CERN COURIER

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CERN COURIER

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Cover photograph: Already having featured in our July/August issue (page 259), the enchanting Miss Illinois in her very original Fermilab/upsilon number is no stranger to COURIER readers. Her splendid ensemble, made totally by volunteer efforts, recently gained a commendable third place in the costume part of this year's Miss USA pageant, where the aim is to describe something about the contestant's home state. (Photo Fermilab)

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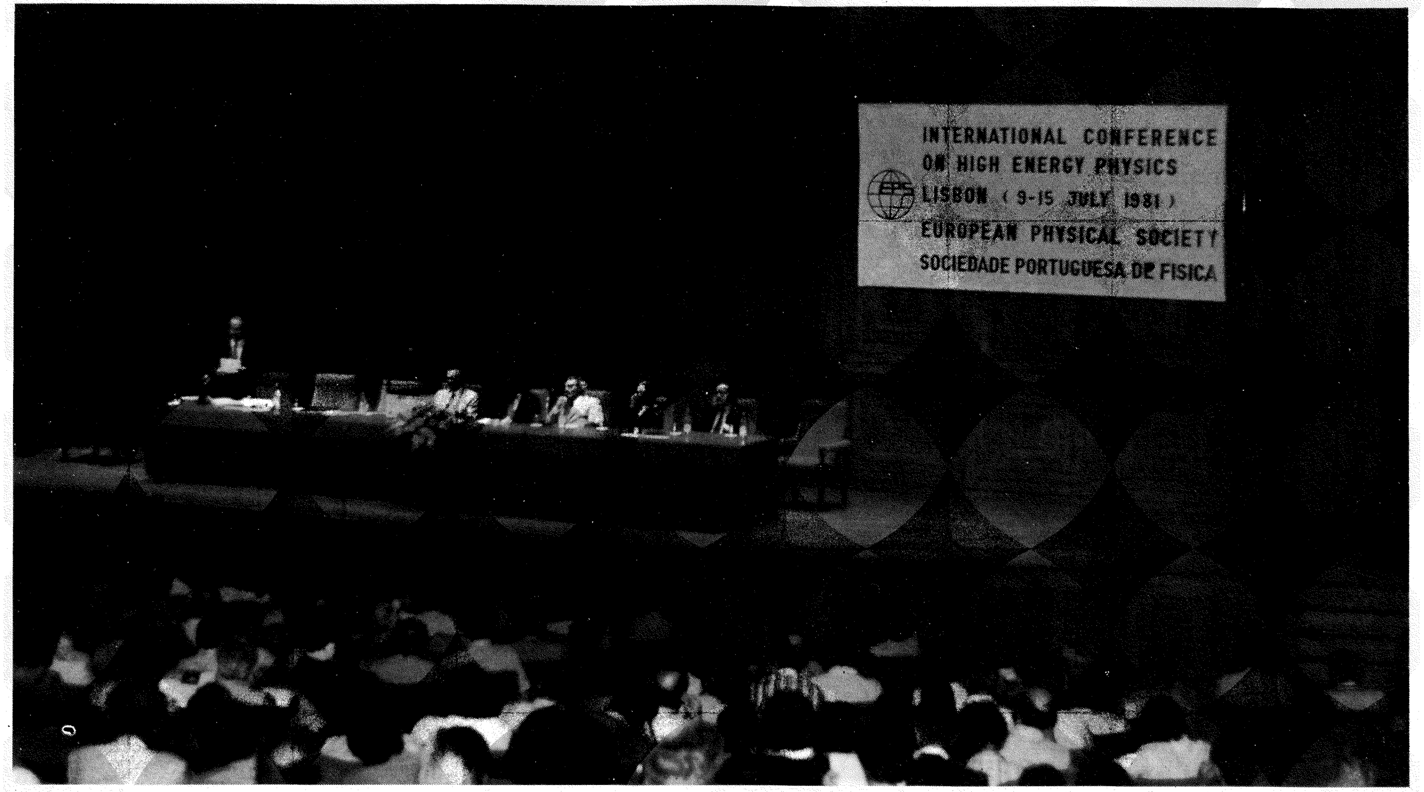
Lisbon Conference



Bragança Gil, President of the Portuguese Physical Society, addresses the Lisbon conference.

(Photo A. Amor)

Although no major physics discoveries were announced, the European Physical Society's International Conference on High Energy Physics, held in Lisbon from 9–15 July, was significant in that it showed the emerging pattern of physics for the 1980s.

With the electroweak theory adequately explaining almost all of leptonic physics and with quantum chromodynamics (QCD) emerging as the theory of inter-quark forces, physicists are confidently looking to broaden their horizons. However the comparison of QCD predictions with experiment still looks sometimes more like an art than a science, and there is a lot of ground to be covered before any QCD textbooks can be written.

Putting QCD problems to one side, new unifications are being suggested to merge the electroweak and QCD pictures, and a new breed of experiments is emerging to test the predictions of these broader theories. Some experimentalists are turning away from their traditional haunts at high energy accelerators to mount new 'passive' experiments deep underground to search for new phenomena. Theoreticians are striving to use the new insights on the structure of matter to aid cosmologists in their bid to reconstruct the early history of the universe. Gravity too is being fed into the new unification schemes.

Apart from specialized workshops, Lisbon was the first example of a major international meeting which included substantial coverage of passive experiments looking for new behaviour, notably proton decay. Although it is too early for confident new results to be available, the international effort under way in this sector reflects how physicists are beginning to look away from accelerators and storage rings.

Another pointer to the future came on the first day of the conference, when CERN Director General Herwig Schopper, in a talk on the future development of European particle physics, indicated the initial success of tests with antiprotons in the SPS (see page 289). He proudly emphasized that this remarkable achievement had been accomplished just three years, almost to the day, since the antiproton project had been formally approved at CERN.

The next day saw the arrival of Carlo Rubbia hotfoot from CERN where only hours before, some evidence for proton-antiproton collisions had been picked up in the forward telescope of the UA1 detector in the SPS ring. This announcement was greeted with spontaneous applause, and conference chairman Giuliano Preparata rushed messages of congratulation to CERN on

The conference opened with R. Barloutaud speaking on the search for evidence of baryon number violation.

(Photo A. Amor)

this 'spectacular success'.

By next year's conference season, passive experiments and the CERN studies of 540 GeV proton-antiproton collisions might have a lot of fascinating new material to report.

Rubbia's talk at Lisbon centred on the objectives of the new physics opening up at the collider. Spotting heavier quark flavours by looking directly for new quark-antiquark bound states might no be easy, and alternative flavour mechanisms would have to be exploited. Assuming of course that they exist at the predicted masses, the long-sought intermediate bosons of weak interactions should not present such problems. High on the experimental agenda is the job of fixing their masses as accurately as possible. If it could be measured, the width of the neutral Z boson would give information on the number of species of neutrino which exist in the universe. The measurement of this parameter in the collider would be a major breakthrough and would have important implications.

For the possible future development of the collider, Rubbia mentioned the use of polarized protons, already being actively investigated at other machines. Higher luminosities, if achieved, would increase the chances of uncovering more new particles, in particular the Higgs bosons, which are just as fundamental to the underlying theory as the weak bosons. For the longer term, Rubbia touched on the possibility of building a proton-antiproton collider in the proposed LEP tunnel at CERN.

While Rubbia could not report any collider physics, experiments at the Intersecting Storage Rings (ISR) have already had their first look at proton-antiproton collisions, albeit at a lower energy (see June issue, page 196). In the early sessions, Martin Block presented first results from experiment R211 (a Louvain/Northwestern collaboration) which uses the 'Roman Pot' technique. With meagre statistics and using instrumentation resurrected from some of the first experiments carried out at the ISR ten years ago, a first shot at the proton-antiproton total cross-section gives 46 millibarns. Although the errors are, in Block's words, 'still obscene', this suggests that the proton-antiproton reaction rate, like that of proton-proton, is still rising, but might be approaching the proton-proton figure from above. Other ISR experiments also reported initial antiproton results.

In the new department of passive experiments, the conference in fact opened with a talk by R. Barloutaud, who described the motivation behind the range of studies under way or being mounted to search for signs of baryon number violation.

