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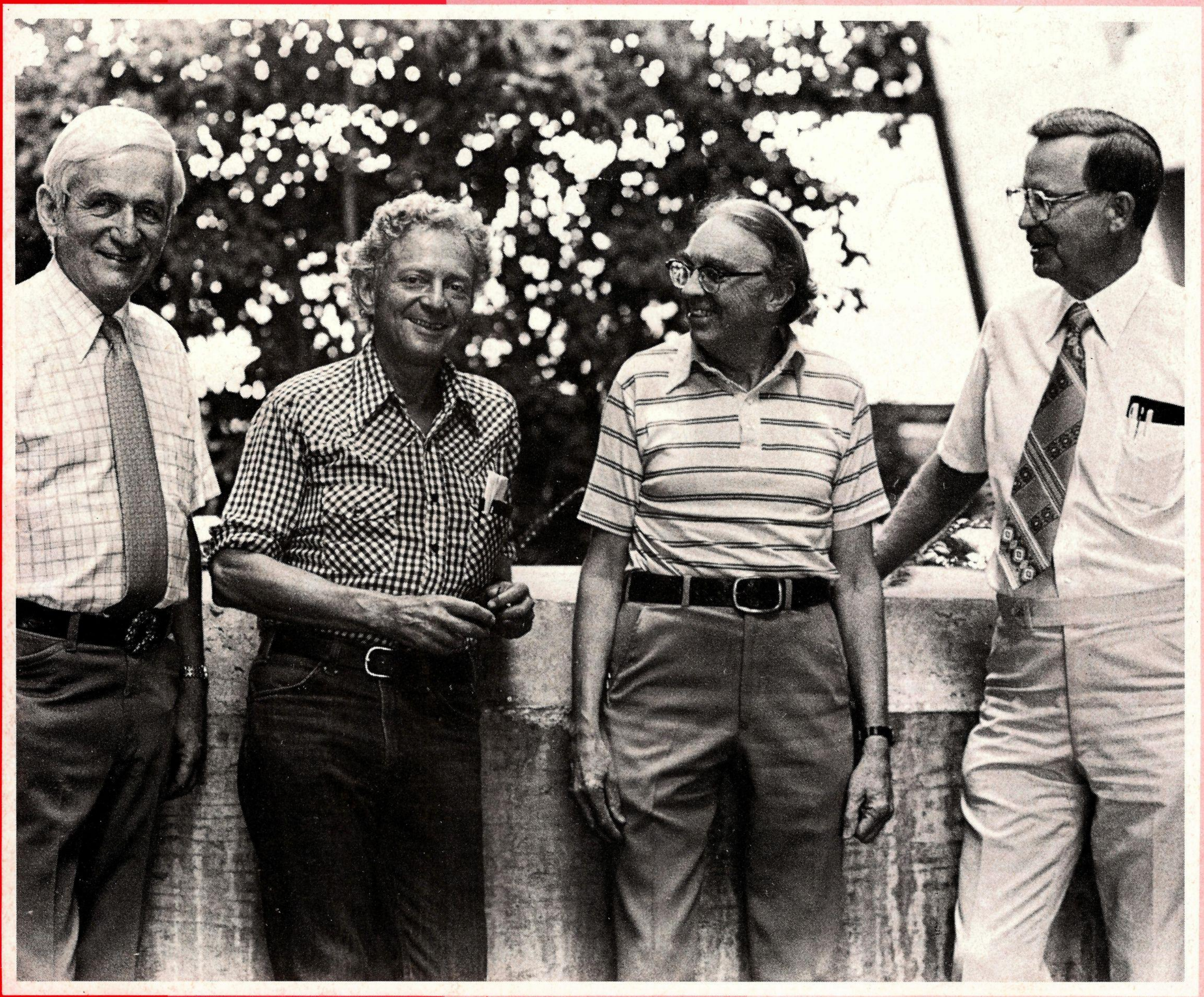

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Cover photograph: On 24 October came the formal announcement of the appointment of Leon Lederman as Director Designate of the Fermi National Accelerator Laboratory, taking office on 1 June 1979 (story page 401). Seen here in the Fermilab line-up are, left to right, Norman Ramsey (President of Universities Research Association Inc.), Leon Lederman, Milt White (URA Board of Trustees Chairman) and Phil Livdahl (Acting Director of Fermilab). (Photo Fermilab)

Nobel Prizes 1978

1978 Physics Nobel prize-winner Peter Kapitza of the Institute for Physical Problems, Moscow, seen here (centre) on a 1975 visit to the CERN SPS (hence the safety helmets), with Russian colleagues Vitaly Kaftanov (right) and Igor Golutvine (left).

(Photo CERN 304.9.75)

Sharing the coveted Nobel Physics Prize this year are Peter Kapitza, of the Institute for Physical Problems, Moscow, and Arno Penzias and Robert Wilson of Bell Telephone Laboratories, New Jersey. Kapitza was nominated for his work in experimental low-temperature physics, while Penzias and Wilson received their accolade for low temperature work of another kind — the discovery of the 2.7 K radiation which permeates the whole of Space.

Kapitza has been Director of the Moscow Institute for Physical Problems since its inception in 1934. Previously he worked with Rutherford at Cambridge from 1921, eventually becoming Director of the newly-founded Mond Laboratory in 1933.

His work at Cambridge was largely in the area of strong magnetic fields, but subsequently his attention turned to low temperature machines and the investigation of the behaviour of liquid helium where he displayed great mastery of experimental techniques and great analytic ability.

Reminiscing on his time spent with Rutherford at Cambridge, Kapitza once wrote about a conversation with Rutherford over dinner at Trinity College. "I was expressing the view that every good scientist must to some extent be a madman. Rutherford overheard this conversation and asked me, 'in your opinion, Kapitza, am I mad too?'. 'Yes Professor,' I replied. 'How are you going to prove it?' he asked. 'Very simply,' I replied. 'Perhaps you remember a few days ago you mentioned a letter you had received from the USA, from a big American company. In this letter they offered to build you a colossal laboratory, and to pay you a fabulous salary. You laughed at the offer, and would not consider it seriously. I think you would agree with me that from the point of view of a normal person you acted like a madman!' Rutherfor laughed. He agreed that in all probability I was right."

The work of Penzias and Wilson established a major link between cosmology — the study of the immensely large — and high energy physics — the investigation of the structure of matter on the smallest possible scale.

Their measurements were carried out at 4 GHz (7 cm wavelength) in 1964-5, using apparatus built at Bell Labs for the satellite communications projects of the early 1960s. One aspect of these projects was to optimize the transmission of messages by reducing the 'noise' signals received from an antenna and amplifier system.

The apparatus consisted of a 20-foot aperture horn antenna linked to a 4 GHz ruby maser amplifier. The antenna signal was compared to a standard source cooled with liquid helium and maintained at about 4 K.

With this apparatus, they picked up a small constant signal which would not go away. Its intensity corresponded to the radiation which would be emitted by a perfect radiator ('a black body') at a temperature of 2.7 K. The signal was moreover isotropic and unpolarized, and showed no seasonal variations during nine months of data taking.

Penzias and Wilson painstakingly tried to eliminate possible sources which could contribute to this mysterious signal. One precaution involved removing some pigeons which had nested in the antenna and cleaning the apparatus of their droppings!

Even while the investigation was still under way, the new measurement provided immediate fuel for cosmologists searching for explanations of the origin of the Universe. Earlier work, including the celebrated 1948 Alpher-Bethe-Gamow paper, had led to the idea of the 'Big Bang', in which the Universe is supposed to have originated in a violent initial cataclysm.

If so, then some of the intense radiation of this initial proto-Universe could be left over, so that now the furthest reaches of the Universe would not be completely empty, but would have a temperature a few degrees above absolute zero. The observations of Penzias and Wilson confirmed that the sky was indeed warm.

According to the theorists, these signals are the fossil remains of the intense radiation which existed when the Universe was opaque and when particles were packed together about 1000 times more closely than they are now.

After Penzias and Wilson, subsequent measurements, including experiments above the earth's atmosphere to investigate ultra-short wavelength radiation, established that the observed spectrum was that of black-body radiation.

These background signals are therefore the oldest information that we have ever received, dating back to the time when the Universe consisted of a bunch of free particles in thermal equilibrium.

As time passed, the Universe cooled and electrons began to be ensnared by protons to form atoms. With fewer particles, the radiation cloud expanded and was shifted in wavelength by the Doppler effect, eventually reaching the puny level first detected by Penzias and Wilson.

With the broad guidelines of the history of the Universe thus sketched out, theorists can speculate about the types of particles which existed in the thermal equilibrium of the initial hot 'soup'.

For instance, there seems to be an upper limit for the number of types of massless neutrinos existing in the early hot Universe. This implies that in our emerging picture of electro-weak interactions, which groups together quarks and leptons in a definite way, there is a limit to the number of new quark flavours waiting to be discovered at higher energies.

As a result of this link between cosmology and high energy physics, perhaps we can begin to glimpse with the aid of modern accelerators some of the phenomena which happened when the Universe was being formed. If so, it means that the big machines, as well as uncovering the secrets of the structure of matter, could reveal other secrets as well.

Even before the announcement of the Nobel Awards, the Penzias and Wilson discovery had been hailed as one of the greatest advances of modern astronomy.

Heavy Ion Fusion Workshop at Argonne

The third in a series of annual Workshops on 'Inertial Fusion Driven by Beams of Heavy Ions at GeV Energies' was held from 19 to 26 September at Argonne National Laboratory. There were 158 participants mostly from Laboratories, Universities and Industries in the USA with a few European and Japanese representatives. They were pursuing the idea that intense pulses of high energy heavy ions are the most efficient way of imploding deuterium-tritium pellets to provide power by fusion.

The Workshop had three goals: the first was a critical examination of proposed designs for prototype 1 MJ 'reactor drivers' which have been prepared at Argonne, Berkeley and Brookhaven. This examination was also to decide on the suitability of a heavy ion demonstration experiment based on these designs and the possible upgrading of the designs to a few MJ. The USA Department of Energy hopes to confront such a demonstration experiment early in the 1980s.

A second goal was the exchange of information on the progress of heavy ion fusion programmes which are under way at the Laboratories. The third goal was the communication of present thinking on heavy ion fusion in order to encourage industry and university support as was suggested by a recent DOE 'Fusion Review'.

Heavy ion fusion is under study at Argonne, Berkeley and Brookhaven. Each Laboratory has an experimental programme as well as designs of accelerator systems as drivers of large pellet fusion power plants. The requirements for these drivers are stated as a total energy of 1 MJ at a peak power of 100 TW in a shaped pulse with a repetition rate of 1 Hz or more and an energy deposition rate of 20 MJ/g of target material.

To date, Argonne has designed systems using rapid cycling synchrotrons with storage rings, Brookhaven and Argonne have designed systems using conventional r.f. linacs and storage rings, and Berkeley has designed systems using linear induction accelerators. These conceptual designs for accelerator systems were reviewed at the Workshop.

It is now the stated plan of the DOE to build a Heavy Ion Demonstration Ex-

Leading participants at the Argonne heavy ion fusion Workshop:

1. Dennis Keefe (left) of Berkeley and Al Maschke of Brookhaven.
2. Ron Martin of Argonne.

(Photos Argonne)

periment (HIDE) beginning in October 1981. HIDE is to be some part of one of the proposed designs and the aim of the construction will be to demonstrate the credibility of the entire design.

Since the first Heavy Ion Fusion Summer Study (see September 1976 issue, page 291) conceptual designs and experiments have allowed more detailed assessments of the alternative concepts to be made. At the 1978 Workshop, four different designs were presented and, to accomplish the first goal of the Workshop, a technical review was carried out in parallel sessions, examining the areas of ion sources, low velocity linacs, beam manipulations, beam transport and focusing, plasma effects in the reactor chamber, ionic collision cross-sections, and cost estimates.

The second goal of information exchange was accomplished by presentations on the first day from each of the principal Laboratories currently funded for heavy ion fusion work by DOE (those mentioned above and the Lawrence Livermore Laboratory where work on pellet design is concentrated).

Towards the end of the Workshop tutorial sessions were held on all aspects of heavy ion fusion, primarily for industrial and university observers, in pursuit of the third goal. These sessions were videotaped for wider distribution and will be available sometime in November. Proceedings will be published early in 1979.

Experimental programmes at the Laboratories

Experiments with an existing source and preaccelerator have been carried out at Brookhaven. Xenon was introduced into a duoplasmatron ion source and a beam was accelerated to 750 kV in a Cockcroft-Walton preaccelerator. Initial studies of beam neutralization, transport, and acceleration in a 16 MHz cavity containing eleven accelerating gaps have been performed.

1.

2.

Of particular interest is the investigation of strong focusing of ion beams using a trapped electron cloud (Gabor lens). Possible uses of such lenses would be in the source terminal to isolate the source from the column, in the transport line between the preaccelerator and the linac, and in the early sections of the low velocity linac. In all of these regions, strong focusing is required to counteract the defocusing forces of the space charge dominated beams.

The work at Brookhaven is being moved into a new building with adequate space for a longer range programme. A preaccelerator to provide a voltage of 400 to 500 kV and a transmission line to drive 2 MHz Wideroe structures are being built. Surplus industrial transmitters are being modified to drive this linac at 2 MHz.

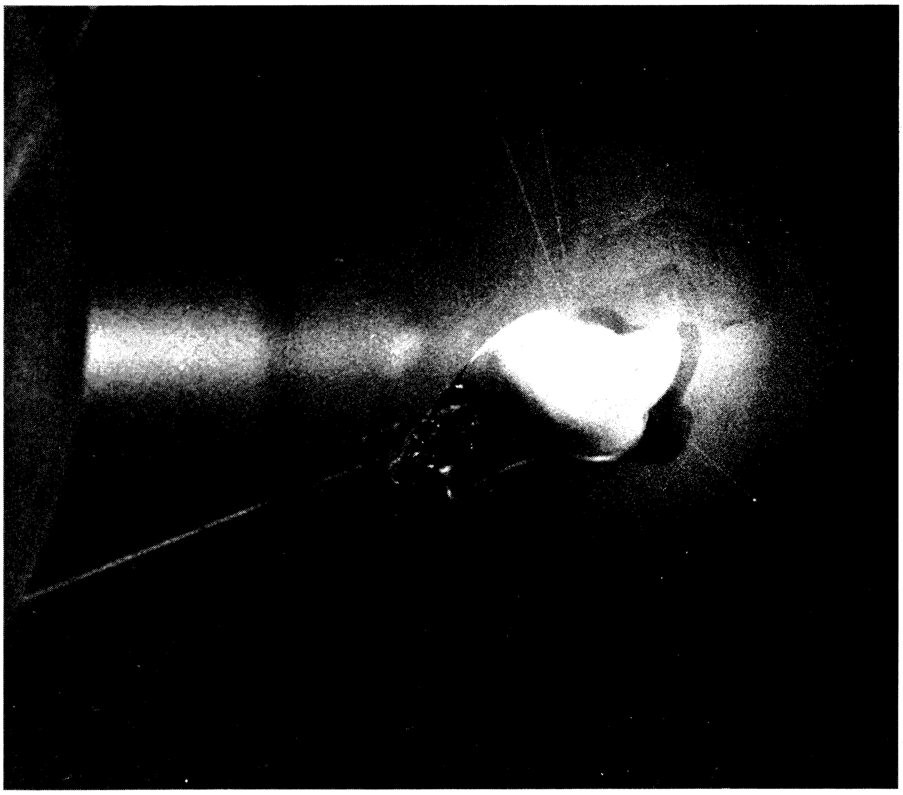
Argonne has been experimenting with a high brightness xenon source from Hughes Research Laboratories. The source is a Penning discharge, Pierce extraction type and delivers 2.5 mA of Xe^{+1} with 80 kV extraction. The beam has been transported with 90% efficiency over a distance of 3 m and its emittance measured to be about 1 cm mrad (0.001 cm mrad normalized). This is an order of magnitude brighter than is required for the heavy ion fusion driver but not yet high enough in current.

