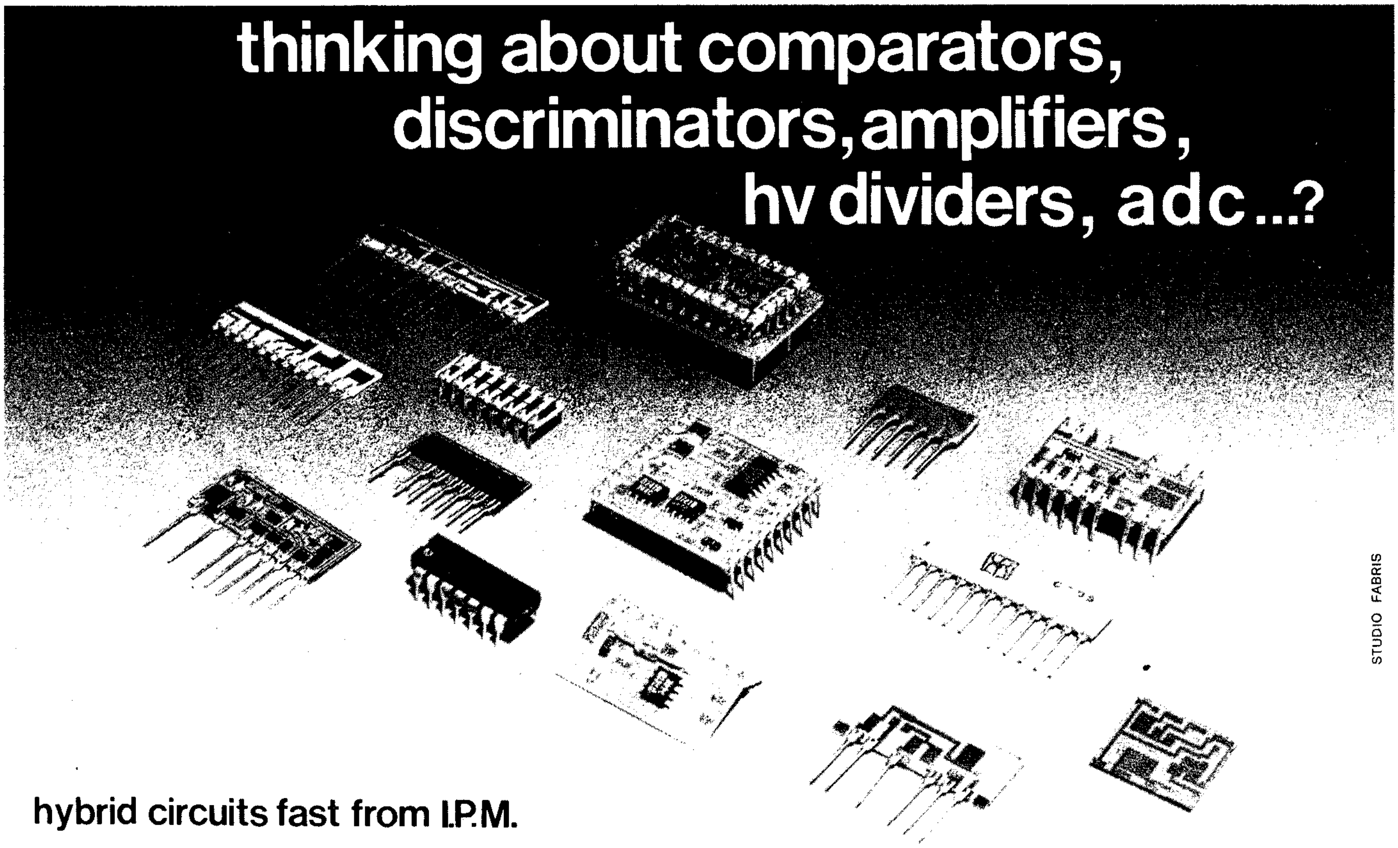



thinking about comparators,
discriminators, amplifiers,
hv dividers, adc...?
STUDIO FABRIS

---

two NEW high voltage systems from LeCroy

1 LeCroy's new Model HV4032A is a complete multichannel high voltage system consisting of 32 microprocessor-controlled, remotely-programmable high voltage supplies. Voltages can be set and monitored with ± ½ volt precision through the front panel, from a terminal, or through the unit's CAMAC interface, Model 2132. The Model HV4032A is based upon the popular, proven HV4032. It offers all of the features and performance of its predecessor *and more.*

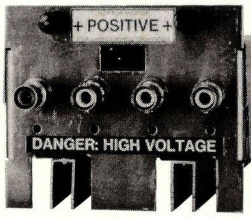
HIGH-PERFORMANCE SUPPLIES

3.3 kV positive or negative—any combination of quad supplies.