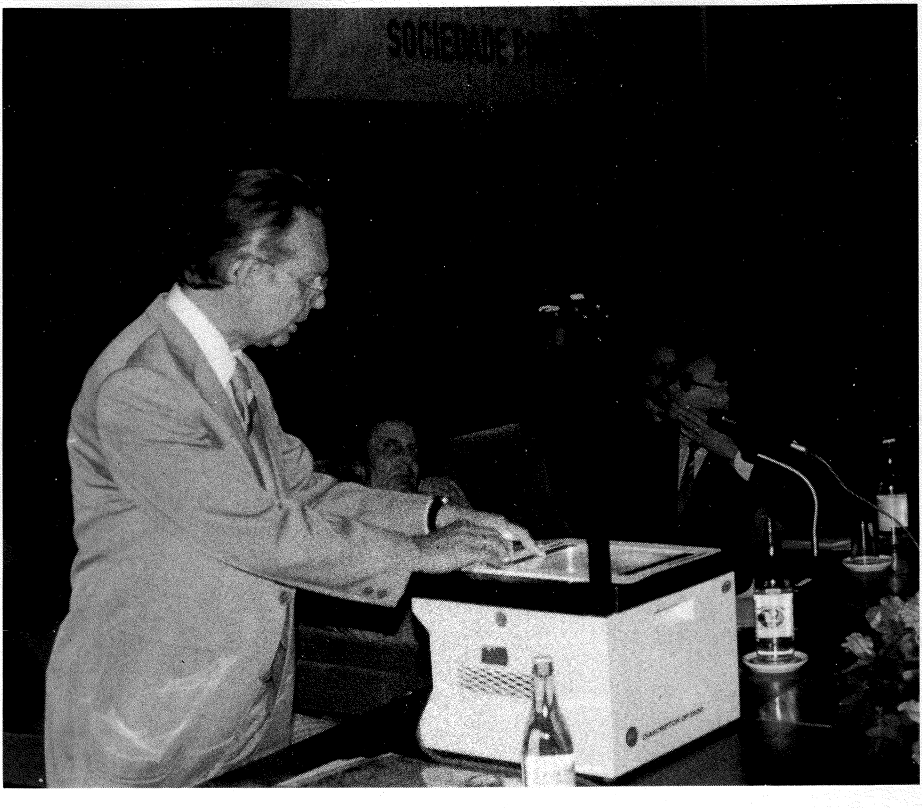
This initial talk was supplemented later in the conference by a session on proton decay searches, chaired by Abdus Salam, who has provided significant motivation for these experiments. In his introductory remarks, Salam emphasized the long-term implications of this work. Rather than being an ad hoc series of short-term studies, he advocated that this type of physics should develop into a regular long-term effort, and indicated in no uncertain way that funding arrangements should take this into account. If the proton is indeed found to be unstable, then its exact decay modes could have serious implications for the future of high energy physics machines. Certain decays, because of the mass-scale involved, could mean that this new physics would be inaccessible to conventional high energy machines.

In the proton search session, the results from the Japan/India collaboration at the Kolar Gold Fields were presented (see July/August issue, page 253). However no new events could be reported to supplement the three proton decay candidates recorded up to the end of April. Another detector, weighing 31 tons, has begun operation 2000 feet underground at the Soudan site in Minnesota. Embarrassingly quickly, this detector has recorded an event which could be interpreted as proton decay. However the group prefers at this stage to explain it away as multiple scattering.

Another feature of the conference was that, unlike the more recent European biennial particle physics meetings, Lisbon included parallel sessions. With a total of some 700 participants (significantly less than the conferences held in recent years in Madison, Geneva and Tokyo), the parallel sessions were fairly compact and gave a workshop feel to the first

Herwig Schopper spoke on the future of European high energy physics, and was able to reveal the first successes at CERN with tests at the high energy proton-antiproton collider.

(Photo A. Amor)



few days, with plenty of opportunity for discussion, public and private.

On the other hand, the physics which had to be covered ranged over a wide field, so that the parallel sessions included valuable 'mini-rapporteur' talks which brought together results from several experiments. For the plenary sessions, the organizers had included two types of talks – review papers presented after the appropriate parallel sessions, and invited speakers deemed to be worth hearing. Despite this imaginative organization, there were a few topics, like the structure of the weak current, which slipped off the map during the plenary sessions.

Another praiseworthy feature was the reappearance of sessions on experimental instrumentation. Once a regular adjunct to these international meetings, this important corner of particle physics has had no regular international forum in recent years. At Lisbon, these parallel sessions covered particle detectors and data handling. While contributions on particle detectors were naturally well covered by the experimental physicists, data handling has become something of a speciality, and despite some brave attempts, the coverage of this sector was not really representative.

As a European meeting, it was only natural to encouter a preponderance of European data, dominated by results from CERN and DESY. Nevertheless, the scarcity of US contributions was a bit disappointing. A notable exeption was the nice talk by P. Franzini on the results obtained at Cornell's CESR electron-positron collider. There was also some news from Fermilab, but less from the PEP electron-positron collider at SLAC. One had the impression that SLAC was keeping some good things up its sleeve for the Bonn Lepton/Photon meeting.

A not altogether unexpected confrontation was the disagreement between two experiments using the Split Field Magnet at the CERN ISR. While Antonino Zichichi's Bologna / CERN / Frascati group sees signs of a beauty baryon at 5.5 GeV, an Annecy / CERN / Collège de France / Dortmund / Heidelberg / Karlsruhe / Warsaw collaboration sees nothing (see June issue, page 207). After much debate, the issue remained unresolved.

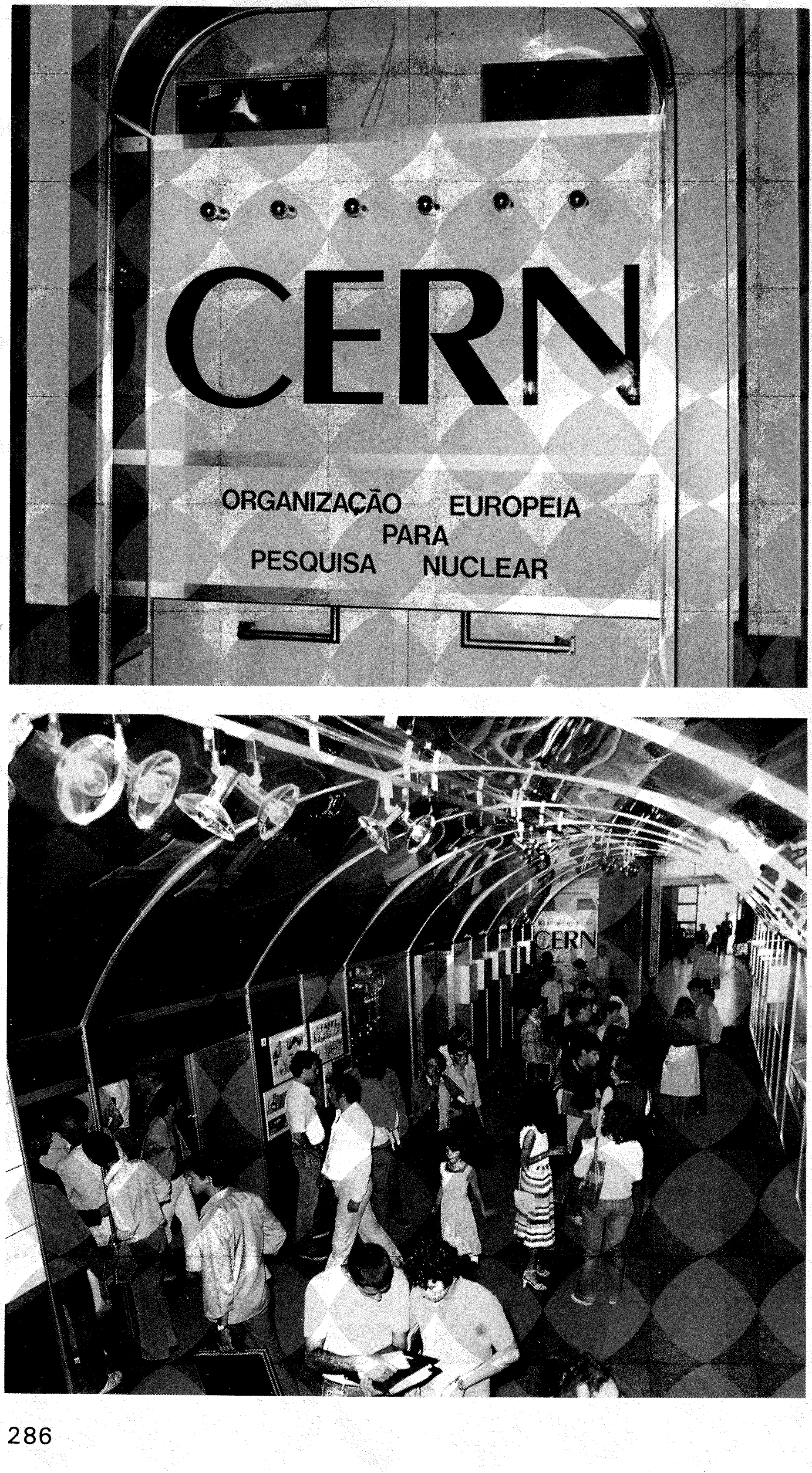
In the high energy electron-positron sector, it was DESY's PETRA ring which dominated, with luminosities at record levels and with data from JADE, PLUTO, TASSO and Mark-J now being supplemented by results from CELLO. At Lisbon, the meagre PEP data which was presented underlined the PETRA findings.