A scaled-up version, with a single aperture of 3 cm diameter, has delivered 100 mA at a current density of 15 mA/cm² at Hughes. No emittance measurements have yet been made on this source which was delivered to Argonne in October. A second version is being adapted to produce a mercury beam.

Modifications to a surplus Dynamitron have been completed and the Dynamitron installed and power tested at Argonne with a dummy load. The existing r.f. power supply will allow a cur-

In a demonstration experiment at Argonne a 1 mA beam of xenon ions, 1 mm in diameter, at an energy of 80 keV was directed onto a thin glass target supported in a vacuum of 10^{-5} torr. The glass is melted and vapourized.

(Photo Argonne)



rent of 30 mA at 1.5 MV and this will be the initial goal with xenon ions. A column for the Dynamitron is scheduled for installation in November. Two single drift tube cavities of different types at 12.5 MHz are nearing completion — one for a buncher and the other for the initial accelerating cavity. Three other cavities are on order to extend the energy.

In initial experiments, Berkeley has achieved a cesium beam of 400 mA at 200 kV from a contact ionization source. The time of flight was consistent with this beam being Cs^{+1}. The aim is to produce 1 A of Cs^{+1} at a current density of 2 mA/cm^2 and to accelerate the beam to 2 MeV in three drift tubes. This would test drift tube accelerators as an injector for a linear induction accelerator.

Also developed at Berkeley is a multiaperture (13 apertures over 2.5 cm diameter) xenon source. Extraction is at 20 kV and the normalized emittance measured at 1.5 m from the source with 40 mA of beam current was 0.03 cm mrad. The source was mounted in the terminal of a Cockcroft-Walton and the beam transported to the column through a pair of quadrupole triplets. A current of 60 mA at 475 kV has been attained to date; no emittance measurements have yet been made.

Unfortunately, despite these expanding research and development programmes, the amount of money that DOE is to make available this Fiscal Year for the heavy ion fusion work is shrinking from $ 5 M to about $ 3.5 M.

Proposed designs for the heavy ion accelerators

Four proposed designs were studied at the Workshop — conceived as possible drivers for a commercial fusion power plant producing beams of at least 1 MJ with peak power of at least 100 TW on target with an overall (pellet burn) repetition rate of one per second or greater.

The Brookhaven design has a conventional r.f. linac with eight accumulator rings to store 10 MJ of beam energy. The beam is delivered in two clusters of four beams each to a 3 mm diameter target in 50 ns for a peak power of 200 TW. The system uses uranium ions accelerated to 20 GeV and has a capability of operating at 15 Hz. As opposed to the more limited aims of the other proposals, Brookhaven's is really a large prototype commercial power plant.

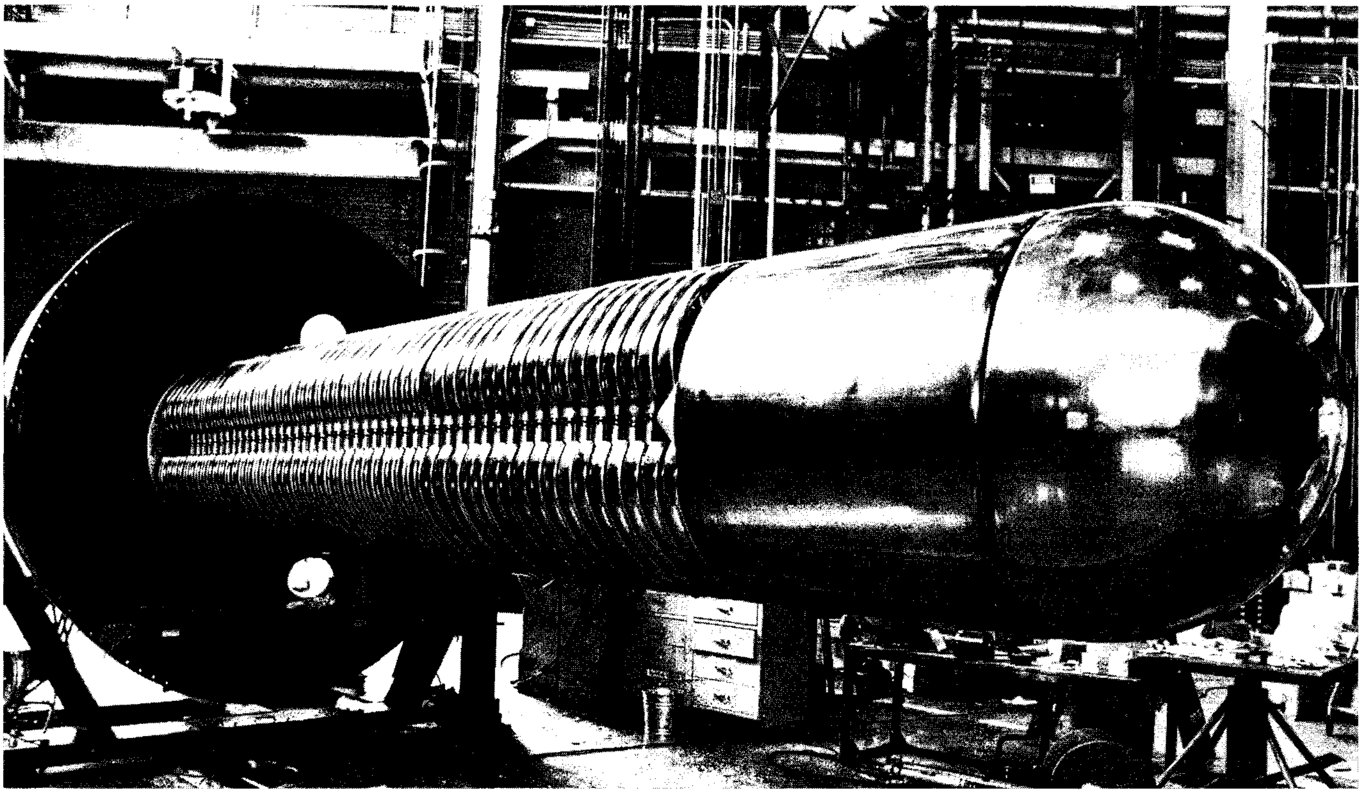
Eight sources are used to give beams of 40 mA of U^{+1} each accelerated through a preaccelerator of 500 kV followed by a 2 MHz Wideroe to reach 6 MeV. An output current of 20 mA from each unit is anticipated. The ions are stripped at this stage to U^{+2} with 50% efficiency and pairs of beams are combined into four 4 MHz Wideroe linacs. Combination of pairs of beams is continued into 8 MHz Wideroe linacs and finally into a 48 MHz Alvarez linac. Further frequency transitions take place in Alvarez linacs to 96 MHz and 192 MHz with the bulk of the acceleration to 20 GeV occurring in the latter.

At this stage, the current is 160 mA in bunches at a 16 MHz rate (using one bucket in twelve of the 192 MHz linac). This beam is injected into a large radius multiplier ring with ten turn injection to give 1.6 A circulating. Upon extraction, the horizontal and vertical planes are interchanged to allow ten turn horizontal injection into a second multiplier ring with a tenth the radius of the first for a final circulating current of 16 A. The process is repeated eight times to accumulate 10 MJ. Compression to the final bunch length is begun in the accumulator rings and completed in the transport line to the target. The accumulator rings are arranged in two clusters so that two clusters of four beams each are fired at the target.

Argonne presented HEARTHFIRE 2

The Dynamitron at Argonne disassembled revealing the voltage multiplier stack and old ion source. A new xenon source to give currents of 100 mA is now installed.

(Photo Argonne)



— a conventional r.f. linac system with accumulator rings. Hg^{+8} ions are accelerated to 20 GeV to store 1 MJ of beam energy in eighteen rings arranged in two clusters of nine rings each. Eighteen beams would be transported to the target with a final bunch length of 6 ns to give a peak power of 160 TW.

Two sources of 50 mA of Hg^{+1} are employed with acceleration to 1.5 MeV in modified Dynamitrons. Bunchers give 80 % capture in 12.5 MHz linacs to provide 40 mA in each. The ions are stripped to charge +8 at an appropriate energy around 20 MeV with an efficiency of 20 %. The electrical current is thus increased to 64 mA and the two beams combined into a single Wideroe linac at 25 MHz. Transitions to Alvarez linacs at higher frequencies give acceleration to 20 GeV.

Current multiplication is accomplished through delay stacking bypasses and rings to combine beams in the transverse plane, four at a time, using thin septum magnets. A transmission efficiency of 93 % with emittance dilution of 1.45 at each combination is assumed. A total of four such manipulations is contemplated, two in each transverse plane, to give a current multiplication of 256.

Coupled with an overall efficiency of 75 % this process results in a current of 24 A injected into each of the accumulator rings. The beam then requires adiabatic debunching and rebunching to a single bunch in the accumulator rings. Longitudinal compression by a factor of 74 is accomplished by linear induction cavities external to the rings followed by half a turn around another ring for transport to the target.

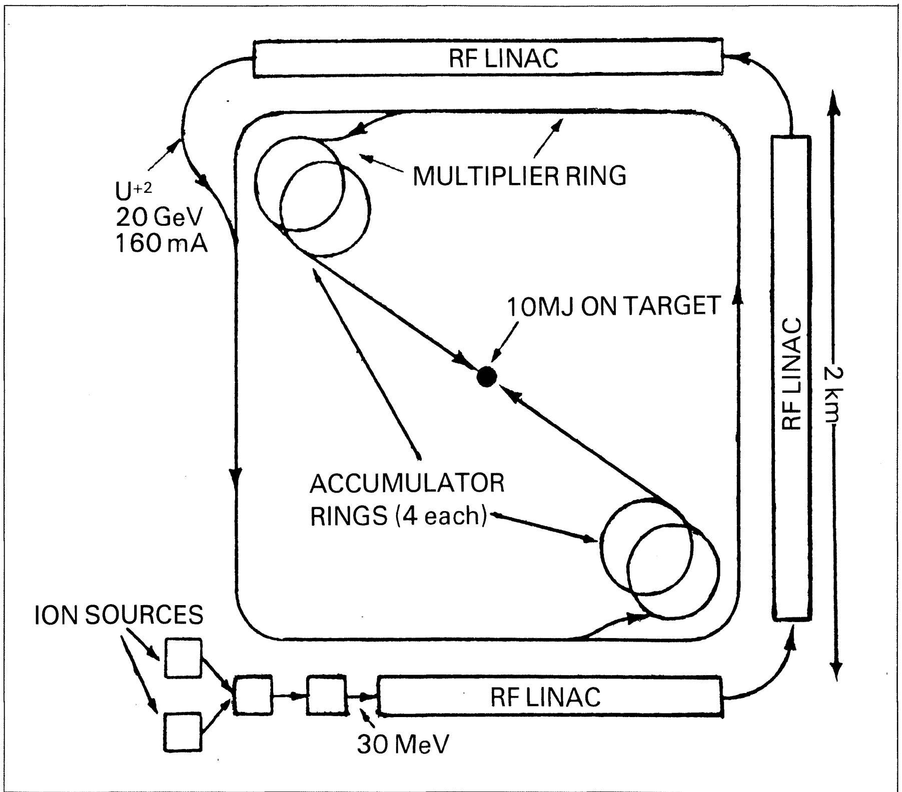
Argonne's synchrotron-based system is called HEARTHFIRE 3. It accelerates Xe^{+8} to 20 GeV for storage of 1 MJ of beam energy in sixteen accumulator rings in 1 s. The choice of Xe^{+8} is related to this time interval, in that the ion has a closed electronic shell and the charge exchange cross-section is expected to be an order of magnitude lower than for xenon ions of lower charge, giving beam losses no more than 10 % during the accumulation.

The system begins with two Xe^{+1} sources of about 20 mA captured with 50 % efficiency in special 12.5 MHz structures followed by Wideroe linacs. Stripping to a +8 charge state takes place with about 20 % efficiency at 11 MeV and the two beams are combined in a 25 MHz Wideroe to give a 30 mA beam. Further frequency transitions take place in Alvarez linacs to produce 30 mA of Xe^{+8} at 4.4 GeV with a bunch structure of 25 MHz.

Nine turn injection into a rapid cycling synchrotron is proposed where the beam is accelerated to 20 GeV and transferred to a rebuncher ring. Rebunching to a harmonic number of two takes place after two synchrotron

Two of the proposed designs of high energy heavy ion accelerator systems to produce intense pulses for the fusion of deuterium-tritium pellets:

1. The Brookhaven scheme with banks of injectors feeding into conventional r.f. linacs followed by multiplier and accumulator storage rings.
2. The Berkeley scheme of attractive simplicity, provided the induction linacs (iron core and ferrite) prove capable of handling heavy ion beams.



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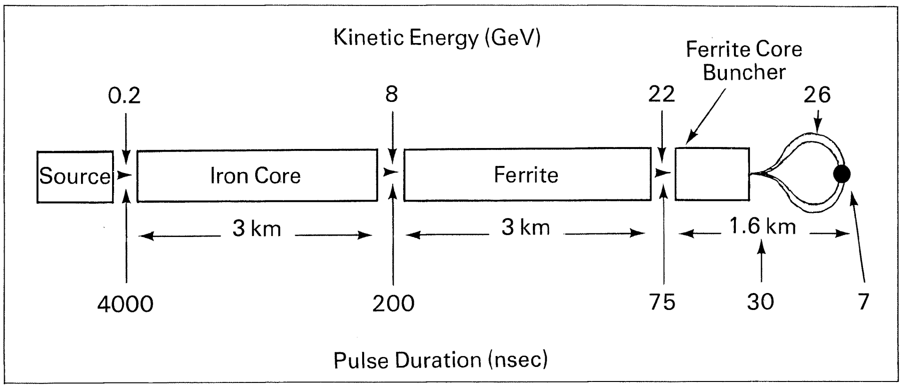


2.

pulses are injected synchronously into the rebuncher ring. Sixteen pulses from the rebuncher are injected into a storage ring. Of these pulses, two turns are injected into the transverse plane and eight into the longitudinal plane, resulting in sixteen circulating bunches, adiabatic rebunching to two bunches per ring in half the storage rings, and one per ring in the other.

With sixteen storage, rings this results in twenty-four beams transported to the target and provides some degree of pulse shaping. Thirty-two synchrotron pulses are required to fill each storage ring. At a synchrotron repetition rate of 64 pulses/s, eight synchrotrons are required to complete the accumulation in 1 s. Four rebuncher rings are necessary to complete the adiabatic operations in this period of time.

The Berkeley design uses the linear induction accelerator. The source is of contact ionization type producing 4 A (at 2 mA/cm²) of U^{+1} for a duration of 40 μs. The beam is accelerated in a series of drift tubes to 5 MeV and stripped to U^{+4} with 37.5% efficiency resulting in an electrical current of 6 A. In addition to further acceleration in drift tubes at 200 MeV, the beam is also compressed to a duration of 4 μs and a current of 60 A for injection into the iron core induction cavity section.

The process of current multiplication by beam compression simultaneously with acceleration is continued there to produce an 8 GeV beam of 1200 A with 200 μs duration. Ferrite core induction cavities are then employed to accelerate to 19 GeV with a final current of 3200 A and a duration of 75 ns.

A final stage of induction cavities has a ferrite core buncher with a gradient of 1 MV/m to provide compression of the beam in a relatively long drift distance to its final duration of 7 ns and 34 kA. However, before the current has achieved this value, the beam is split by septum magnets into sixteen beams and transported to the target in two clusters of eight such that the maximum current in any one beam is about 2 kA.