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

Excellent calibration accuracy factory-set to ± 0.1% ± 1V channel-to-channel.

Rear-panel adjustment per channel: ± 0.75%.



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

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

Battery backup eliminates loss of voltage settings upon power failure or temporary shutoff.

Panic button for protection against human error and the unexpected.

High-power fans guarantee safe, cool operation even at full load.

Fail-safe interlock clamps outputs to zero—essential near wire chambers using explosive gas mixtures.

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

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

CAMAC INTERFACE
Model 2132

A proven performer.

Compatible with the Models HV4032 and HV4032A.

Inputs and outputs are both buffered 32 words deep.

---

*Up to 6.25 watts/channel, 200 watts/chassis.

2 LeCroy's NEW Model HV2432 is a 32-channel high-voltage system packaged in a #2 CAMAC module. This **incredible** density is achieved through the use of hybrid circuit technology. The Model HV2432 contains 32 of the unique high voltage regulator hybrids, designed to accommodate up to ± 3.5 kV from a bulk HV supply and produce an output equal to their demand settings. All channels may be accessed under CAMAC control, allowing the voltage demand to be set and a divided-down sample of the output to be supplied at a front-panel connector.

The Model 2432 has been designed to offer a dramatic increase in packaging density while providing exceptional economy. it is well-suited for large and small systems. As a standard CAMAC module, it may be used in any CAMAC crate, along with other modules.

For further details, contact your local LeCroy office at one of the locations listed below.

Excellent stability—typically 50 ppm/°C in closed-loop operation (attendant computer providing digital feedback).

Excellent calibration accuracy— ± 0.1% (monitor point).

Economical bulk supply—minimizes price and space requirements.

Safety-engineered to provide lockout, avoiding potentially lethal electrical shocks.

Convenient, economical positive locking block connectors with built-in interlock.

High current capability—2 mA/channel.**

Extended voltage range— ± 3 kV.

High resolution—10-bit programmability allows 3V (2V) steps for the 3 kV (2 kV) range.

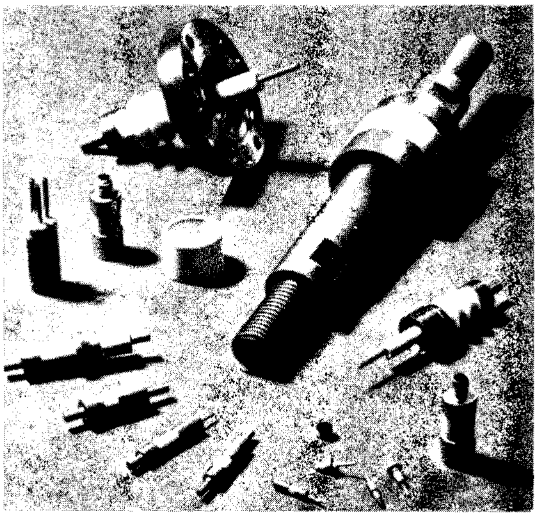
Fully protected—Thermal
Short circuit
Over-voltage
User safety

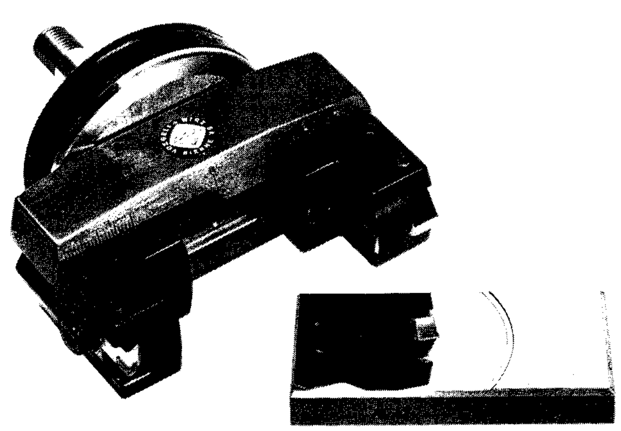
**For Vin - Vout = 1000 V.
Proportionally more for smaller voltage drops and less for greater drops.