Hadron production in electron-positron annihilation is supposed to be a good test bed for QCD, and in certain cases agreement between theory and experiment is quite good. However devil's advocate arguments can be proposed which challenge this. The behaviour seen in gluon jets seems to be similar to that of quark jets, although there could be a systematic broadening. Baryon production in electron-positron annihilation seems to be unexpectedly high.

After the discovery of the upsilon at Fermilab and the subsequent investigation of upsilon fine structure at DORIS, the energy region covered by the CESR ring has enabled the CLEO and CUSB experiments to specialize in the upsilon region. In particular, the fourth upsilon, which is much broader than its lighter counterparts as it can decay strongly, gives a handle on the threshold for the production of naked beauty. Franzini indicated that

In parallel with the Lisbon Conference, a high energy physics exhibition was organized by CERN and Portuguese physicists to communicate with the local population. It was held in the Instituto Superior Tecnico from 8-19 July and attracted an impressively large number of visitors. They were able to see many models communicating physics ideas, to hear talks on modern physics and to learn about CERN, its role and its research equipment.

(Photo CERN 298.7.81)



the lightest beauty meson should be seen at about 5.25 GeV. This is in line with Zichichi's candidate beauty baryon, with its extra quark, at 5.5 GeV. The characteristics of the upsilon decays seen at CESR suggest charm as the favoured decay channel of the beauty quark.

There has been an upsurge of interest in the apparent similarities in the hadron spectra from different types of experiment. The R415 Bologna / CERN / Frascati group uses a technique of subtracting out leading protons to leave a hadron spectrum which has many broad features in common with what is seen in electron-positron annihilation. These similarities are also found in other types of reaction, notably 70 GeV kaon-proton data from the BEBC bubble chamber reported at the conference.

After all these years, the lifetime of charmed particles is still a talking point. At Lisbon, the emergence of new results from the specially built high resolution bubble chambers at CERN, from emulsion experiments at Fermilab and from the hybrid system at SLAC together show that the difference between the lifetimes of the charged and neutral charmed mesons might not be as marked as was once thought. The neutral particle now appears to live for about a third as long as the charged one, a result which is still of interest to theoreticians. The situation is still being confused by occasional events, perhaps due to more exotic particles, giving very different lifetimes.

Charm signals at the ISR are now plentiful. By comparing the observed enhancements with the smooth spectra of other particle combinations, the established selection rules provide an impressive verification of the charm signals. However the reconciliation of the calculated

Paula Fernandes models the Lisbon t-shirt.

(Photo A. Amor)

charm production rates with the observed relative numbers of electrons and pions is a problem which worries some people. Using conventional models, the calculated charm production rates can overtax the observed levels of produced electrons.

Covering the field of hadron spectroscopy, Frank Close indicated how the different levels of hidden strangeness are now emerging (in some cases years after their charmed counterparts). However everything is not yet cut and dried and the labelling of many states has to be settled. Glueballs — states made of gluons but no quarks — have long been expected, and occasional candidates are put forward. Sam Lindenbaum reported on an enhancement seen in the spectra of phi meson pairs, doubly forbidden by conventional selection rules, which could be a candidate glueball.

Baryonium — exotic bound states coupled to baryon-antibaryon pairs — were also once expected on theoretical grounds. After several encouraging initial sightings some years ago, the experimental evidence for baryonium has grown more and more scanty. If baryonium is not yet dead, its recovery now would be very remarkable.

Elsewhere in the hadron area, the dip in the elastic proton-antiproton spectrum (see July/August issue, page 246), was mentioned several times. This appears at the same momentum transfer as the dip in the proton-proton spectrum, but at much lower energies. In this context, it was interesting to learn from Roy Rubinstein of a new Fermilab result which shows a dip in the scattering of 200 GeV pions off protons at a squared momentum transfer of 4 GeV^2. Besides its possible relationship with other diffraction-type effects, the existence of a dip this far out is interesting in itself.

At Madison last year, a talking point was the absence of jet-like structure and the unexpectedly large high transverse momentum hadron yields over the full coverage of the NA5 experiment at the SPS (Bari / Cracow / Liverpool / Munich / Nijmegen collaboration — see also May issue, page 155). These effects are still very much there, and are now supported by minimum bias data from experiment R807 (Brookhaven / CERN / Copenhagen / Lund / Rutherford / Tel Aviv), and from the Split Field Magnet, both at the ISR.

These results have to be reconciled with previous reports of fairly clean jet structures using single particle triggers. In addition, these new results are not just extrapolations of the soft behaviour seen at lower transverse momenta. Something new could be happening. In particular, the high hadron yields have interesting implications for the big detectors being prepared for high energy proton-antiproton colliders.

However specific jet patterns still appear, an example being the three-jet structure at a three per cent level reported by the Columbia / CERN / Oxford / Rockefeller group at the ISR.

Other new results from the ISR came from alpha particle collisions (see May issue, page 163). Latest analysis shows that the atomic mass number dependence in alpha-proton collisions is more gentle than that of alphas on alphas.

There was the now almost traditional contrast of results from different experiments searching for the fractional electric charges in matter which might be indicative of free quarks. While G. Morpurgo in Genoa still sees no effect in iron, W. Fairbank at Stanford repeatedly sees

Ever helpful — the conference secretariat.

(Photo A. Amor)

fractional charges in niobium. Although this apparent incompatibility is always handled by the parties involved, in public at least, with consummate good taste, the continual disagreement is now a serious problem, and ways are being sought to resolve it (see page 301). However it should be remembered that the techniques of the two experiments are very different, and, as Fairbank commented, 'if you dig in the mountains and find gold, it does not mean that you can dig on the beach and find gold'.

In neutrino physics, once the glamour spot of particle physics conferences, there was little to report. The possibility of neutrino oscillations — the mixing of different kinds of neutrinos — has cooled off since last year, when it was a hot topic.

Scattering experiments with different kinds of lepton beams provide a powerful probe of hadronic structure, and the computation of the quark composition of nucleons through their structure functions has developed into a minor industry. Results from a range of experiments using electron, muon and neutrino beams appear to be in broad agreement, although there are some points to be resolved. However the structure function game seems to be getting very complex and the extraction of parameters from the mass of experimental data is not straightforward. At Lisbon, the CHARM neutrino experiment (WA 18) from CERN added its contribution to the structure functions available for consultation. There was some debate on the relatively low value of the QCD parameter given by the NA 4 muon scattering experiment (Bologna / CERN / Dubna / Munich / Saclay) at CERN. Because of the kinematical range covered, this low value did not cause too much distress.

Peter Landshoff was scheduled to cover the current theory of the universe on one hour, and succeeded by confining his attention mainly to the successes (or otherwise) of QCD. The quantitative formulation of this theory is still very shaky and the calculational techniques do not inspire confidence. Landshoff reeled off a long list of effects in need of an explanation, and remarked 'if the situation seems muddled, it is because we are muddled'. He pointed out the growing interest in diquarks as a reaction unit. For about ten per cent of the time, it looks as though it is a diquark, rather than a quark or an antiquark, which is picked up from the vacuum by an interacting particle.

In contrast, G. 't Hooft concentrated on pure QCD theory and emphasized the possible complexities of the formalism. Whatever its calculational difficulties, QCD is the right theory, according to 't Hooft. 'What else is there?' he asked, and assured his audience that the complete solution of QCD would provide plenty of employment.

The pure theory review talks were compressed towards the end of the conference, and provided a refreshing change of emphasis after the experimentalists' inevitable preoccupations with statistics and parametrizations. At least the theorists usually make do with far fewer transparencies per unit time than their experimental colleagues.