Conclusions from the Workshop

The Workshop evaluation of designs were assembled by a 'Reference Design Committee' and conclusions about technical feasibility were presented by Lee Teng of Fermilab, Chairman of the Committee, at the final session of the Workshop.

None of the designs was judged sufficiently complete to allow a detailed comparison, nor do they all address a common parameter regime. Furthermore, none of the designs are optimized and differences in many aspects are related more to preferences of the designers rather than to any fundamental issues. Nevertheless some general conclusions were drawn.

There was a clear consensus that at least one accelerator configuration, that of conventional r.f. linacs with accumulator rings, could meet the requirements with confidence, based on current knowledge. There are no profound differences between the Argonne and Brookhaven designs, except in scale and cost. The Brookhaven estimate for their 10 MJ driver was $ 800 M (the cost group at the Workshop gave a figure of $ 1000 to 1500 M). The Argonne figure for their 1 MJ system was $ 360 M (the cost group estimated $ 400 to 500 M).

The linear induction accelerator is attractive because of the simplicity of the concept. However, judgement had to be reserved because acceleration of ions by linear induction accelerators has not yet been demonstrated. Considerable development is required to bring this configuration into the same confidence ball-park as conventional linacs. Berkeley's cost estimate was between $ 400 and 500 M (the cost group agreed).

Synchrotron-based accelerator systems are now considered less promising than a year ago. The apparent cost advantage over conventional linac systems has narrowed because of the recognition that, at high field, the bunching factor must be kept low to maintain the small momentum spread required for good final focusing. Hence, the space charge limit is reduced and more synchrotrons are required. In addition, a special ion (such as Xe^{+8}) of significantly lower charge exchange cross-section is required, the vacuum requirements and the required repetition rate are at the border of technical feasibility.

For these reasons, synchrotron-based accelerator system appear significantly more difficult than systems based on linacs, unless technology demonstrations and cross-section measurements are carried out first to prove feasibility. Argonne's cost estimate for their 1 MJ system was $ 255 M (the cost group was not able to examine this in detail).

Summing up the meeting, Terry Godlove of DOE said 'This Workshop marks a milestone in the heavy ion fusion programme. The claims of the originators of HIF, that existing accelerator technology can be adapted and modified to create a driver for ICF in the energy range suitable for a power reactor, have now largely been verified'.

Thinking Very Big

From 15 - 21 October a 'Workshop on Accelerator and Detector Possibilities and Limitations' was held at Fermilab. It was promoted by the International Committee for Future Accelerators in the context of its long-term thinking about the future of high energy physics.

As we have described in CERN COURIER previously, ICFA (set up under the auspices of the International Union for Pure and Applied Physics) is a forum where representatives from the various regions of the world involved in high energy physics can discuss further cooperation in the use of existing and planned facilities and, particularly, discuss world-wide participation in the construction of an accelerator (often referred to as the VBA - Very Big Accelerator). Any such construction is obviously not envisaged for many years to come and each of the regions have their hands full with their own projects for the near future. Nevertheless it is a responsibility of the high energy physics community to think of the physics needs ahead, and of the extent to which machines and detection systems could meet these needs.

The Workshop at Fermilab was proposed in January of this year at an ICFA Meeting in CERN. It attracted about forty representatives from Eastern Europe, Japan, USA, Western Europe and China (present at such a meeting for the first time).

Working groups were set up on seven topics: Proton accelerators (reported by Victor Yarba), Colliding beams: proton-proton, proton-antiproton, electron-proton (Eberhard Keil), Electron accelerators and storage rings (John Rees), Neutrino experiments (Ugo Amaldi), Hadron experiments (Bob Diebold), Lepton and photon experiments (Barry Barish), Detectors (Georges Charpak and Bill Willis).

The proton accelerator group came out with several parameters for what they considered to be a machine of appropriate scale — energy of 20 TeV, intensity of 10^{13} protons per second, magnetic fields of 10 T using high field superconductor, radius about 12 km, 3200 MJ of energy in the beam, power requirement about 300 MW. The area of greatest difficulty that they covered is a need to keep beam loss below 10^{-6}.

The first of the storage ring groups took off from the parameters of such a proton synchrotron and saw no serious technological difficulties in adding storage rings. For proton-proton collisions a luminosity of over 10^{33} per cm^2 per s would emerge from 6×10^{14} protons, 0.5 A current in 2400 bunches around the rings. There could be experimental difficulties though, because each collision of two such bunches would give seven interactions on average and these could be hard to untangle. Unbunched beams would still have a luminosity in the 5×10^{32} range.

For proton-antiproton collisions rather conservative assumptions of antiproton accumulation at the rate of 10^{12} per day plus the proton synchrotron parameters gives a luminosity of 2.6×10^{30} at 20 TeV per beam. As with the CERN SPS and Fermilab machines this would be a comparatively cheap way of getting access to higher interaction energies given the basic machine. Bypasses around the interaction regions could allow ordinary machine operation independent of the existence of the colliding beam detection systems.

For electron-proton collisions, a luminosity of 10^{32} is feasible with an electron energy of 140 GeV. The synchrotron radiation power of the circulating electron beam is about 100 MW.

An interesting realization emerged from the electron-positron group. They looked at an idea, which has existed in several forms for some years, to collide beams from linacs. The problem has always been the production, or conservation, of enough positrons. At the Fermilab Workshop, Burt Richter wanted to test the idea of 'throwing away' the positrons and using the electrons emerging from a colliding bunch to regenerate positrons. With energies over 100 GeV this looks feasible.

When looking at the question of shrinking these beams, a phenomenon nicknamed 'beamstrahlung' raised its head. Just as an electron emits synchrotron radiation when travelling through the electromagnetic field of a magnet, so it emits synchrotron radiation when travelling through the electromagnetic field of a bunch of positrons (and vice versa for the electron bunch effect on positrons). This grows in seriousness with beam energy.

The phenomenon was looked at in the course of the LEP study at CERN but was not pursued once it was shown that, though hard X-rays will emerge from the beam crossing region, they should not upset the experiments or the beam. The group at the Fermilab Workshop took thinking a stage further and asked at what energy would the growth in energy spread of the beam due to beamstrahlung become troublesome. They emerged with the (possibly a little pessimistic) conclusion that beamstrahlung limits electron-positron storage rings with only a few bunches to energies below 180 GeV.

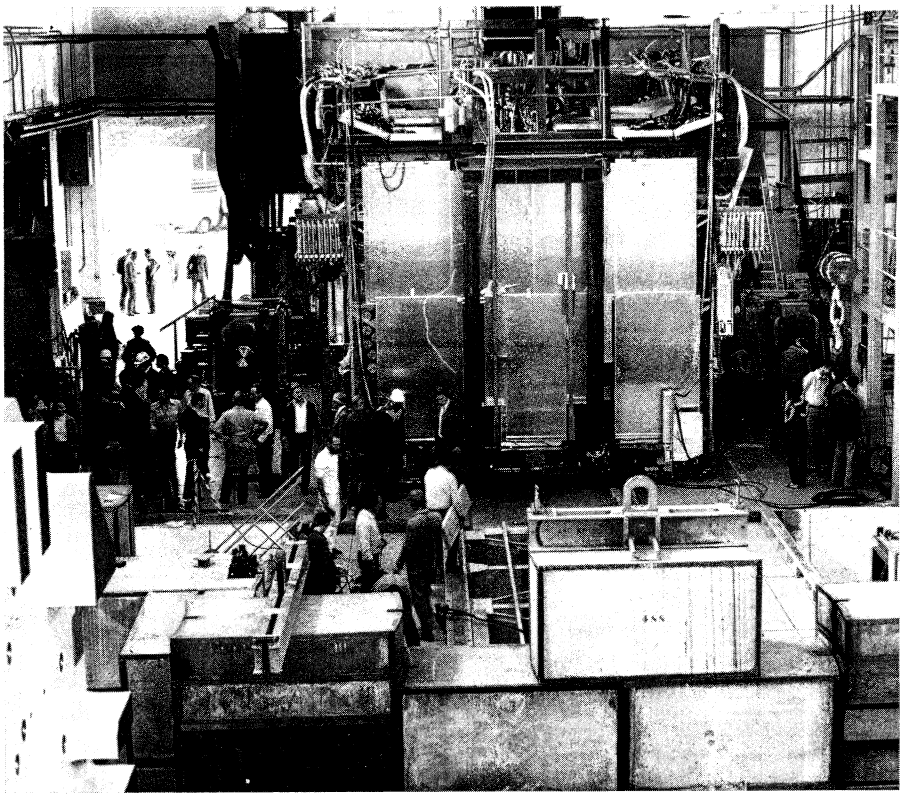
From the groups looking at experiments, the general conclusions were: Neutrino experiments could be done with detection systems not much bigger than at present. The beams would be very long (30 km for 10 TeV) but earth shielding would be adequate because of muon bremsstrahlung. Photon physics would be feasible but difficult. Hadron physics would see the proportional cost of beams decreasing with energy since they scale with the square root of the momentum.

Detection systems are expected to rise to the challenges of a higher energy range where particle identification will, in general, be easier. Spatial resolution will probably be pushed to 10 - 20 μm by then, in detection systems able to accept very high intensities. Calorimetry should also be good with accuracies in the 10 TeV energy range of about 1 %.

A general conclusion from the physics and detector groups was that experiments should be no harder to perform at these extremely high energies than they are with existing accelerators and storage rings. In fact in many ways our present range of peak energies is the most difficult in terms of particle detection systems.

There was an ICFA Meeting at the end of the Workshop. John Adams was elected Chairman for a further year and it was decided to hold another Workshop in a year's time in the Geneva region.

Around the Laboratories



The PLUTO detection system, which has built itself a fine reputation in experiments on the DORIS storage ring, being rolled into place in its revamped configuration at PETRA. All PETRA detection systems are designed to be installable in the ring within a week.

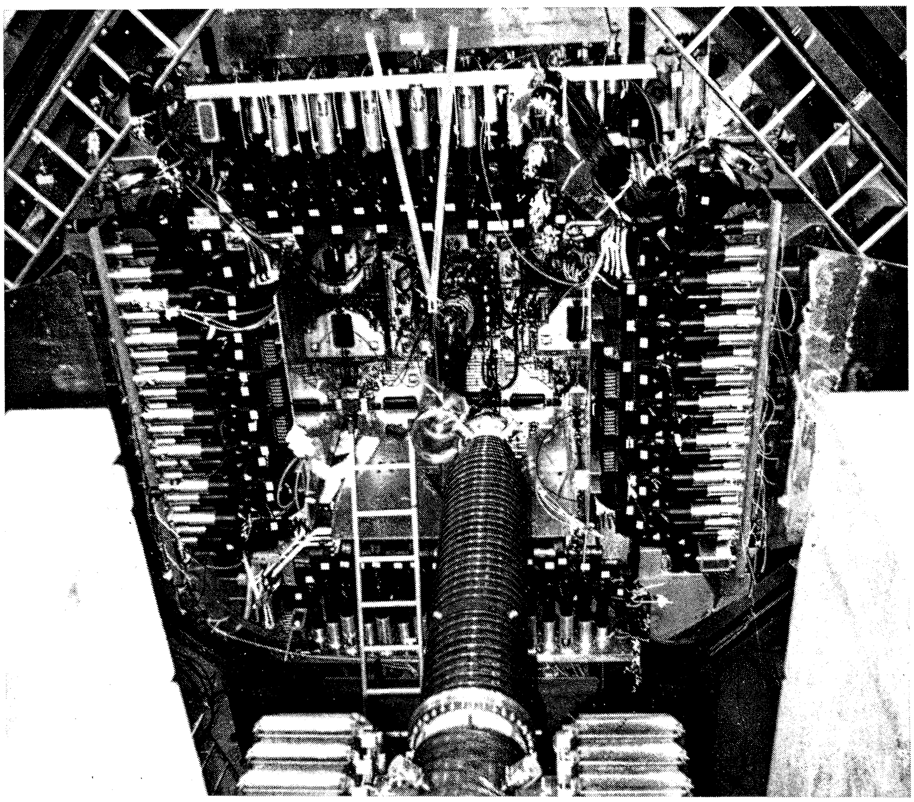
(Photo DESY)

DESY
Experiments now in PETRA ring

The rapid progress in bringing the electron-positron storage ring, PETRA, into operation at the DESY Laboratory is typified by two major achievements in the first period of machine development which ended on 9 October. Soon after a short shutdown for cavity installation in August, an electron beam was accelerated to 11 GeV without loss. In the middle of September a luminosity of 2×10^{29} per cm^2 per s (about 1/4 the design value) was measured and a beam lifetime of about two hours was obtained. Four hours lifetime is expected at a later stage.

The drive of the PETRA machine group presented a great challenge to the experimental groups to advance their own time schedules and to install their detectors in the interaction regions during the two weeks of the October shutdown. Originally experiments were scheduled to start only in summer 1979 !

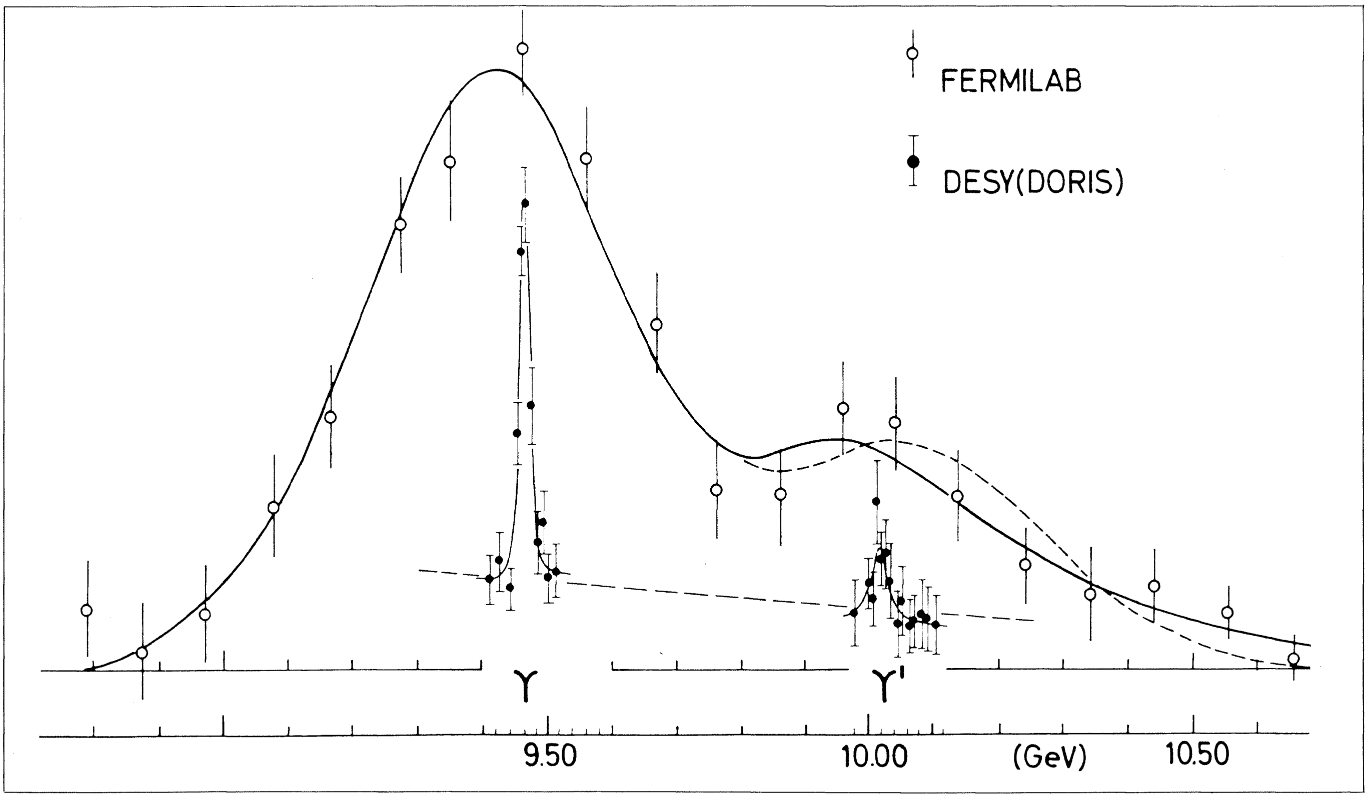
The PLUTO detector, which was transferred from DORIS to PETRA during the summer, has been upgraded by enlarging the muon filter and adding a forward detector. All components have been checked in extensive tests with cosmic rays. The other two groups who decided to move their detectors into the PETRA ring in October are MARK J and TASSO. Although these detectors do not yet have all their components, the installation is so far advanced that the major elements can be checked out with circulating beams and, if adequate luminosity is available, physics results can be produced.