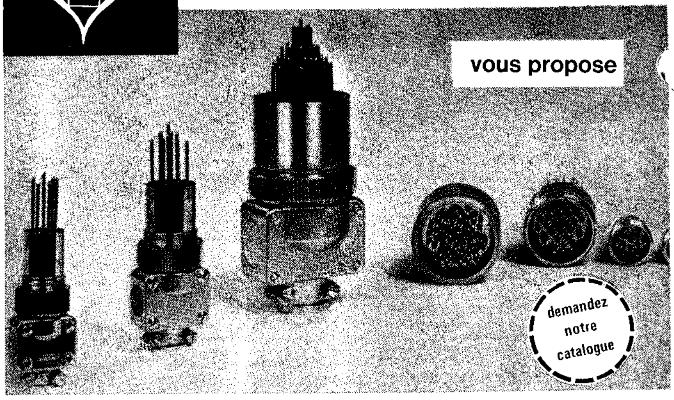
LeCroy
RESEARCH SYSTEMS

Innovators in Instrumentation

Headquarters: 700 S. Main St., Spring Valley, N.Y. 10977. Offices: Chicago, (312) 626-6726; New England, (603) 483-8755; New York, (914) 425-0412; Palo Alto, (415) 856-1806: Geneva, Switzerland, (022) 98 97 97; Heidelberg, W. Germany, (06221) 28192; Hamburg, W. Germany, (040) 54 2713; Paris, France, 907.38.97; Wheatley, Oxford, England, (08677) 3540. Representatives throughout the world.



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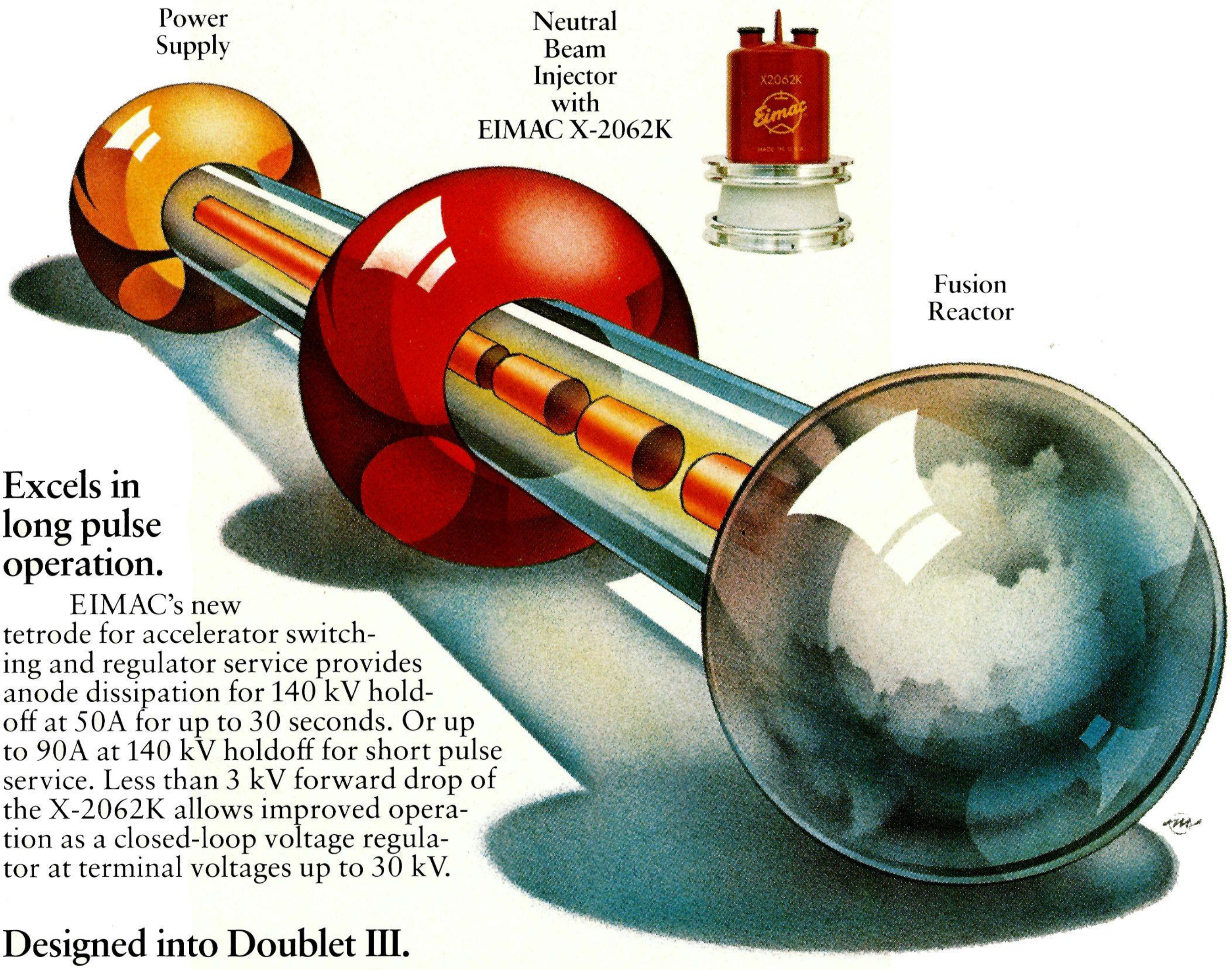
Power Supply
Neutral Beam Injector with EIMAC X-2062K
X2062K
Eimac
MADE IN U.S.A.
Fusion Reactor