Despite its formidable title, Bruno Zumino's talk on the efforts to produce 'grand' and 'super' unified theories was enlightening. He explained that in the current jargon, 'grand' refers to attempts to merge electroweak theory with QCD, while 'super' theories go a giant step further and try to pull in gravity as well.

Richard Feynman, sadly absent from the international conference scene for several years, was originally billed as giving the concluding talk. Although he was indeed the final speaker, he described his own theory of quantum chromodynamics rather than trying to summarize what had been said by everyone else. Whatever the outcome of his theory, it was instructive to watch the great man's highly individual way of handling formalism.

Perhaps the hottest topic of all at Lisbon was the weather, with the mercury climbing towards the 40 degree C mark during the second week — among the highest temperatures ever recorded in Lisbon. Fortunately the superb conference rooms in the Gulbenkian centre were equipped with some of the best air conditioning in town.

Antiprotons in the big machine

Right, the beamline which injects 26 GeV antiprotons into the SPS. Centre, the beamline which sends high energy protons from the SPS towards the West Experimental Area. The main ring is on the left.

(Photo CERN 38.4.81)

On 7 July a pulse of antiprotons was sent to the CERN Super Proton Synchrotron, accelerated to 270 GeV and (briefly) stored. Two days later the exercise was repeated with greater success and the first evidence obtained for proton-antiproton collisions at 540 GeV — by far the highest collision energies ever achieved. Although there is still much to be done before the scheme becomes fully operational, this achievement is a major milestone in the CERN antiproton story.

The origins of the project

Antiprotons, since they presumably have the same properties as protons except for the sign of their electric charge, can be accelerated and stored in the same magnet ring as protons. Thus colliding beam systems, like the familiar electron-positron machines, are, in principle, feasible. However until recently it was not possible to produce antiproton beams of sufficient intensity and density to give sufficient collisions in a reasonable enough time for useful physics to be done.

This situation has changed with the invention of 'beam cooling'. The technique gets its name from the relationship between temperature and particle energy — the higher the temperature of a body, the higher the particle energies. However beam cooling refers not to a process whereby all the particle energies in the beam are reduced (so that the beam is made cold), but to a process which concentrates all the particle energies around a particular value. It is the variation of energies around this value which is 'cooled down'.

Antiprotons are produced in the collisions of protons with a metal target at relatively low rates — typically it needs about a million protons to produce each antiproton. In addition, the antiprotons emerge with a wide range of momenta, distinctly unsuitable for a magnet system in a beam transfer line, an accelerator or a storage ring which is designed to handle a well defined particle momentum. Only antiprotons at or very near to the design momentum could be guided — the rest would stray off into the walls of the vacuum chamber.

The advent of beam cooling enables an antiproton beam with an initially quite wide span of momenta to be concentrated around a particular momentum so that a dense beam can be built up and the subsequently encountered magnet systems can hold the beam.

A cooling technique was proposed in 1966 by Gersh Budker and his colleagues at the Institute for Nuclear Studies at Novosibirsk in the USSR with the specific aim of achieving intense antiproton beams for colliding beam physics. It involves using electron beams travelling along with the antiproton beam at the same velocity. The electron beam, which is much easier to control, has particles at precisely the desired momentum. In the subsequent antiproton-electron collisions, the antiprotons transfer momentum to the electrons in such a way that the antiproton momenta are concentrated around the desired value.

This idea of 'electron cooling' was successfully tested at Novosibirsk in 1975, and has subsequently also been demonstrated at CERN and at Fermilab. However at CERN, an alternative idea called 'stochastic cooling' was invented by Simon van der Meer in 1968. The word stochastic means random — stochastic cooling operates by reducing the random motion of the particles in a beam. It was invented to improve the density (and hence the luminosity) of

The ICE Ring, scene of much of the early development work on beam cooling at CERN.

(Photo CERN 80.9.78)

the beams in the Intersecting Storage Rings.

The distribution of particles across a beam is observed at 'pick-up stations' in the ring, and from this information the centre of gravity of the beam density is calculated. As it passes further around the ring, the same section of the beam is subjected to an electric field which nudges the measured centre of gravity towards the desired value. Because of the random distribution of particles, this push acts unfavourably on some particles, taking them further from the required conditions, but works favourably on the majority. Over millions of repetitions, the beam is progressively cooled.

The technique was first successfully demonstrated at the ISR in 1975. This led to the construction of a small storage ring aptly known as ICE — Initial Cooling Experiment — specifically to study stochastic and electron cooling. The results from ICE, particularly on stochastic cooling, were so spectacular that in 1978 CERN was able to give the green light to an antiproton project which had been promoted particularly by Carlo Rubbia. This was then authorized in the confidence that, for the first time, antiproton beams of sufficient intensity and density could be achieved to make proton-antiproton physics possible.

According to our present understanding of particle physics, the proton and its antiparticle should be equally stable. The proton lives for at least 10^{30} years, if not for ever. However up till quite recently physicists had never been able to test the stability of the antiproton. If it had turned out that the antiproton were nowhere near as stable as the proton, theorists would have had to have a major rethink, and the whole antiproton project might have foundered. In tests in the ICE ring in 1979 (see October 1979 issue, page 312), it was also clearly established that antiprotons live long enough to make the whole scheme feasible.

The role of the Antiproton Accumulator

The heart of the antiproton project is the Antiproton Accumulator (AA) where the stochastic beam cooling technique is applied to build up antiproton beams tens of thousands of times more intense than have ever been achieved before.

Protons are first accelerated in the Proton Synchrotron. Instead of being evenly distributed in twenty bunches around the PS ring, as in a normal acceleration cycle, they are crowded into five bunches occupying a quarter of the ring. As the 50 m diameter AA ring is one quarter the size of the PS, these protons, when they strike a target, produce a length of antiproton beam which fills the circumference of the AA.

When the protons reach 26 GeV they are ejected from the PS and strike a target in front of the AA ring. From the spray of secondary particles, a focusing system selects antiprotons of energy around 3.5 GeV for injection into the AA. This energy gives the maximum yield of antiprotons — for each pulse of 10^{13} protons on target, some 2×10^7 antiprotons are injected. (In other words, for every million protons hitting the target only two antiprotons are collected!) This operation is repeated every 2.4 s.

Eventually the AA is required to provide beams containing 6×10^{11} particles, and about 30 000 PS pulses (representing about a full day's operation of the machine) will be needed to supply all these antiprotons.

The AA's vacuum chamber is unusually large (70 cm wide) to give space for all the necessary manoeuvres and is held at high vacuum (10^{-10} torr) to minimize loss of antiprotons due to collisions with residual gas molecules.

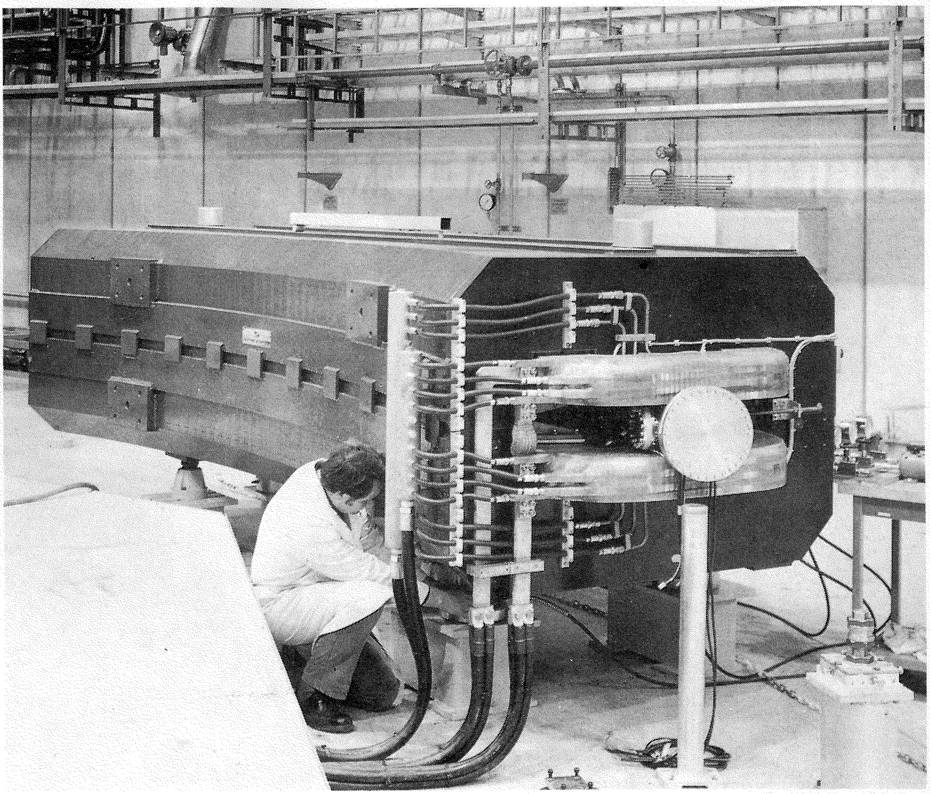
The first pulse is injected and bent by 'kicker magnets' so that the antiprotons orbit on the outside of the vacuum chamber. During injection, this region is shielded from the rest of the chamber by a mechanically operated shutter. This protects the antiprotons subsequently stored in the main body of the chamber from the magnetic fields of these kickers, and makes it possible to cool the low density injected beam without being swamped by the much stronger signals from the high density stack. The first injected pulse is monitored at pick-up stations and other kicker magnets act upon it to cool the antiprotons.