The MARK J detection system, now installed at PETRA, viewed along the beam pipe.

(Photo DESY)

Comparison of the data on the upsilon resonances from the Fermilab experiment, where the particles were discovered, and from the DORIS storage ring. Notice how much cleaner the signals from electron-positron annihilation appear.



The MARK J experiment is a collaboration of Aachen / DESY / MIT / NIKHEF (Amsterdam) and the Institute of High Energy Physics, Peking. The detector is designed to measure R (thereby searching for new particles) and to measure muon asymmetries as well as hadron asymmetries coming from weak interaction effects. It consists of ten layers of counters which sample the pulse height from hadrons and muons, as well as drift chambers, which measure the trajectories of muons in magnetized iron. In order to study asymmetries down to one percent accuracy the detector is designed to be able to rotate both in polar angle θ (by 180°) and in ϕ (by 90°).

TASSO stands for Two Arm Spectrometer SOlenoid and is being built by a collaboration of Aachen / Bonn / DESY / Hamburg / Imperial College London / Oxford / Rutherford / Weizmann Institute and Wisconsin. It consists of a 4π magnetic detector plus two spectrometer arms. A thin-walled solenoid provides a field of 0.5 T parallel to the beam axis. Direction and momenta of charged particles are measured by proportional chambers and a large volume drift chamber. Particle identification in the low energy region is achieved by time-of-flight counters inside the solenoid, while the spectrometer arms provide particle identification up to the highest momenta, using Cherenkov counters — one aerogel ($n = 1.02$) and two normal pressurized gas counters. Photons and electrons are identified and their energies are measured in liquid argon shower counters. The spectrometer arms as well as the main liquid argon counters have not yet been installed.

When the first experiments were approved by the PETRA Research Committee, whose members come from all over Europe, it was decided that all detectors should be designed so that they can be moved into an interaction region within a week. Consequently all experiments are mounted on rails and in some cases more than 1000 tons are pushed along rails at a gentle speed of a couple of centimetres per minute. Only because of this mobility was it possible to install three experiments during a two week shutdown.

During the running period until the end of the year, priority will be given to machine development, the main aim being to try out ring optics for high energies and to optimize luminosity. If physics shifts are scheduled, the beam energy will most probably be about 5 GeV and the properties of the upsilon resonances can be investigated. If above the upsilon (9.45) and upsilon prime (10.02) which have already been observed at the DORIS storage ring at DESY (see September issue, page 298) there exists an upsilon double prime, all three experiments are capable of detecting it.

It is impressive to see how much

more clearly the upsilon signals appear above the continuum background when they are produced in electron-positron annihilation rather than in classical spectrometers at accelerators.

At PETRA the signals should become even more pronounced because of the smaller energy spread in the beams.

BROOKHAVEN Groundbreaking for ISABELLE

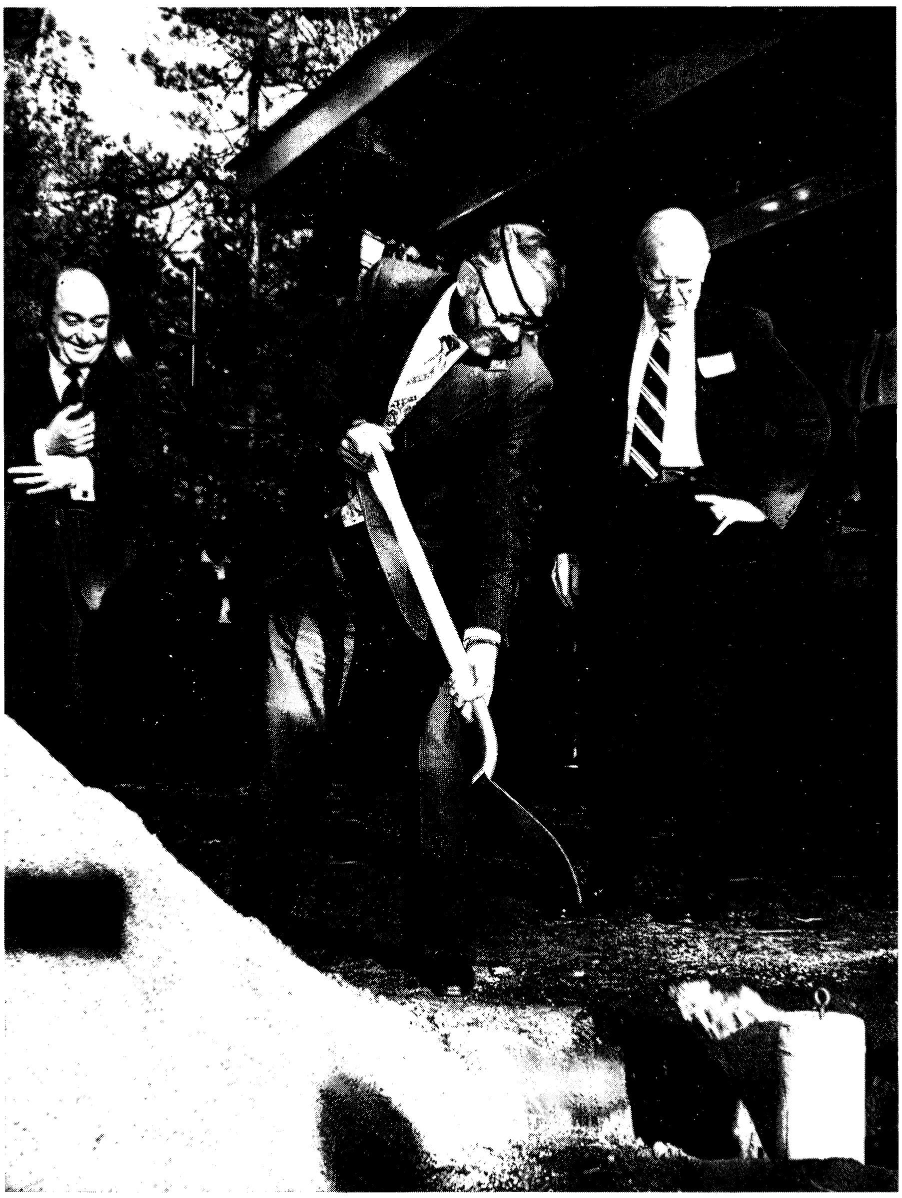
On 27 October ground was broken at the Brookhaven Laboratory in a ceremony to mark the start of construction of the 400 GeV proton-proton storage rings, ISABELLE.

Speakers at the ceremony included Jerome Ambro and John Wydler (U.S. Congressmen), Dale Myers (Under-Secretary in the U.S. Department of Energy), Michael Zeller (Chairman of the High Energy Discussion Group of the BNL Users' Organization), Gerald Tape (President of Associated Universities Inc.) and George Vineyard (Director of Brookhaven). Jim Sanford (ISABELLE project Director) and Bill Wallenmeyer (Director of the DOE Division of High Energy Physics) positioned the first survey monument.

October was a good month in several other ways for the ISABELLE project. A superconducting dipole magnet topped 5 T and the U.S. Congress approved $23 million for machine construction in Fiscal Year 1979.

The initial design of ISABELLE aimed for colliding proton beams of energy up to 200 GeV. This required the superconducting bending magnets to reach a peak field of 4 T. At a later stage, the top energy was moved to 400 GeV and the design of the rings then required a peak field of 5 T which is pushing the niobium-titanium superconductor as high as it can reasonably go. Early in October, the first magnet designed to reach 5 T exceeded this goal.

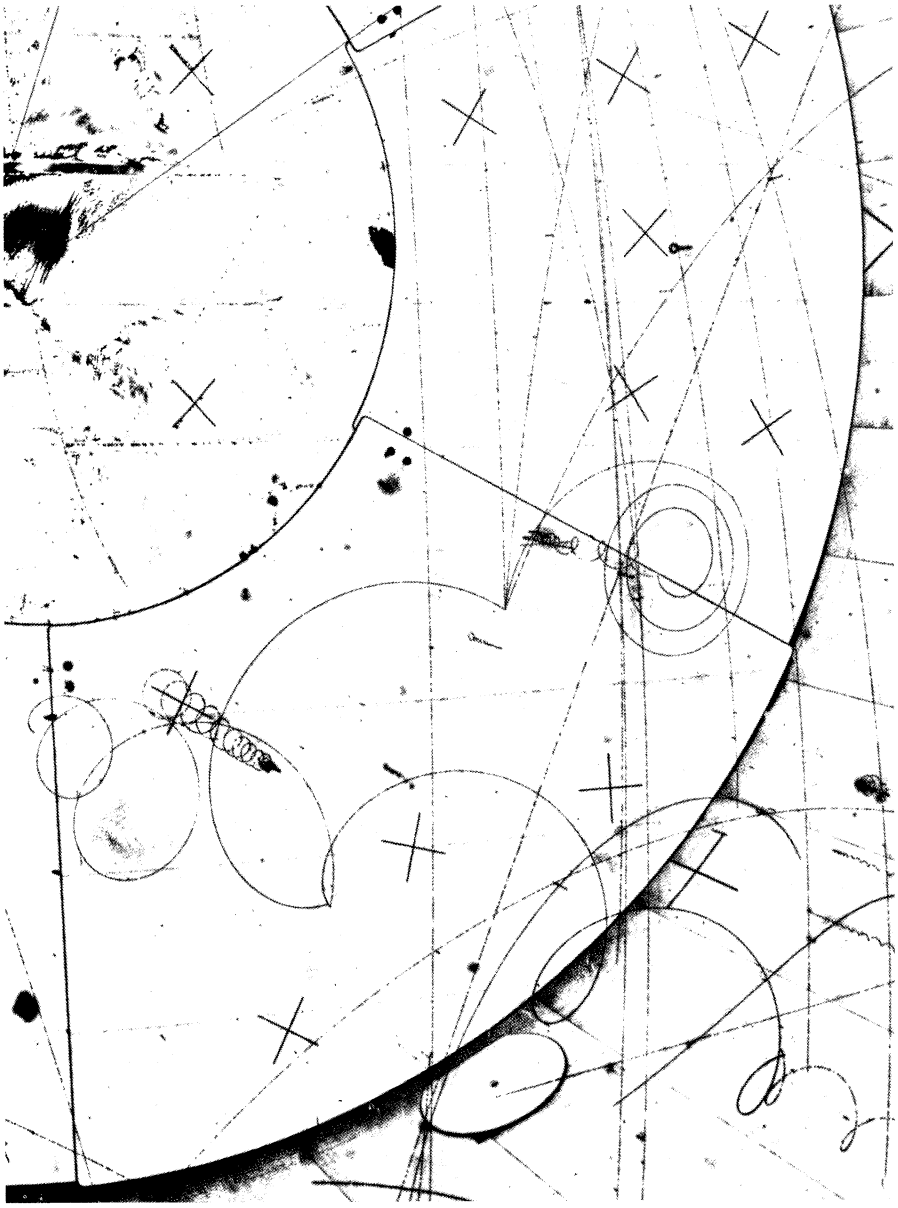
Later in the month, Congress blessed $23 million for construction. It will be used to build a third of the ring tunnel and one of the experimental halls (the 'Wide Angle' hall near the two injection points on the rings). Components for a hundred of the magnets will also be obtained and assembly will follow in subsequent years on the floor of the hall which used to house the Cosmotron accelerator.



The ISABELLE groundbreaking ceremony on 27 October: Left to right, Congressman Jerome Ambro, Under-Secretary of the Department of Energy Dale D. Myers and Gerald F. Tape, President of Associated Universities Inc., setting the first concrete survey monument for ISABELLE.

(Photo Brookhaven)

Textbook charm production as seen in neutrino interactions in the BEBC bubble chamber by the Aachen / Bonn / CERN / Munich / Oxford collaboration. Although their short lifetime prevents the two charmed mesons from being seen directly, all other particles from the production vertex and subsequent decays are charged and give observable tracks. This gives a very reliable indication of the kinematics of the decay chain.



CERN
Textbook charm

From a run with the BEBC bubble chamber filled with hydrogen and exposed to the wide-band neutrino beam from the SPS, an Aachen / Bonn / CERN / Munich / Oxford collaboration has discovered an event which is an explicit example of the production and decay of charmed mesons.

Rather than measuring the level of charm production by analysing produced muons and / or electrons, the object of the BEBC experiment is to search for explicit examples of charm production and decay, with maximal identification of all particles.

The event is a textbook example of charm production and subsequent decay, and is also the first sighting of explicit charm production at CERN. In the basic reaction, the incoming neutrino hits a proton, producing a negative muon and an excited charmed meson, D^{*+}. The muon is identified through simultaneous hits in both planes of the BEBC External Muon Identifier (EMI). The initially-produced D^* very quickly decays into a lighter charmed meson, D°, plus a pion. The D° in turn breaks up into a kaon and a pion.

Although neither of the two charmed mesons can be seen in the photograph because of their short lifetime, all other particles from the initial production vertex and the subsequent decays are electrically charged and give observable tracks.

No additional invisible neutral particles have to be included and measurements therefore give very reliable information on the kinematics of the decay chain. This gives the masses of the charmed D^* and D° mesons, and the mass difference between them is found to be 145 MeV, in agreement with measurements at SLAC.

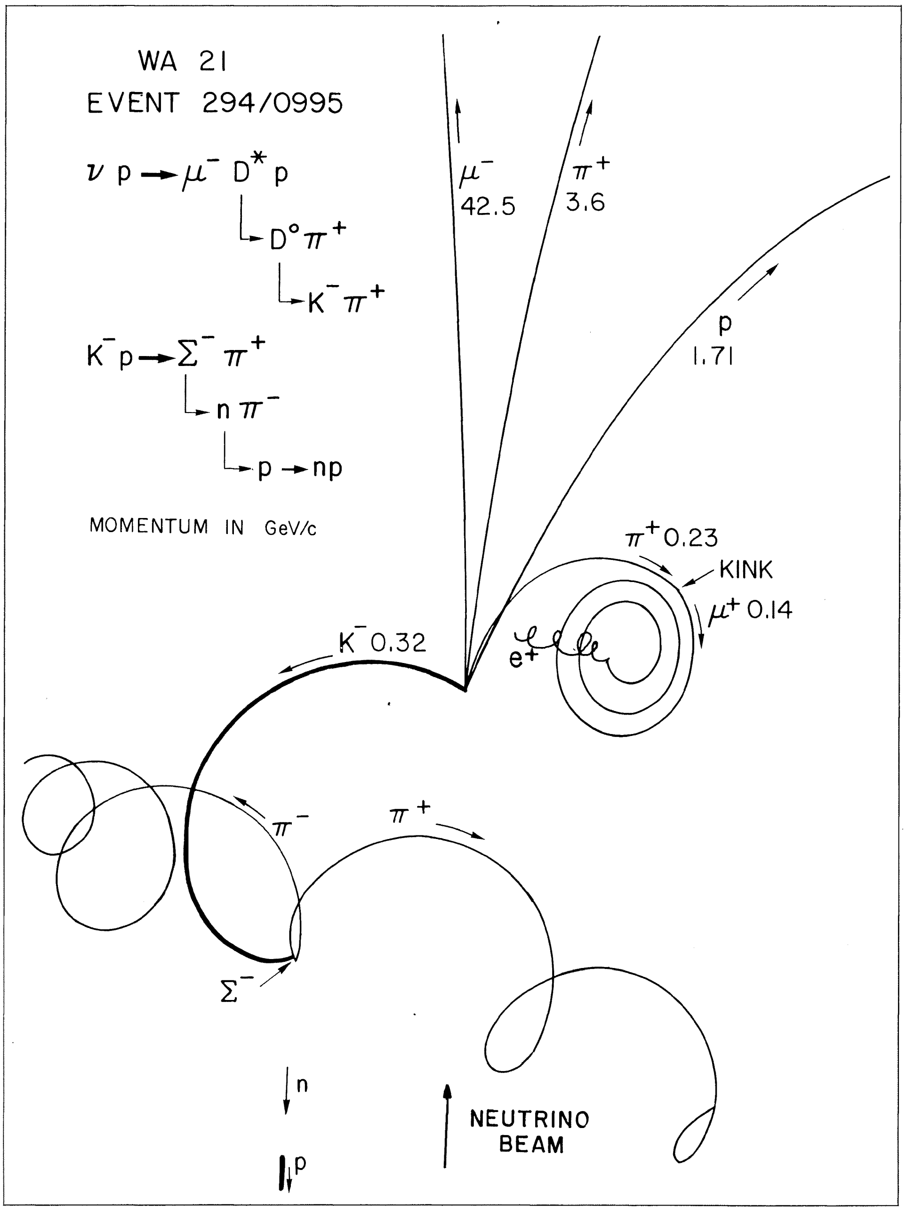
A nice touch is provided by the negative kaon from the decay of the D°, which curves round in the magnetic field, finally stopping and interacting with a proton. This produces a sigma and a pion which have to emerge in exactly opposite directions to conserve momentum.

After travelling about a centimetre, the sigma decays into a neutron and a pion, and just to complete the picture, the invisible neutron hits a proton, which recoils and produces a short stub track.

Also the slow positive pion from the charm decay is seen to decay in flight, emitting a positive muon and a neutrino. There is a tell-tale kink in the track at the point where the otherwise invisible neutrino is produced. The positive muon continues to spiral until it comes to rest and produces a positron.

Although the lifetime of charmed particles seems to rule out observable bubble chamber tracks, their decay

Explanation of the charm production event seen in BEBC. As well as the production and decay of charmed mesons, the photograph shows a negative kaon stopping and interacting with a proton, with interesting consequences. The weak decay of a positive pion can also be followed, the decay point and emission of a neutrino showing up as a definite kink in the spiral.



products can be studied in detail in bubble chamber experiments. This could supplement the knowledge of charmed particle spectroscopy gained so far from experiments at electron-positron machines.

With the first charm production event containing such a wealth of information, the BEBC collaboration is hoping that the remainder of the 285000 photograph sample will reveal a great deal.

Hypernuclei

Experiments at CERN using hypernuclei have discovered a remarkably simple behaviour in the interaction between lambda particles and nuclei. While the results are not yet fully understood, they could provide an additional clue in the quest to explain the details of nuclear forces.

Hypernuclei are formed when the usual nucleons in atomic nuclei are transformed into heavier particles (hyperons) by bombarding a target with a low-energy kaon beam. The investigation of these artificial nuclei supplements our knowledge of particle behaviour gained from scattering experiments.

Of the commonly-encountered hyperons, only the spin one-half, electrically neutral lambda particle of mass 1115 MeV is stable against strong decays. As the lightest baryon carrying strangeness and being only slightly heavier than the nucleon, the lambda cannot decay through strangeness-conserving strong interactions into a nucleon and a kaon.

Instead, the free lambda decays weakly with a lifetime of 2.6×10^{-10} s, violating strangeness and producing a nucleon and a pion. In nuclear matter, the presence of nucleons makes another decay possible, in which a lambda and a nucleon decay weakly into two nucleons. It is in fact this decay which governs the lifetime of lambda particle hypernuclei, which at about 2×10^{-10} s is long enough to allow their strong and electromagnetic properties to be studied.

The lambda-nucleus interaction is comparable in strength to the nucleon-nucleus one. Carrying spin one-half but no electric charge, the lambda could be expected to behave in a nucleus much like a neutron, were it not for the fact that the lambda carries strangeness. Thus the study of hypernuclei provides important information about the strangeness properties of the strong interaction.

In a series of experiments at CERN, a Heidelberg/Saclay/Strasbourg collaboration used a low energy (about 700 MeV) separated negative kaon beam from the 28 GeV Proton Synchrotron. These experiments detected transitions where the struck nucleon, when converted to a lambda, also shifted into another nuclear energy level. These results revealed that the lambda-nucleus interaction has a particularly simple form, where the lambda, although carrying spin one-half, seems to behave like a spinless particle.

With low-energy kaon beams (typically less than 1 GeV), the recoil energy of the lambda particle formed from a struck nucleon is less than the Fermi motion of the individual nucleons. This means that the lambda will tend to remain in the same energy level as the parent nucleon. These transitions are termed 'recoilless'.

In addition, other interactions are possible in which the struck nucleon receives enough momentum to knock the lambda into another energy level in the nucleus. The probability of such reactions, known as 'quasi-free', increases with the energy of the incident kaons.

The aim of the initial experiments by the Heidelberg/Saclay/Strasbourg collaboration, using 715 MeV negative kaon beams on carbon-12 and oxygen-16 targets, was to study the fine structure of hypernuclei formed in recoilless transitions and to search for quasi-free transitions, never before studied in detail. In these experiments the rate of hypernucleus production was increased almost a hundred-fold over previous investigations.

Besides the dominant pair of recoilless transitions, the oxygen spectrum showed an additional doublet which has the properties expected of quasi-free transitions where the lambda falls into a lower energy level with different angular momentum.

What is remarkable is that the splitting within these doublets is the same for the recoilless and the quasi-free transitions, showing that the spin-orbit interaction does not seem to change with angular momentum. This is in contrast to the nucleon-nucleus interaction, in which the spin-orbit effect is dominant over everything else.

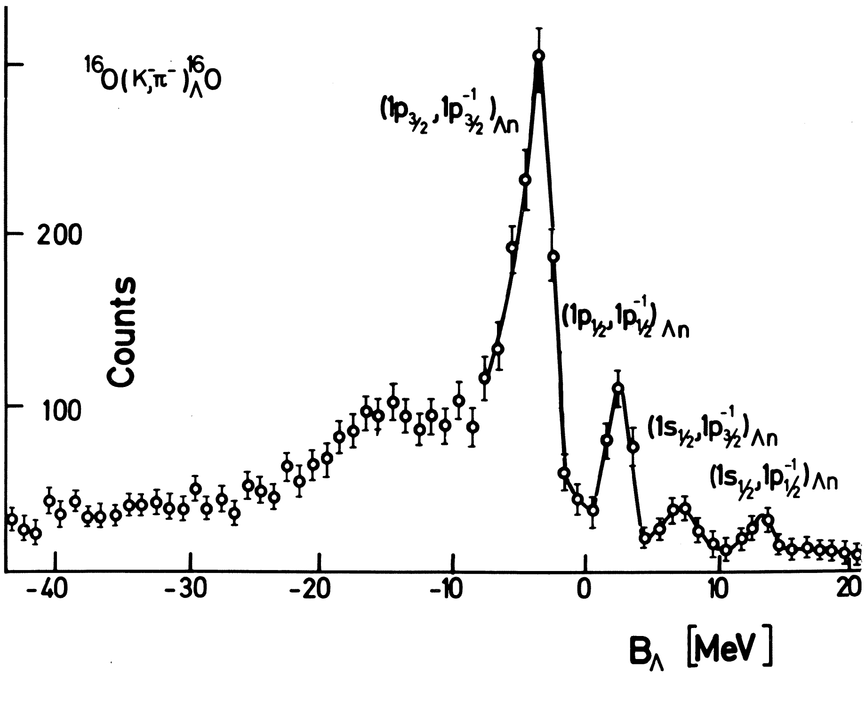
Results from investigations using calcium-40 and sulphur-32 with a 790 MeV negative kaon beam again show minimal spin-orbit coupling, and reveal as well that the splitting between neighbouring energy levels seems to be roughly constant. It is as though the lambda-nucleus force is described by a spin-independent potential of a simple harmonic oscillator type.

The spin-orbit force plays an important role in nuclear physics, and lies behind many prominent features of nuclear behaviour. However its origin and its remarkable strength with nucleons are still not fully explained. Perhaps the discovery of the radically new behaviour with lambda particles could shed new light on this old problem.

Niobium-tin route to 8 T

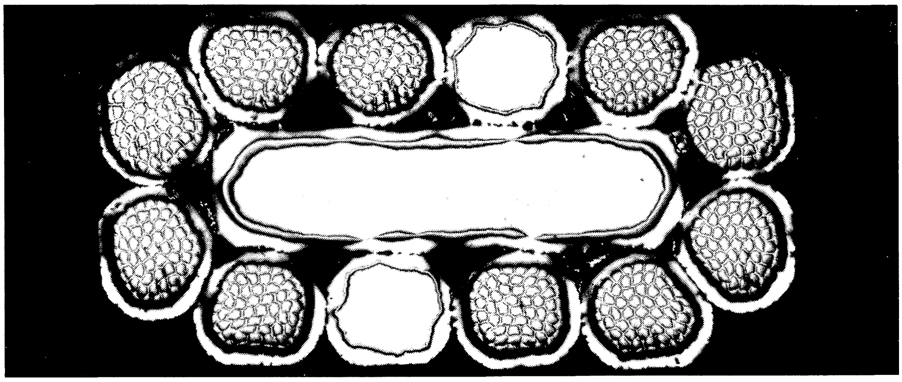
For many years it has been known that the niobium-tin alloy has considerable advantages over the 'conventional' niobium-titanium alloy as a superconductor. It has a much higher transition temperature (18 K) before losing its superconducting property and can take extremely high currents even at high fields (10^7 A per cm^2 at 10 T).

Unfortunately its metallurgical properties are much less favourable, which is why niobium-titanium has been the preferred alloy for almost all applications up to now. Niobium-tin is



Spectra from the Heidelberg/Saclay/Strasbourg collaboration studying the production of hypernuclei at CERN using low-energy kaon beams incident on oxygen-16. B is the binding energy of the lambda particles in the hypernuclei. The two prominent enhancements are those where the produced hyperon remains in the same energy level as the struck nucleon, while the two smaller peaks correspond to transitions where the lambda falls into a lower energy level. This is the first time that these transitions have been detected, and reveals startling new information about the lambda-nucleus-interaction.

The conductor used in a niobium-tin superconducting solenoid which has given 8.8 T in tests at CERN. The conductor has a cross-section of 1.1 × 2.2 mm^2. The white areas are copper and there are ten strands with niobium-tin filaments in a bronze matrix.



very brittle and strains of less than 1 % are sufficient to break filaments. It is thus difficult to fabricate in the configurations needed for magnet coils.

Two techniques in particular have been pursued to overcome this problem. One uses niobium filaments surrounded by copper-tin bronze while forming the coils and then reacts at high temperature so that the tin diffuses into the niobium to give the required alloy. This technique has been developed, for example, by a Rutherford/Harwell collaboration. They produced a solenoid giving 10 T fields some time ago though not using high current density (see October issue 1974, page 349). The other technique uses niobium in tin-coated copper and reacts the formed braid so that the tin diffuses in to give the alloy. Brookhaven have pioneered this technique and have recently powered a superconducting niobium-tin dipole.

A small team, led by A. Asner with D. Hagedorn in the SPS EMA Group, came into the game two years ago and followed the bronze technique in trying to develop magnets using copper stabilized, fine filamentary niobium-tin superconductor to give fields up to 8 T with overall current densities in excess of 300 A per mm^3. They worked with two firms, IMI and Vacuumschmelze, on the superconductor, and Isolawerke and Quartz & Silice on the insulation.

Insulation is a tricky problem because of the high temperature swing from reaction at 1000 K to operation at 4 K. A quartz glass sleeve 0.2 mm thick was used around the conductor, impregnated initially with paraffin (which was later drawn off when the insulation was in place during reaction of the superconductor). After reaction the winding was impregnated with epoxy resin.

The latest results with a solenoid (26 mm internal diameter, 92 mm external diameter, 53 mm long) using conductor of 1.1 × 2.2 mm^2 cross-section have given a field of over 8.8 T with 350 A per mm^2 which is a better performance than was anticipated. These short sample figures were reached without any training. The coil could be pulsed to 7 T in about 60 s.

A lot has been learned on the problems of handling the brittle superconductor, on the insulation and on the current lead connections to the windings. The test solenoid had many features in common with large superconducting magnets and the results are another step towards the application of niobium-tin in magnets to give fields in the 8 T range.

DARESBURY SRS takes shape

Since 1975 a dedicated synchrotron radiation source (abbreviated SRS) has been under construction at the Daresbury Laboratory to replace the synchrotron radiation research facilities which ceased to be available when the 5 GeV electron synchrotron, NINA, was closed down in 1977.

A very active research programme had been built up using the by-product synchrotron radiation from NINA. At present, with no source existing in the UK, many of the previous users are scattered amongst the various synchrotron radiation centres in Europe and the USA. Their return is expected in 1980 when the SRS will come into operation as the first purpose-built high energy source entirely dedicated to synchrotron radiation use.

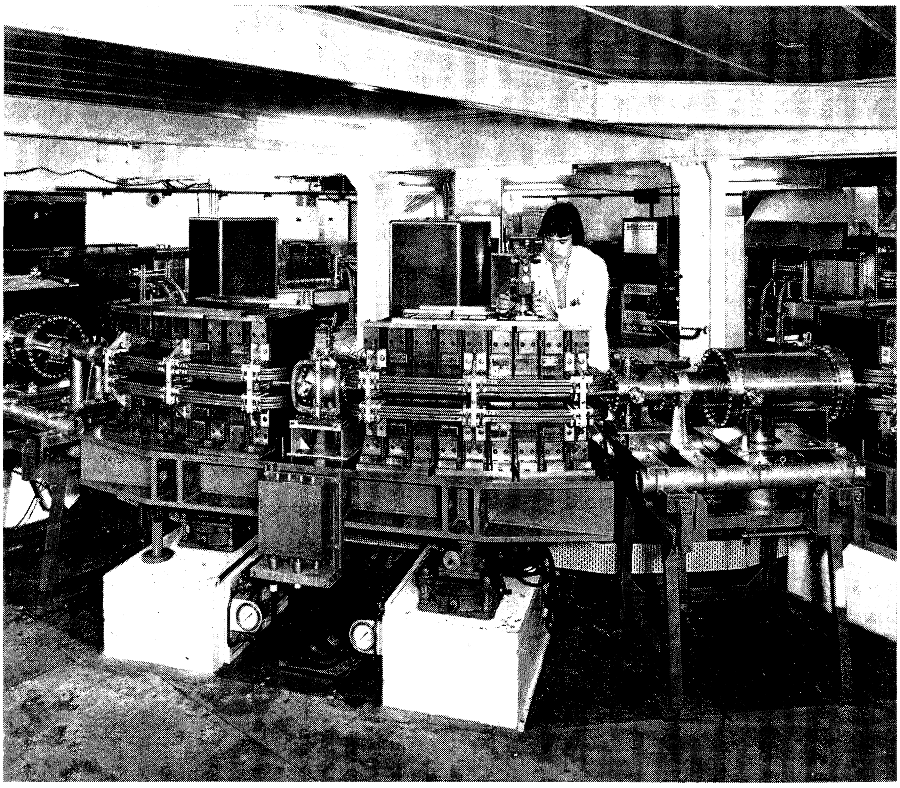
The new 2 GeV electron storage ring is designed for an eventual stored beam current of 1 A, although initially only half the r.f. power will be installed and the current will be limited to about one third of this. The radiation produced in the 1.2 T bending magnets will have a characteristic wavelength of 3.9 Å and the spectrum should be usable down to 1 Å, so catering for ultraviolet, vacuum ultraviolet and soft x-ray physics. It is also planned to install two superconducting 5 T wiggler magnets to extend the radiation into the hard x-ray region. One of these wigglers is now being built.