In two seconds the pulse is precooled so that the momentum spread of the particles is reduced by a factor of ten. The shutter is then lowered and the precooled antiprotons moved into the stack position in the main body of the chamber. The shutter rises again and the second pulse is injected to receive the same treatment.

While this sequence of injection, precooling and transfer to the stack proceeds, cooling is applied to the stack. The ultimate objective is to concentrate the beam by a further factor of a hundred million. After fifty pulses are stacked, some two minutes after injection, about 10^9 antiprotons would be in the stack, being progressively cooled.

After about an hour and 1500 pulses, when some 3×10^{10} antiprotons would be orbiting in the stack, a core 'tuned' by the cooling system forms near the inside of the vacuum chamber. Forty hours and 60 000 injected pulses later, some 10^{12} antiprotons would be orbiting in the stack, with the majority (6×10^{11}) of them concentrated in the core, thanks to the cooling system. It is this core which will provide the intense antiproton beam for colliding beam physics.

A residue of some 4×10^{11} antiprotons would remain in the AA stack to start the next core. Injection of antiproton pulses would continue so that 24 hours later another core of 6×10^{11} cooled antiprotons would be ready for ejection.



One of the magnets of the AA ring, showing its very large aperture.

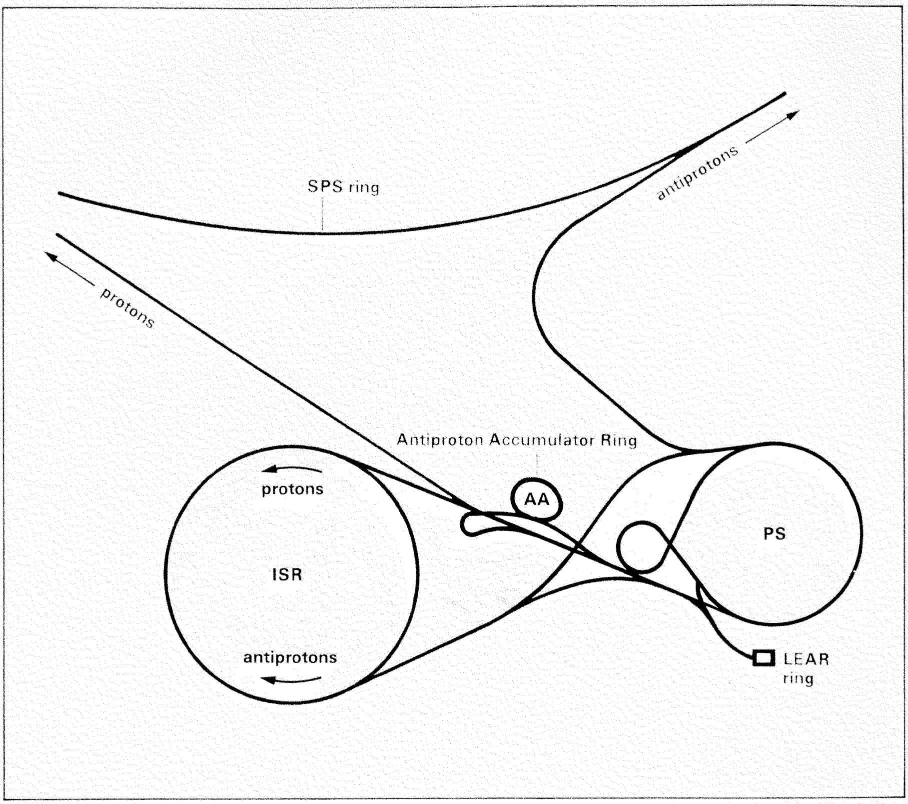
(Photo CERN 49.3.80)

Antiprotons in the CERN machines

All three of CERN's large machines are involved in the exploitation of these intense antiproton beams. The pulse from the AA is first sent to the Proton Synchrotron. Because of space limitations in the AA, the injection and ejection systems are located in the same section of the ring. The antiproton beam therefore has to be turned around in a loop of magnets before it can be injected into the PS, where it circulates in the opposite direction to the protons. The antiprotons are then accelerated in six bunches from 3.5 to 26 GeV, when they can be sent either to the SPS or the ISR.

At the SPS, the antiprotons and protons circulate in the same ring, but in opposite directions. Ultimately, the protons would be injected in one pulse from the PS and made to circulate in six bunches evenly spaced around the ring, with 10^{11} protons in each bunch. The antiprotons would be injected in two pulses from the PS to build up an intensity of 10^{11} antiprotons in each of six bunches around the ring. The two sets of bunches could then be accelerated simultaneously to 270 GeV.

The components of the CERN antiproton scheme, which uses all the Laboratory's major machines. Special beamlines had to be built to supply the SPS and the ISR with antiprotons.



Two beam collision regions are being equipped with large and sophisticated particle detectors to observe the very high energy interactions.

At the ISR, the antiprotons can orbit in one ring at 26 GeV while the PS sends 26 GeV protons to orbit the other ring in the opposite direction. The energy of each beam can be increased up to 31 GeV by using the ISR's own acceleration system. Ultimately, five injections of antiprotons, each containing 6 × 10^{11} antiprotons, are envisaged to achieve a luminosity of 10^{30}. The ISR detectors have already taken their first proton-antiproton data (see June issue, page 196).

At the PS, the 3.5 GeV antiprotons from the AA can be used for a very different range of experiments. It is planned to decelerate the antiprotons to 0.3 GeV, and eject them into a small storage ring (about 20 m across), called LEAR (Low Energy Antiproton Ring, see April issue, page 113). In this case, the aim is not initially to have proton-antiproton collisions (although this may follow later), but to build up low energy antiproton beams of a quality and intensity never before achieved. To fill LEAR, the intricate beam gymnastics necessary for higher energy antiprotons are no longer required. The antiprotons can be drawn from the AA in more modest pulses of over 10^9 particles. The LEAR antiproton energy will cover the range 0.1–2 GeV and stochastic beam cooling systems will help preserve the beam quality.