The design of the storage ring was influenced very much by the requirements of the synchrotron radiation users. A FODO lattice allows good access to the radiation and wide angle beams can be extracted without obstruction. The r.f. frequency of 500 MHz was selected to give very short electron bunches since there is great interest in using short bursts of radiation.

The storage ring and its surrounding experimental area will fit nicely into the Inner Hall which formerly contained the power supplies for the NINA r.f. and magnets. Construction work in the Inner Hall is well advanced and the project is on schedule for the start

A view of the booster synchrotron for the SRS showing the metallic vacuum chamber and the combined function magnets. The straight section in the right foreground contains a fast kicker for beam extraction.

(Photo Daresbury)

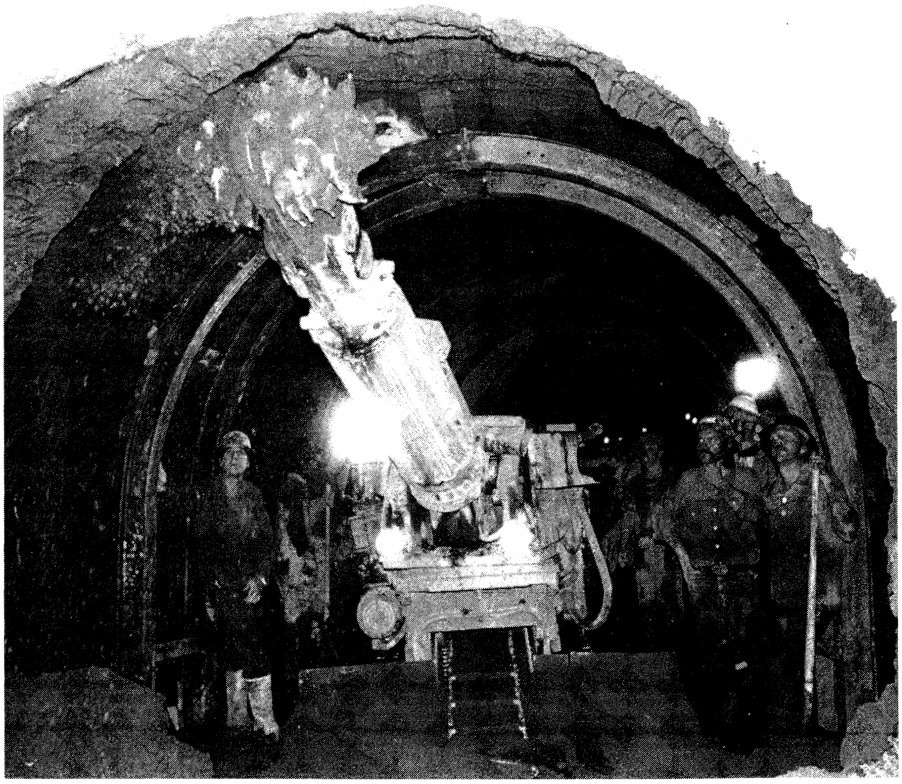


of commissioning in April 1980. Prototypes of the r.f. cavity and all the magnets have been made and measured and all major components are now in the process of being manufactured.

An important milestone was passed on 10 October when the injection accelerators for the storage ring, a 15 MeV electron linac which feeds a 600 MeV booster synchrotron, accelerated beam for the first time. This booster, completed during the summer, is a combined function synchrotron with a mean radius of 5 m.

A feature of the booster is its clean, all-metal vacuum system which is necessary because it will be connected directly to the sensitive vacuum system of the storage ring. In the magnet gaps, the vacuum chamber is made of thin stainless steel (0.25 mm) which is convoluted, rather like a bellows, for strength.

Acceleration takes place at 10 Hz — the maximum rate at which the storage ring can accumulate at its injection energy. The cycling magnetic field produces eddy currents in the metallic vacuum chamber but no problems have been experienced in accelerating a beam. After the initial capture, the beam accelerates cleanly without loss.



This photograph was taken at Stanford on 10 October when tunnelling for the PEP electron-positron storage ring was completed.

(Photo Joe Faust)

Physics monitor

Grand unification

'There is the scent of a new grand synthesis in the air.' These were the words of Murray Gell-Mann in his closing talk at the 1974 Stanford Accelerator Conference. Now, four years later, theories based on symmetry ideas have made further progress. With quantum chromodynamics maturing as a theory of inner hadronic interactions, and with the 'Weinberg-Salam model' almost ready for the textbooks as a unified picture of weak and electromagnetic interactions, the scent of 1974 must have ripened into an all-pervading aroma !

In quantum chromodynamics (QCD), the key idea is that while inter-quark forces are strong over relatively large regions of space-time (for example over the extent of a single nucleon), they get 'weaker' as the space-time region of the interaction gets smaller. It is this variation in the strength of the inter-quark forces which opens the door to further progress.

It means that the forces at work when high energy leptons pierce through to the deep interior of hadrons are much simpler than had previously been thought possible. Traditionally, strong interactions had been attributed with a cumbersome coupling strength which prevented any quantitative progress.

The new simplicity allows the techniques of perturbation theory to be used, quantum electrodynamics style, in new areas of physics and gives good predictions (see October issue, page 335).

The variation in the strength of the inter-quark force also means that out at an extremely high energy, these components of the 'strong' force may become comparable in strength to the electro-weak effects. Under such conditions, it is possible that there is some larger symmetry which encompasses those of both the strong and electro-weak worlds.

In the standard electro-weak theory, some of the available degrees of freedom in the ideal symmetry picture are 'frozen out', so that part of the symmetry is destroyed. The symmetry is said to be 'spontaneously broken'. Although vestiges of the full symmetry remain, the electromagnetic and weak interactions appear as different forces.

In the same way, a larger symmetry describing both strong and electro-weak effects could be spontaneously broken so that the strong and electro-weak components split. As well as having the aesthetic appeal of achieving a grand unification of three apparently highly different fields of force, this idea also produces important quantitative results which are unobtainable with separate theories of strong and electro-weak interactions.

In the standard 'Weinberg-Salam' formulation of electro-weak interactions, there is one free parameter — a mixing angle. This describes how the intermediate boson held responsible for the neutral current of weak interactions appears in the theory, fixing its mass and coupling strengths.

This parameter also dictates how the familiar description of electromagnetism is embedded in the larger theory of electro-weak interactions. This mixing angle is a free parameter which normally can only be determined from experimental results.

However the introduction of additional symmetry principles gives relationships between the coupling strengths of the component symmetries describing the individual forces, and allows the mixing angle to be calculated. Although there are a number of candidates for the overall grand symmetry, results from a number of calculations give acceptable values for the mixing angle. The fact that such a revolutionary idea gives results in broad agreement with experiment is certainly encouraging.

The basic particles in the grand symmetry theory are the pointlike quarks and leptons. While having totally different properties in the everyday strong and electro-weak domains, the grand symmetry brings these particles together into common multiplets.

If the symmetry were exact, the masses of the quarks and leptons would be the same. However the symmetry breaking shifts the masses of the particles. Since the masses of the leptons are known accurately, the application of ideas from the renormalization group (see September issue, page 304) gives a handle on the spectrum of the quark masses.

The calculations agree with the observed thresholds for the production of heavy quarks with charge $-1/3$, such as the strange quark and the new heavy quark responsible for the upsilon states.

The calculations seem to work best if there are six, or at the most eight, quark flavours. This is good news because six is the minimum number of quarks required to incorporate CP violation into the theory in a natural way, and also ties in with cosmological ideas on the permitted number of different massless neutrinos.

Any 'gauge' theory of a force field naturally produces vector (spin one, negative parity) bosons which mediate the force — photons for electromagnetism, intermediate bosons for the weak interactions and gluons for the inter-quark forces. So far, the photon is the only such particle whose existence cannot be doubted, and the immediate future of QCD and of the electro-weak theory rests on finding evidence for their respective vector bosons.

Introducing a grand gauge symmetry to unify all the other particle forces produces in turn its own force. This additional field would have its own set of bosons bringing about interactions between the basic particles — the leptons and the quarks.

Such a force would not differentiate between quarks and leptons and would convert quarks to leptons and vice versa. Such a transmutability of quarks would show itself as an instability of hadrons, and the new force would apply equally to all hadrons, including the otherwise stable proton. While conservation of baryon number is well-entrenched in our thinking, there is no fundamental principle which dictates that the proton must be absolutely stable.

To ensure that the strong and electro-weak domains are well separated at currently available energies, their meeting point has to be at an extremely high energy. This implies that the bosons of the grand symmetry are very heavy, say in the range 10^{14}-10^{16} GeV, and that the resulting force is very feeble.

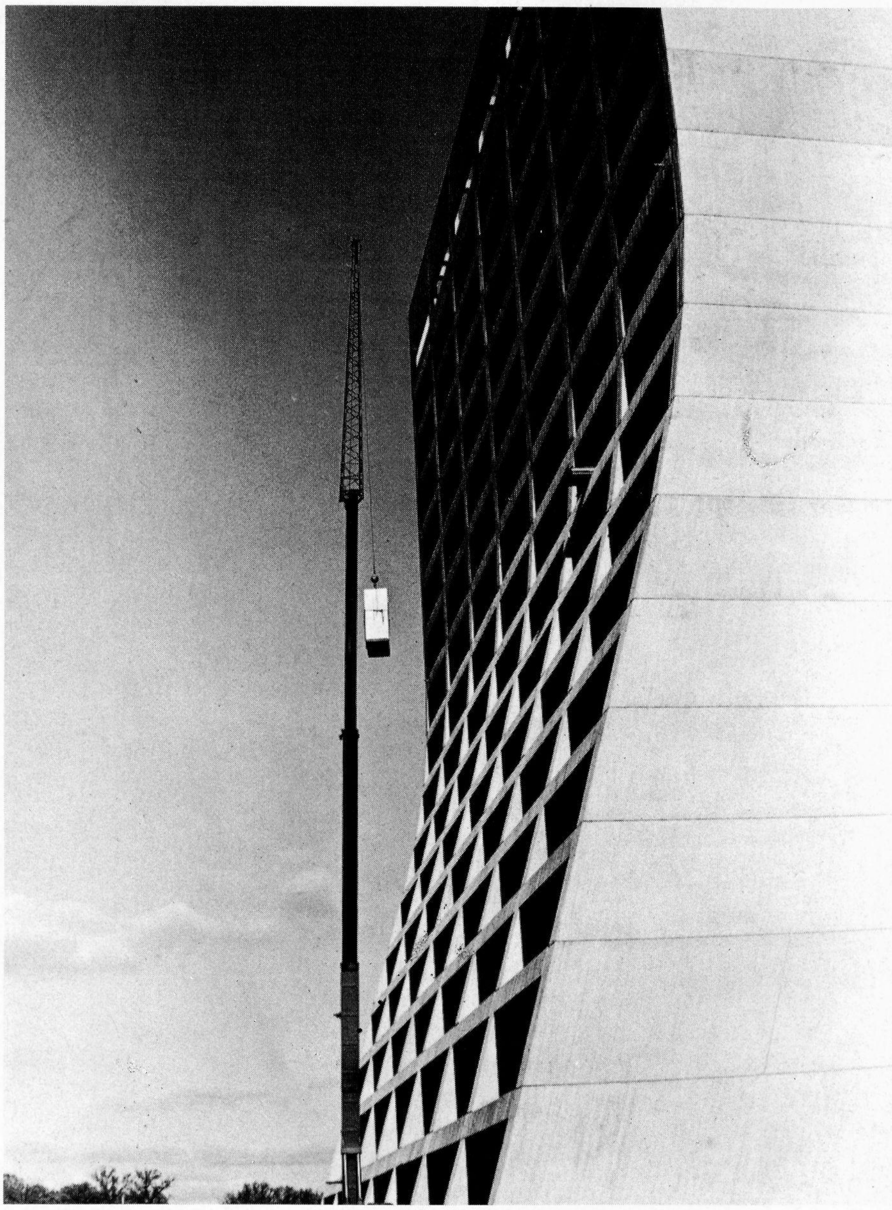
While such a 'hyperweak' force would be masked by other effects in the decays of most hadrons, the proton would still be unstable, although only just. Methods can be brought in to restore stability to the proton, but they tend to spoil the general appeal of the scheme.

The history of modern physics is littered with attempts to unify the various fields of force. Some of the most heroic were those of Einstein and Weyl earlier this century, who did not have the benefit of our new insight into the possibility of electro-weak synthesis.

After the successes of the electroweak theory, the way was clear to attack again the problem of grand unification. Most efforts centre on establishing a minimal overall symmetry which incorporates the different symmetries required for the strong and electro-weak worlds. Others propose different sets of particles, possibly even more fundamental than the quarks and leptons.

According to some formulations of the unification scheme, new phenomena are conceivable from a new generation of particle accelerators.

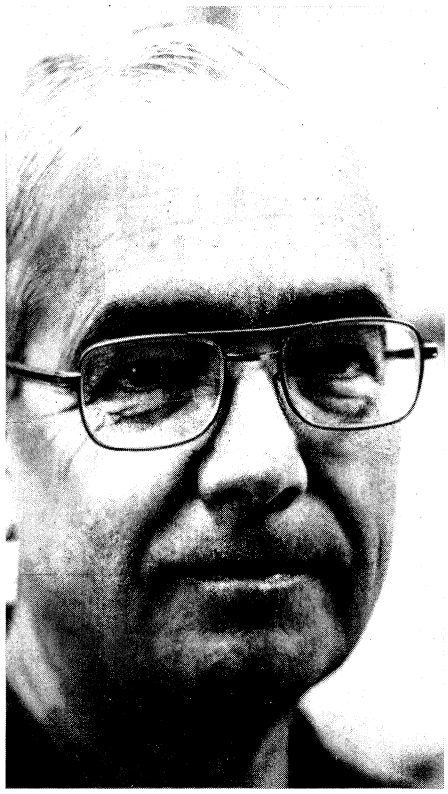
Whether present efforts are still premature, only time will tell. However in the words of Howard Georgi and Sheldon Glashow, among the first to reattempt this unification, 'our hypotheses might be wrong and our speculations idle, but the uniqueness and simplicity of the scheme are reasons enough for it to be taken seriously'.



Hardware for the new Fermilab computer system being hoisted into place on the eighth floor of the Central Laboratory Building. The system consists of three powerful CDC CYBER 175 computers with a full set of peripherals. Initial operation started in November with the full system capacity scheduled to become available in the Spring of 1979.