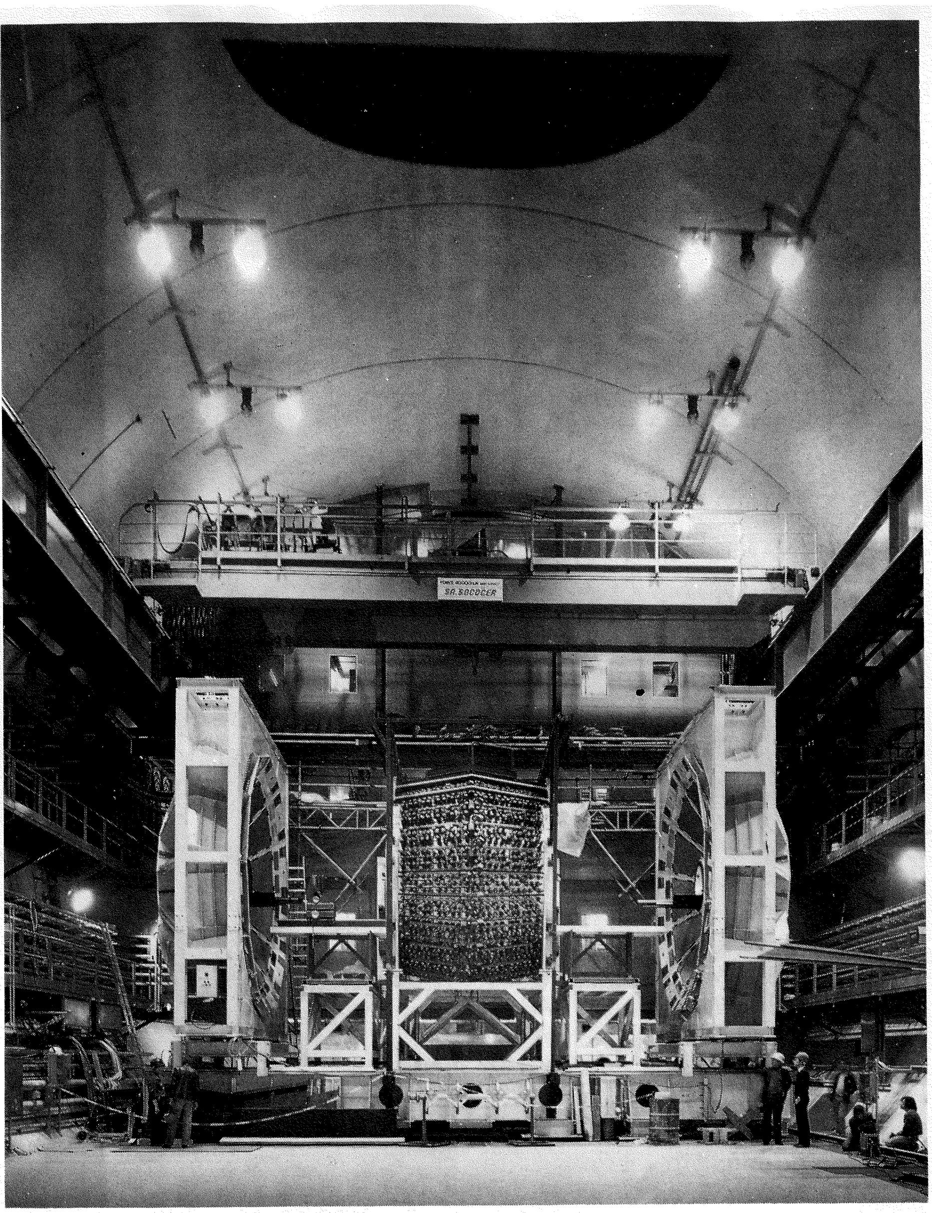
The SPS experiments

Most interest is centred on the experiments at the SPS where the highest collision energies will be available. To study these collisions, detectors are being installed at two of the long straight sections (LSS4 and LSS5) on the SPS ring. At both locations extensive excavation was necessary to make room for the big experimental set-ups and to allow them to be moved in and out of the ring (see June 1980 issue, page 143).

At LSS5 is the impressive detector of the UA1 experiment, an Aachen / Annecy / Birmingham / CERN / Queen Mary College London / Collège de France / Riverside / Rome / Rutherford / Saclay / Vienna collaboration, involving about a hundred physicists. The apparatus weighs well over 2000 tons and is housed in an experimental area which was excavated from the surface, and consists of two cylindrical shafts, each 20 m in diameter, roofed over and joined by a connecting chamber.

The detector can be rolled out of the SPS ring on rails into the 'garage' shaft for modification, or while the SPS is running for fixed target physics. The large central magnet weighs over 800 tons and provides a field of 0.7 T in a volume of 85 m^3. The surrounding instrumentation is designed to record many different types of emerging particles, so that the experiment will be able to cover a wide range of phenomena. Incorporated in UA1 is the Annecy / CERN UA3 experiment using a modest detector to search for magnetic monopoles.

For the other experimental area at LSS4, a large underground 'cathedral' was excavated. It houses the UA2 experiment (Berne / CERN / Copenhagen / Orsay / Pavia / Saclay), which uses no magnetic field but a large array of apparatus to record the energies and directions of the emerging particles. The central part of this detector is also to be used



Assembly of the UA2 experiment well under way in the specially constructed underground experimental area at long straight section LSS4 of the SPS. At the top can be seen the shaft leading to the surface some 50 m above.

(Photo CERN 479.4.81)

in the UA4 experiment (Amsterdam / CERN / Genova / Naples / Pisa) to look at proton-antiproton elastic scattering and total cross-sections.

These detectors can be moved out of the ring on air cushions while the UA5 assembly (Bonn / Brussels / Cambridge / CERN / Stockholm) is lifted into the ring over the top of them. UA5 contains two long (7.5 m) streamer chambers, in which the tracks of the emerging charged particles can be photographed. This will provide the first visual record of the highest energy particle collisions ever produced artificially, and could immediately show interesting results. The detector has already recorded proton-antiproton collisions in the ISR (see May issue, page 165).

Recently approved is the UA6 experiment, to use an internal hydrogen jet target to study inclusive electromagnetic final states and lambda production at 22.5 GeV centre-of-mass energy, by a CERN / Lausanne / Michigan / Rockefeller collaboration.

Physics interest

The Holy Grail of the SPS collider experiments is the discovery of the carriers (the W and Z bosons) of the weak force. According to the so far highly successful theory which combines electromagnetism and weak interactions, the masses of these particles should be well within the reach of the collider, and their discovery would be the crowning glory of the electroweak theory, as well as a major achievement by the experimenters.

If they are observed, it will be important to measure their masses and their lifetimes as accurately as possible. The mass measurement will really pin down the electroweak theory, while the lifetime could give an insight into the number of different types of particle in the Universe. It could tell us whether there are further 'generations' of quarks and leptons to supplement the three (each containing two quarks and two leptons) identified so far.

The high collision energies could reveal rare types of behaviour which have so far only been seen in a few photographs of cosmic rays arriving in the earth's atmosphere with energies of hundreds of thousands of GeV (the 540 GeV centre-of-mass energy at the SPS collider is equivalent to a 155 000 GeV proton beam hitting a fixed target). In addition to searching for rare events, the energies and detection capabilities at the SPS collider should also extend our knowledge of hadron production at high energies.

While physicists might have all sorts of preconceived ideas about what they will see, experience has shown that new energy regimes often reveal totally unexpected phenomena which radically change our understanding of the structure of matter. The significant breakthrough with the CERN antiproton project is that scientists will be able to study interactions under a range of very different conditions. That this has been achieved for a relatively modest outlay, without constructing a new high energy machine, is even more remarkable.

Around the Laboratories

FERMILAB
Beams for antiprotons

On 7 June an 80 GeV proton beam was extracted from the Fermilab Main Ring for the first time and transported towards the antiproton target hall. This beam will be used to produce antiprotons for the colliding beams project, where counter-rotating bunches of protons and antiprotons will be injected into the Energy Saver/Doubler for collisions at up to 2 TeV centre-of-mass energy.

The immediate use of the new target area will be a programme of research and development to study target behaviour to help design the final target system for the production of antiprotons. The proton transport and the targetting studies are headed by Carlos Hojvat within the Colliding Beams Department.

Success came during the last run before a long shutdown period of the accelerator. Beam was extracted downstream of the Main Ring r.f. system and transported through a 200 m-long transport line, leaving the Main Ring tunnel and entering the new antiproton target area. The beamline will also be used for the reverse injection of antiprotons, after accumulation and cooling, into the Main Ring for transfer to the Energy Saver/Doubler.

The original concept for the transport line was developed by Don Edwards, George Chadwick (now at SLAC) and Bruce Chrisman. The final design and installation were carried out with help from the University of Wisconsin led by David Cline. Personnel from Argonne also helped. Scientists from Novosibirsk are working on targetry experiments and the design of the antiproton target (see July/August issue, page 249).

The Proton Department crew which constructed the cryogenic transfer line for the Fermilab Energy Doubler/Saver with a truckload of finished sections awaiting shipment to the Main Ring. Special fabrication techniques were developed for the transfer line, composed of 24 m sections and with a total length of 5 km.

(Photo Fermilab)

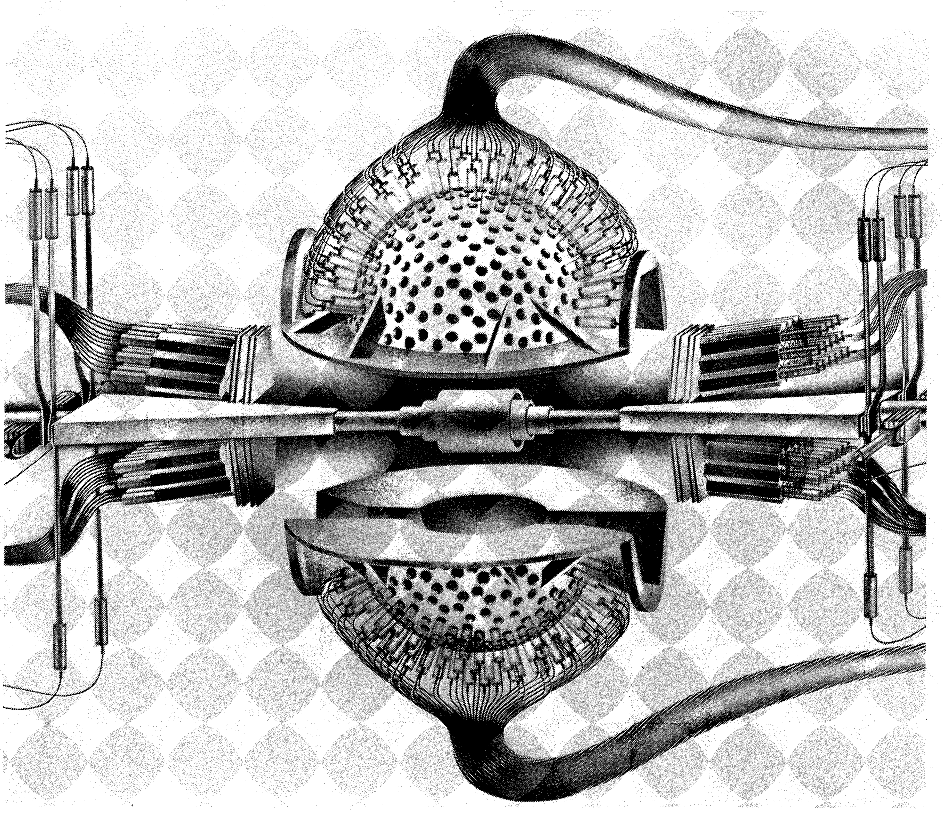
Cryogenic transfer line for the Doubler

Five kilometres of 24 m sections of cryogenic transfer line have recently been completed for the Energy Saver. The transfer line will be installed on the berm over the Main Ring of the accelerator, completely circling the ring and connecting the Central Helium Liquefier to the 24 satellite refrigerator buildings equally spaced around the ring. The refrigeration provided by the satellite refrigerators is supplemented by liquid helium and liquid nitrogen delivered by the transfer line from the Central Helium Liquefier.

The transfer line sections were built by members of the Proton Department led by Peter Mazur, Rich Stanek, and John Norris. This group had already completed and installed what was then the longest helium transfer line in existence (see July/August 1980 issue, page 195). Because of the scale of the project, new production techniques based on the prototype work for the Energy Saver had to be developed. As a result, the line was produced at the rate of 60 m per day, more than twice the anticipated rate, and the project was completed six months ahead of schedule with substantial cost savings.

The transfer line, designed by an engineering team led by Claus Rode, consists of the 24 m sections, which are four concentric stainless steel pipes separated by glass fibre-epoxy spacers, and multi-layer insulation in a vacuum. At 24 positions around the ring an 'expansion box' with flexible inner pipe connections will allow for the 16 m thermal contraction of the inner pipes of the transfer line when they are cooled to cryogenic temperatures. At each satellite building, bellows are added to the

A drawing of the 'Crystal Ball' detector on the SPEAR storage ring at Stanford by W. Zawojski. The detector has no magnet and consists of sodium iodide segments surrounding the interaction point, giving very good detection of gamma rays. The Crystal Ball will be withdrawn from SPEAR at the end of the year.



vacuum jacket to permit thermal expansion due to climatic temperature variations.

Installation of the sections will proceed soon using a helicopter to lift them into place around the ring. Because of the scale of the project, substantial savings should result from using the helicopter rather than trucks and cranes.

STANFORD

Experiments on the move

During the summer months the High Resolution Spectrometer will be installed in Interaction Region 6 on the PEP electron-positron storage ring at Stanford. HRS, (see June issue, page 201) which incorporates the rebuilt large superconducting magnet from the Argonne 12 foot bubble chamber, will replace the free quark search. Most activity on the machine itself at present is concentrated on bringing a mini-beta scheme into action by the end of the summer shut-down with the aim of doubling the PEP luminosity.

On the smaller SPEAR storage ring, the Mark III detector will occupy one of the two interaction regions and the other will become vacant at the end of the year with the removal of the Crystal Ball. This is a non-magnetic detector built of a segmented array of sodium iodide crystals surrounding the interaction point giving very good detection of gamma rays. This will leave a SPEAR experimental hall empty and interested users are invited to make contact with Stanford.

On the electron linac itself, an experiment by a US University/Bonn/SLAC team has been approved to make a detailed study of the elastic cross-section in electron-proton interactions at large momentum transfer. It should then be possible to check quantum chromodynamic calculations more precisely than with the present data.

CERN

Council considers the LEP project

The 69th Session of the CERN Council took place on 25-26 June under the Presidency of Jean Teillac. Delegates of the twelve Member States heard a report on the present research programmes from Director General Herwig Schopper and, for the future, the LEP project to construct a high energy electron-positron storage ring was submitted to the Member States for approval.

The approval concerned authorization for the construction of LEP Phase I – a 27 km circumference ring equipped to operate at 50 GeV and fed by the existing CERN synchrotrons, with initially four of its eight experimental halls housing experiments. The cost of LEP Phase I is estimated (at 1981 prices) to be 910 million Swiss francs, plus 40 MSF as CERN's contribution to the detection systems, and the construction is to be spread over eight years.

Nine of the CERN Member States were able to vote in favour of LEP at the June meeting - Austria, Belgium, Denmark (ad referendum), Federal Republic of Germany, France, Greece, Italy, Switzerland, and United Kingdom. The other Member States – the Netherlands, Norway and Sweden – did not express any opinion against the project but discussions and formal procedures within these countries have not reached the stage where they were able to cast a vote. It is hoped that the decision making processes will be sufficiently far advanced by the Autumn to enable their votes to be made known at a special session of the Council in October.

An important element in these discussions is the level at which the CERN budget would be sustained during the construction period. It has been accepted that LEP could be considered as part of the basic programme of CERN and the construction money would be found within the annual CERN budgets (involving the closing down or restriction of some of the existing programmes). To confront such a major project as LEP, it is realized that CERN would need to have some confidence in the budgets it would be accorded over the coming years.

For this reason the traditional 'Bannier procedure' for arriving at CERN budgets would be extended so that the budget level accorded in the first year of construction would be sustained for five years unless a two-thirds majority of the Member States voted for a reduction. (Any increase would require a unanimous vote.) In the hope that it will be possible to begin LEP next year, the budget for 1982 is therefore of particular importance. At the June session, the Member States were not yet in agreement on the figure to be adopted and this also will be left until the proposed October session.