(Photo Fermilab)

People and things



Bill Fowler

Fermilab Director Designate

On 24 October it was formally announced by Norman Ramsey (President of Universities Research Association Inc.) and John Deutch (Director of Energy Research, DOE) that Leon Lederman has been appointed next Director of the Fermi National Accelerator Laboratory. Leon Lederman's appointment has been an open secret for some months and he will take office full time as from 1 June 1979 (because of previous commitments at Columbia University). In the meantime he will be involved in all major policy decisions at Fermilab in collaboration with the Acting Director, Phil Livdahl.

Leon Lederman needs no introduction to COURIER readers. He has a great reputation in experimental high energy physics with participation in the discoveries of non-conservation of parity, two neutrinos and the upsilon to his credit. He is also an elegant and witty exponent of his subject. (As an example of this, try his 'unauthorized autobiography' in the October 1977 issue, page 337). We wish him well in the challenging task of leading Fermilab in the years to come.

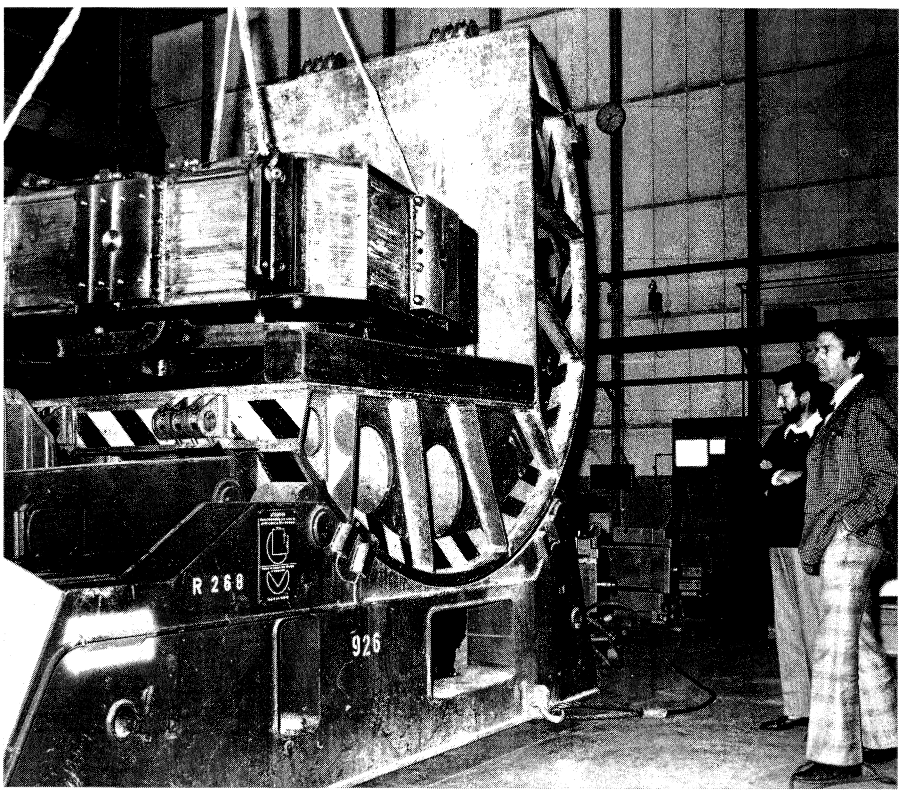
On people

As from 1 October, the Energy Doubler at Fermilab has moved from its R and D phase to its construction project phase. To build the superconducting magnets which will make 1000 GeV proton beams available from the Doubler, a new 'Energy Doubler Magnet Division' has been set up with Bill Fowler as Division Head and Dick Lundy as Deputy Head. Alvin Tollestrup is Associate Head in charge of the superconducting magnet development. Don Young has been appointed Deputy Head of the Accelerator Division.

Following elections in the High Energy Discussion Group of the Brookhaven Users' Organization, the composition of the HEDG Executive Committee now reads: Michael Zeller - Yale (Chairman), Paul Grannis - Stony Brook, Mark Sakitt - Brookhaven, Al Mann - Pennsylvania, Myron Good - Stony Brook, James Bensinger - Brandeis, Alan Carroll - Brookhaven.

R.R. Wilson, former Director of Fermilab, is to remain active in the Laboratory on a joint appointment with the University of Chicago where he holds the Peter B. Ritzma Professorship. Bob Wilson is 'liaison physicist' in the newly formed Energy Doubler Magnet Division.

It was announced on 3 November that Harold Agnew is to resign as Director of the Los Alamos Scientific Laboratory as from 1 March 1979. Dr. Agnew has been Director of Los Alamos since 1970, succeeding Norris Bradbury and Robert Oppenheimer.



Roy Billinge (right) and Colin Johnson of the Antiproton Accumulator (AA) Group at CERN look on as the prototype wide aperture quadrupole magnet for the AA ring is prepared for test measurements. This 14 ton monster is the largest aperture (80 × 30 cm) quadrupole at CERN and was built in the CERN workshops. After measurements on this prototype are completed, contracts will be placed for the manufacture of the 9 wide quadrupoles required for the AA ring.

(Photo CERN 401.10.78)

Recent visits to CERN:

1. A scientific delegation from the People's Republic of China on 16 October.
2. The Swedish Research Council on 24 October.
3. The DESY Council on 25 October.

(Photos CERN)


1.


2.


3.

Raymond Davis from Brookhaven has been awarded the 1979 American Chemical Society Award for Nuclear Applications of Chemistry. The award will be presented next April at the ACS Meeting in Honolulu. It recognizes Raymond Davis' pioneering study of solar neutrinos using chemical techniques. (See October issue, page 351, for an account of solar neutrino work.)

Tributes to Bernard Gregory

Two brochures in honour of Bernard Gregory, who died at the end of last year, have been prepared. One, 'Bernard Gregory 1919-1977' has been produced at CERN and contains the speeches given at the memorial gathering held on 27 February (see March issue, page 84). It contains tributes from Charles Peyrou, John Adams and Louis Leprince Ringuet. The brochure is available from Danielle Metral, Publications Group, CERN, 1211 Geneva 23, Switzerland.

The second brochure 'Hommage à Bernard Gregory' is being published by the Ecole Polytechnique and will be available from Patrick Fleury, LPNHE, Ecole Polytechnique, 91128 Palaiseau, France. It contains the speeches given at the gathering on 23 May by Pierre Aigrain, André Astier, Hubert Curien, Patrick Fleury, André Giraud, Louis Leprince Ringuet, Xavier de Nazelle, Jean Teillac and Ionel Solomon.

Mobile monitoring

A mobile medical unit for measuring the concentration of dangerous chemical elements in the body has been developed by Ken Ellis and David Vartsky of the Medical Department at Brookhaven, using a neutron absorption technique and gamma ray detectors.

As a typical example of the potential of the unit, they are wheeling it to a zinc smelting plant and cadmium refinery in Denver, Colorado, to examine industrial workers exposed to cadmium contamination.

Cadmium is highly toxic. It concentrates particularly in the kidneys and liver and can cause high blood pressure and emphysema. It now has many industrial uses (rust inhibition, plating or galvanizing metal, battery production, light bulbs, paints and pigments, solder...) and it is useful to be able to monitor concentrations of the element in the bodies of people working in these production plants.

The Brookhaven facility uses a plutonium 238-beryllium source to provide a collimated beam of neutrons to irradiate the relevant parts of the body. The neutron flux is essentially constant in time and the concentration of cadmium can be estimated by the capture of neutrons by cadmium nuclei, which is accompanied by the

1. Bill Reay setting the bicycle endurance record around the Fermilab ring.

2. John Cumalat (left) and George Luste winning this year's round-the-ring canoe race.

(Photos Fermilab)

emission of gamma rays. Gamma detectors are positioned close to the body.

The technique probably can be extended to measure, for example, total body nitrogen and mercury concentrations.

Sportfests at Fermilab

The four mile circumference of the Fermilab main ring is a great challenge for active people because the ring road appears to be one of the largest circular tracks in the world. Hundreds of people circumnavigated the tunnel during the accelerator construction phase. Five years ago an annual canoe race around the ring cooling ponds was instituted. Joggers use the ring road as a track. In September a first biking outing was convened. Both the canoe and bicycle outings progress clockwise around the ring, in the same direction as the protons.

Bill Reay, a Fermilab user from Ohio State, set the bicycle endurance record. He completed twenty main ring laps in three and a half hours for an average speed of 23 miles per hour. His ride was cut short by rain. No single lap speed record exists but knowledgeable bikers suggest a possible lap time of eight minutes.

The annual canoe race is as much a test of portage skill as paddling. Eighteen portages are needed to skirt the small retaining dams in the cooling ponds. This year, George Luste, a user from Toronto, and John Cumulat of Fermilab won the race with a time of forty-five minutes and nineteen seconds. There is some indication that teams containing Canadian members perform best.

No formal records appear to exist for running times. A reasonably good runner can lap the ring in thirty minutes or less, or in other terms, beta = 0.000000012. People regularly run two laps around the ring but no endurance mark has been established.

1.

2.

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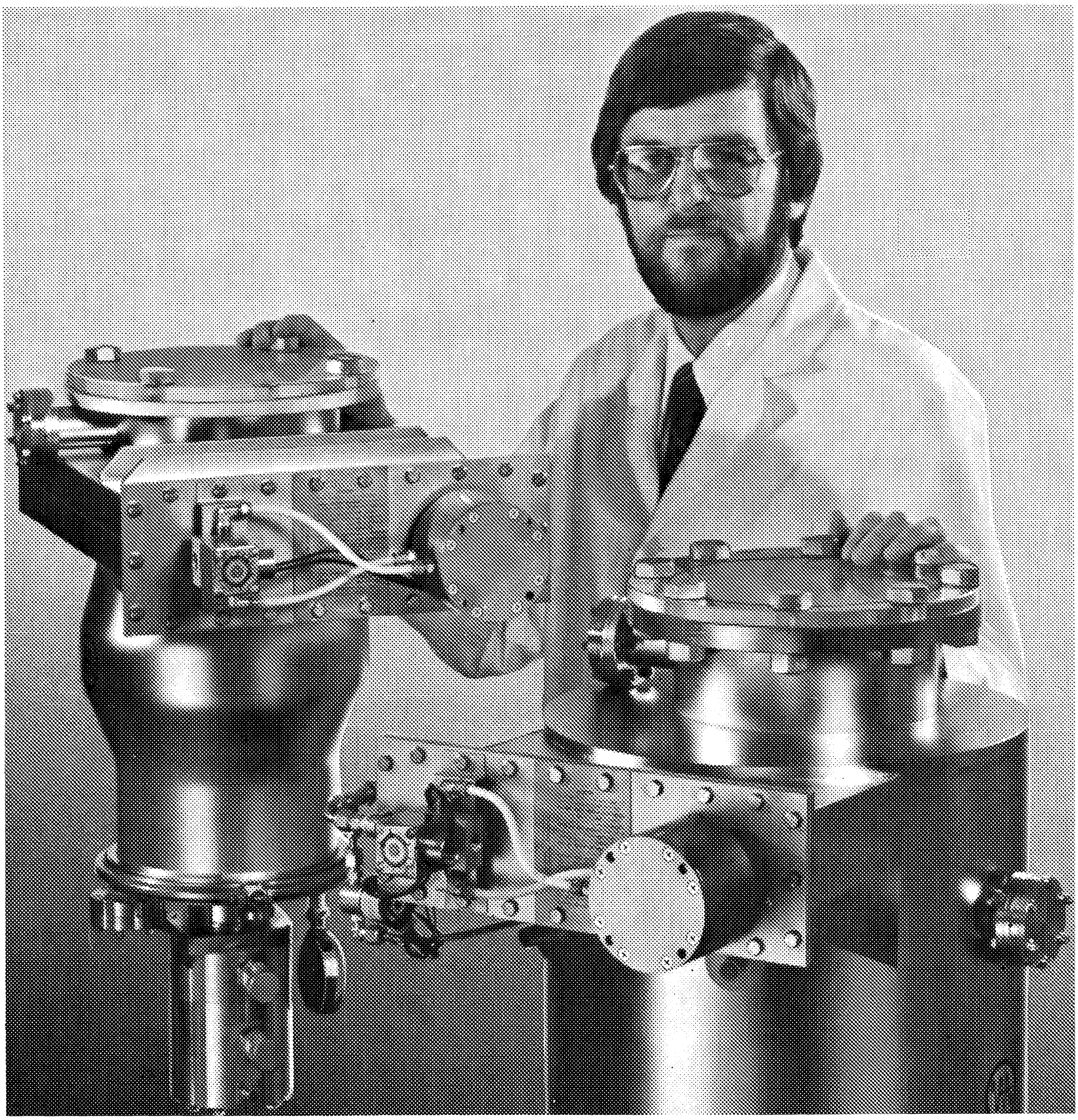

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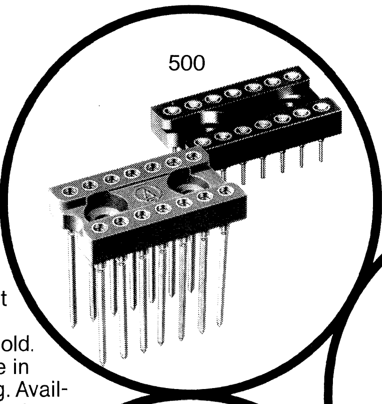

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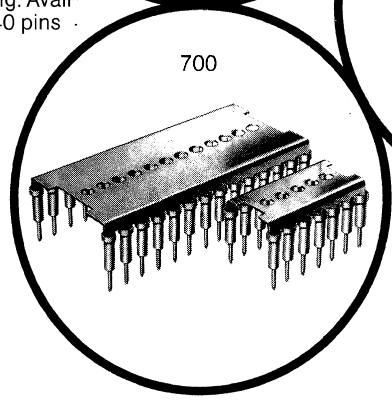

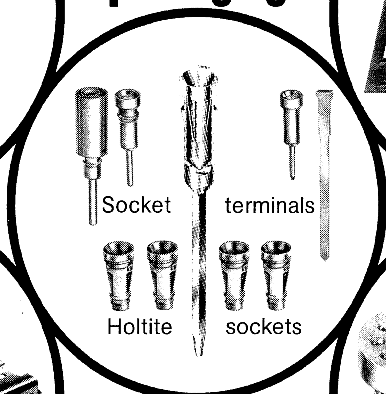

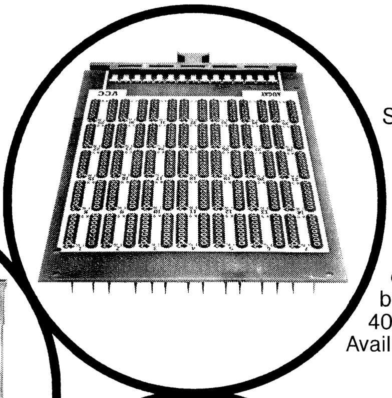

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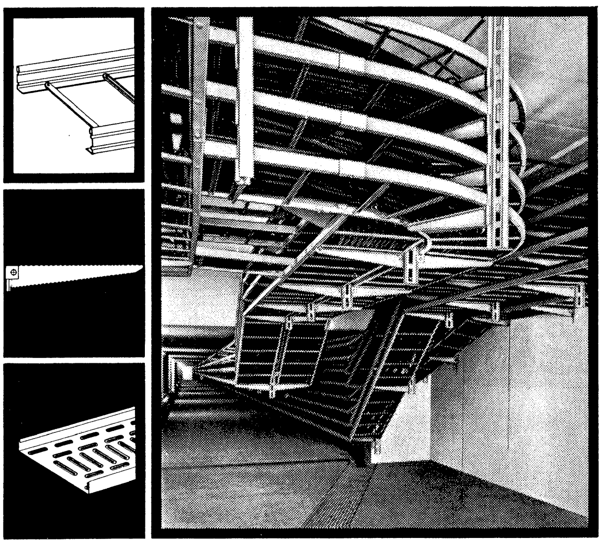

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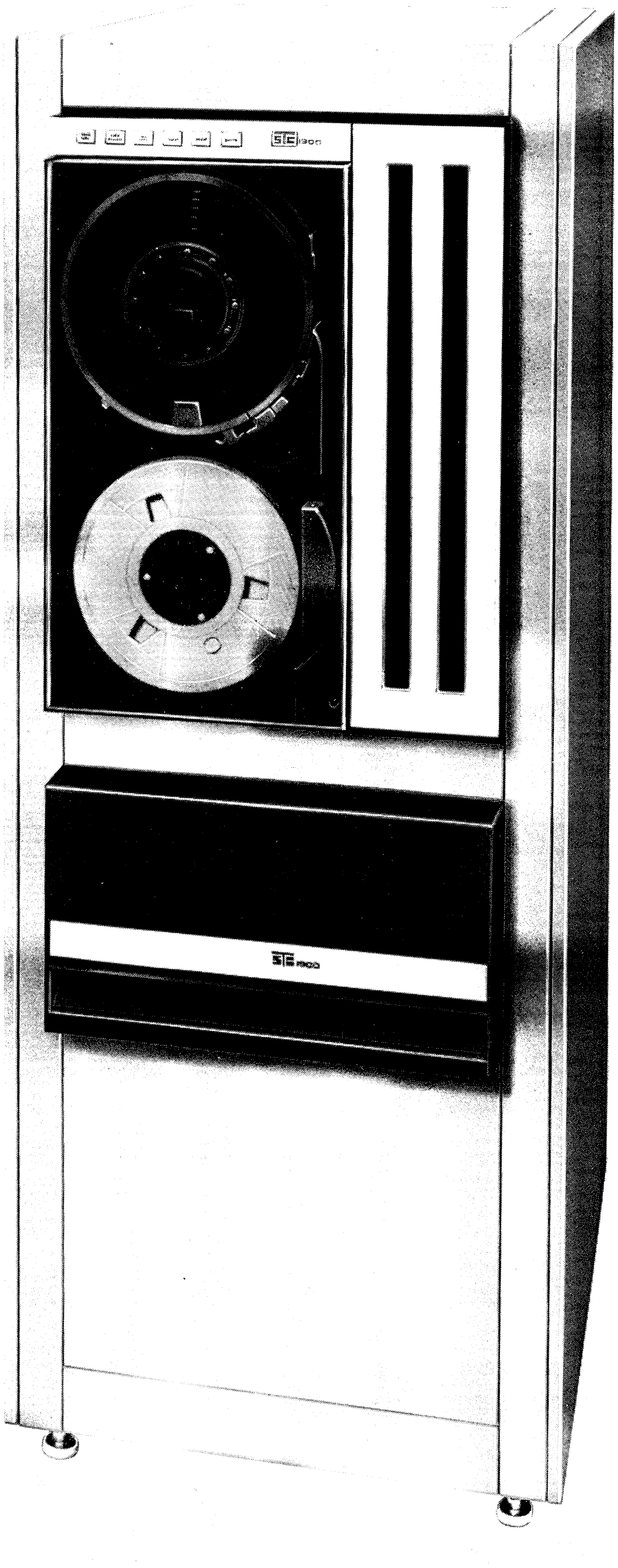

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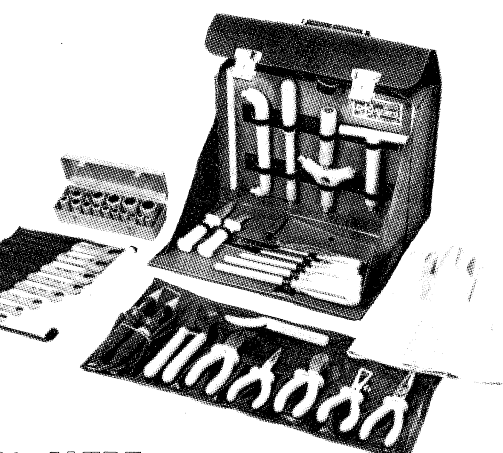

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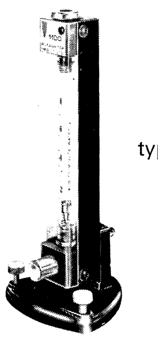

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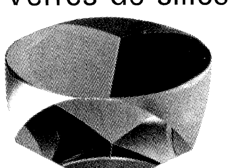

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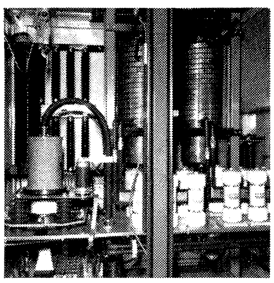

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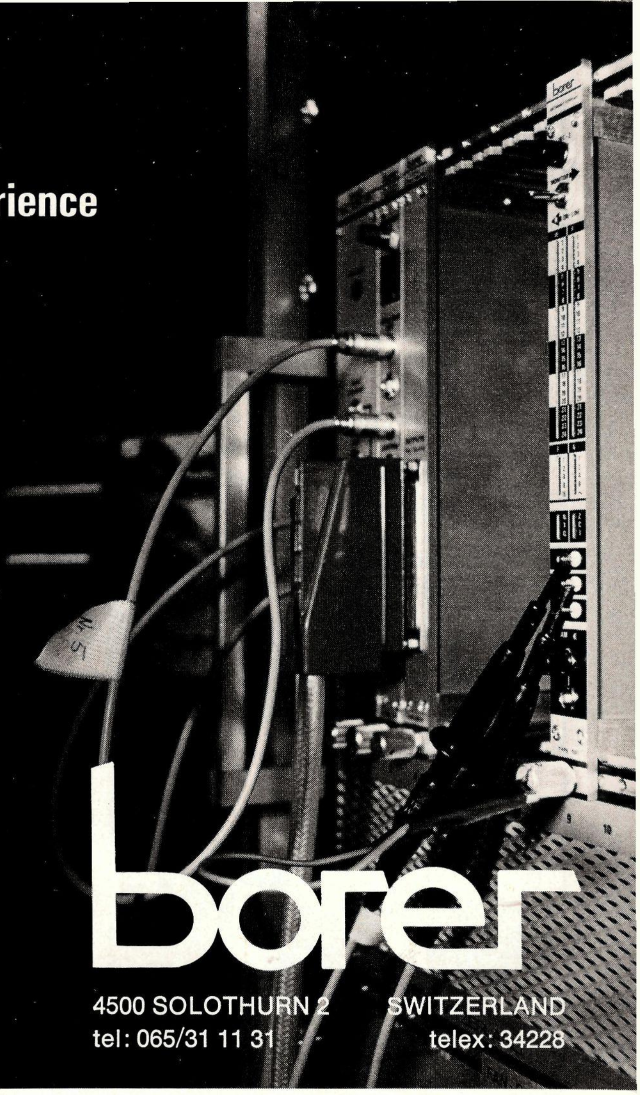

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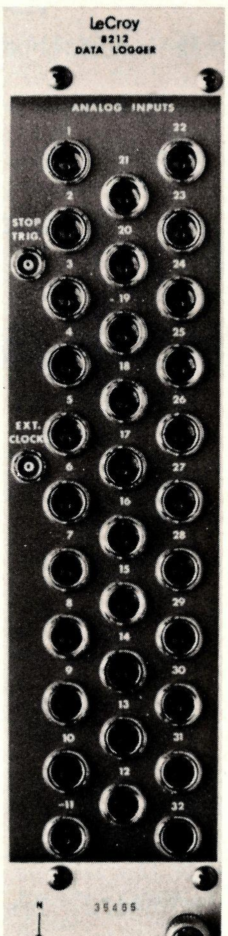

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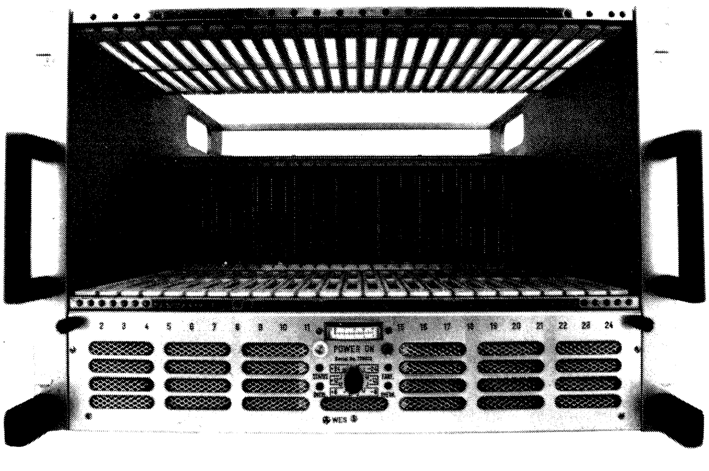

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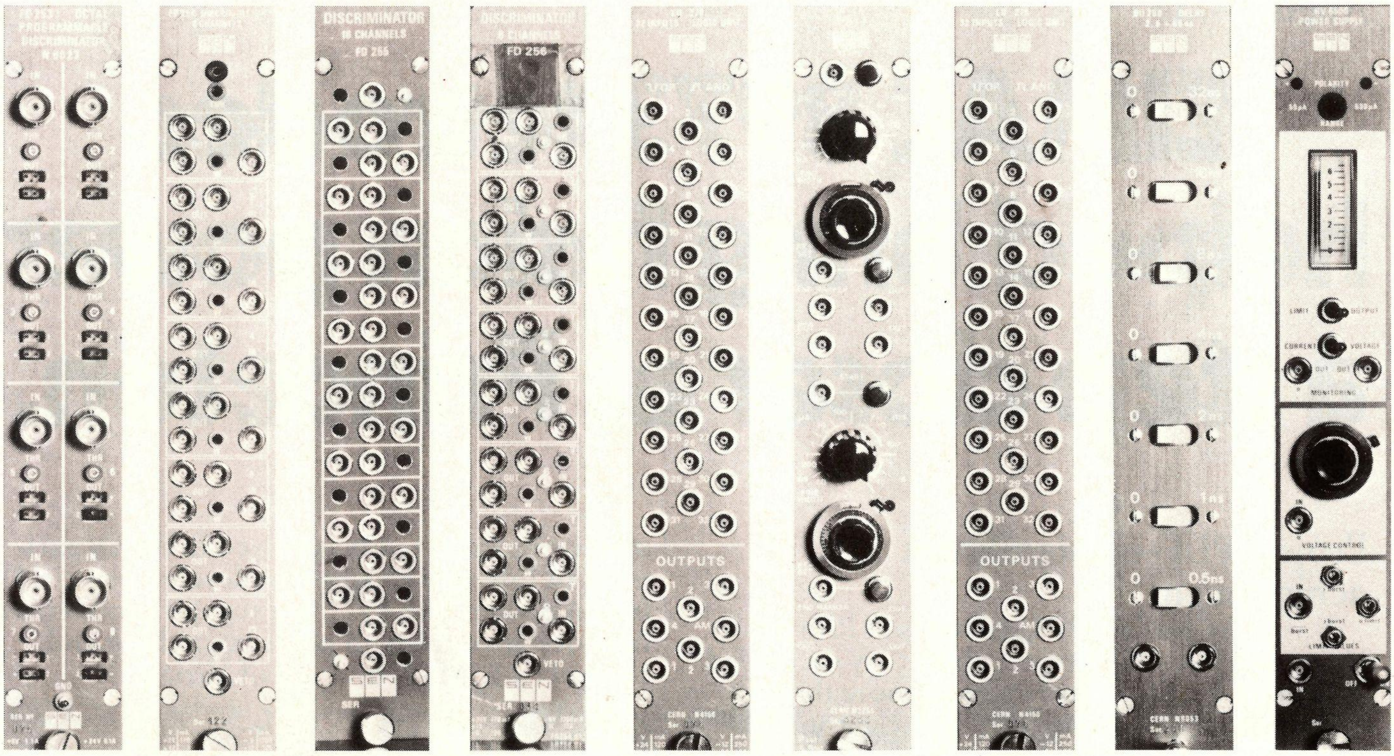

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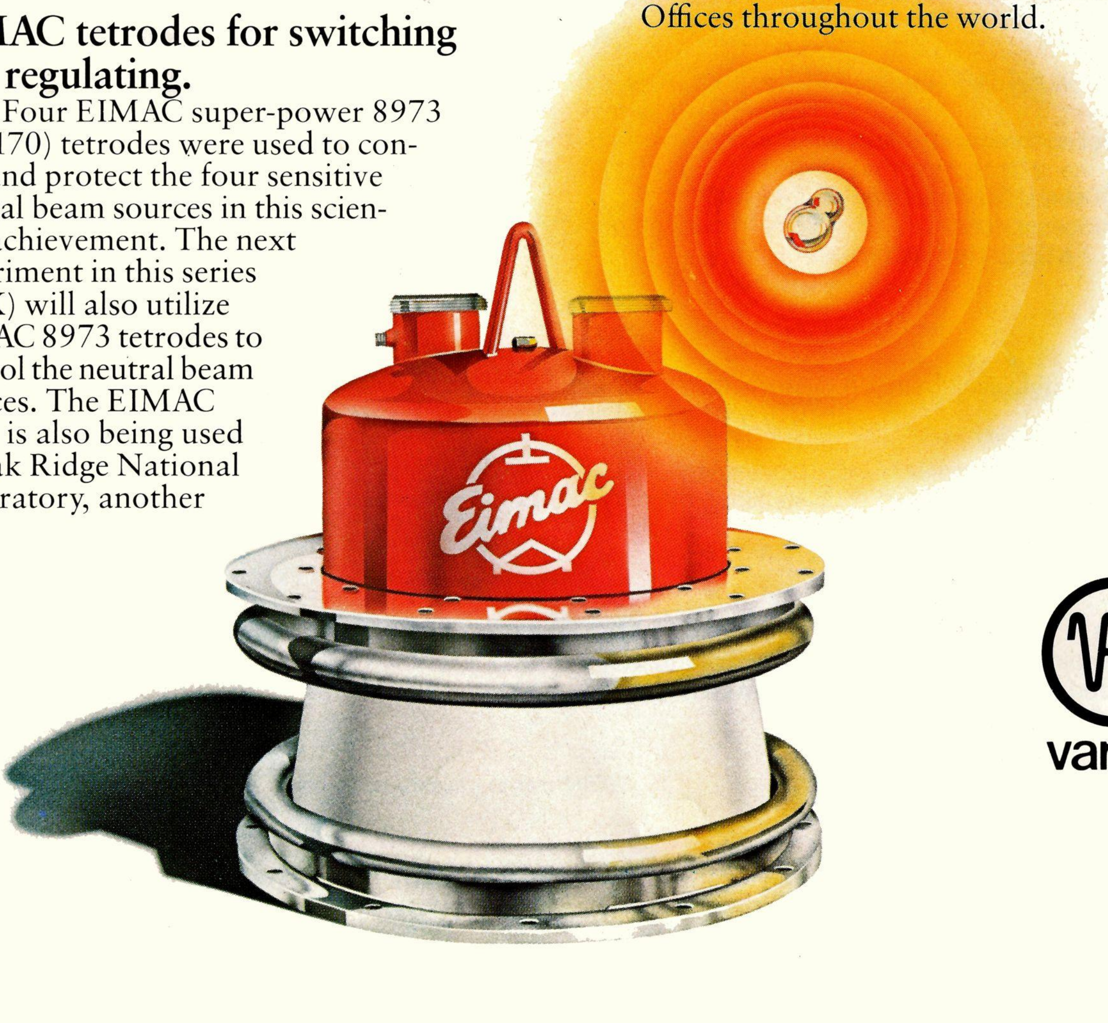

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