High field superconducting quadrupole

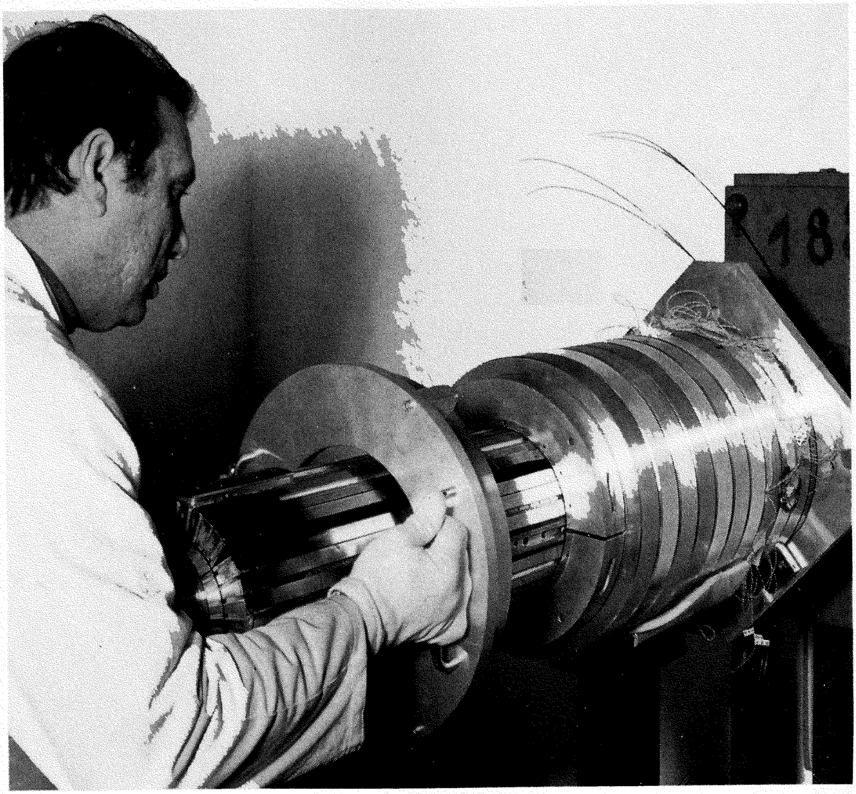
Niobium-tin has already demonstrated its usefulness as a possible superconductor for high field magnets for future accelerators. At CERN, for example, a small solenoid containing fine niobium-tin filaments attained a field well in excess of 8 T (see November 1978 issue, page 396). However solenoids are one of the simplest magnet configuration to produce with brittle material. Now this work has been taken a stage further with the successful testing of the more complicated configuration of a quadrupole by the small team led by A. Asner. The quadrupole is about 1 m long with an inner warm bore of 10 cm. It has a filamentary niobium-tin 1.1 x 2.2 mm^2 cable produced by the Vacuumschmelze firm in Germany using the technique described in the November 1978 article. The magnet was tested at the beginning of June : a current of 1 kA was reached at the first quench increasing to 1.1 kA after four quenches. This confirms previous experience of little training with niobium-tin superconductor. The highest field was 7.5 T with a useful field gradient of 69 T/m. The current density (averaged over the whole insulated cable, not just the superconductor) was 300 A per mm^2.

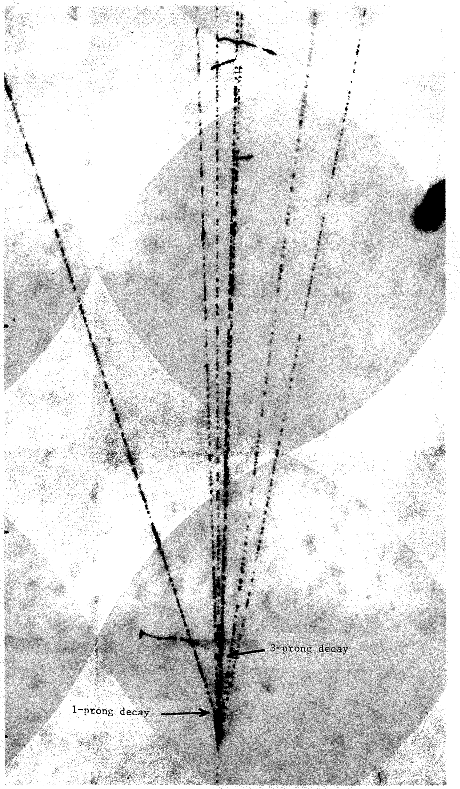
The resultant 'wind, react and impregnate' technology looks promising and encouraging. It proved possible with coils of quadrupole configuration to retain the brittle materia with its quartz insulation in good shape with high geometrical preci sion while swinging the temperature from the niobium-tin reaction tem perature of 1000 K to the magne operating temperature of 4 K. The non-trivial problems of connection to the niobium-tin are also solved.

It looks like one route which could lead to the high field magnets (8 t 10 T) of the future and it would b interesting now to move to the mor difficult dipole magnet configura tion. However before such a ste could be considered a lot of desig work would be needed, for exampl

Assembly of the high field quadrupole at CERN which has a filamentary niobium-tin superconductor. In the picture, heated aluminium rings are being put in place to shrink fit over iron half rings, producing a well stressed magnet. The quadrupole configuration of the inside coil windings can just about be distinguished.

(Photo CERN 156.01.81)





Candidate charm production and subsequent decay as recorded by the 20 cm LEBC bubble chamber at CERN.

to deal with such problems as handling stored energies as high as 1 Megajoule per m, and extracting them at voltages the epoxy impregnated quartz insulation will safely withstand.

Big things from little bubble chambers

Not that long ago, bubble chambers were out of fashion. Bubble chamber development appeared to have slowed down and the only idea seemed to be to equip powerful big chambers with additional electronic detectors to extend their capabilities. Many bubble chamber physicists decided the time had come to reeducate themselves in counter techniques.

However in a relatively short time, physics has seen the emergence of the small custom-built bubble chamber. Exploiting state-of-the-art high resolution optical techniques, these mini detectors now provide one of the best available tools for studying rare particles with short lifetimes. This was particularly evident in the new results on the lifetimes of charmed particles presented at the Lisbon conference (see page 286).

In 1977, Colin Fisher from Rutherford proposed the use of a small bubble chamber to look at charmed particles. Experience with track-sensitive targets in large bubble chambers had made possible the construction of 'clean' chambers with no spurious boiling. Optically, the new development required the photography of small (typically 50 micron) bubbles at high density (say 60 bubbles per cm). Such resolution can only be obtained at the expense of a reduction in the depth of field.

This led to the construction of LEBC, of diameter 20 cm and using liquid hydrogen, and BIBC, just 6.5 cm in diameter and filled with a heavy liquid (see April 1980 issue, page 58). However without additional spectrometry and particle identification, such detectors cannot by themselves identify charmed particles and measure their lifetimes.

At CERN, LEBC was used as the vertex detector in the initial stage of the European Hybrid Spectrometer (see March issue, page 81), while a Berne/Munich collaboration used BIBC placed upstream of the streamer chamber and associated spectrometer of the NA5 experiment.

These far-sighted developments are paying off. After many years of swinging to and fro on the tide of experimental statistics, charmed particle lifetimes are now beginning to firm up.

The other new weapon in the bubble chamber armoury is holography (see January/February issue, page 14). At CERN, an experiment is to be carried out using a 12 cm holographic high resolution hydrogen chamber (HOLEBC), operating at 50 Hz, with the EHS spectrometer. As in the previous study using LEBC, a simple interaction trigger will be used for the bubble chamber laser and camera, with no attempt being made to select charm candidates on-line. Rather than accumulating good statistics on charm (or other heavy flavour) decays (there is as yet little experience of scanning large numbers of holograms), the initial objective of this experiment is to gain experience in using this new technique.

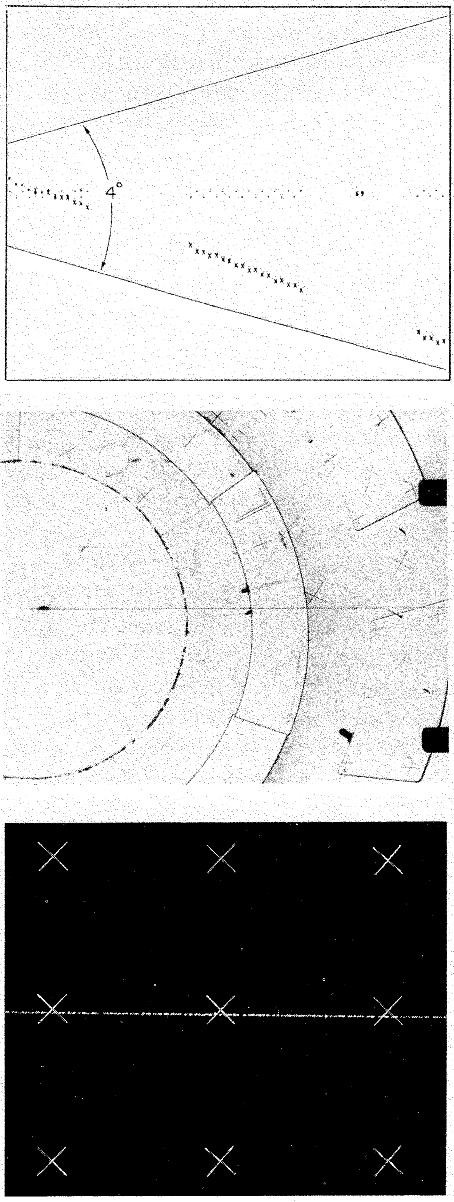
Another new CERN experiment will use a 10 cm heavy liquid bubble chamber (HOBC) running at 25 Hz. This will make use of an on-line trigger from a muon detector in order to enrich the fraction of events containing charm and other heavy flavours. However the use of this muon filter (based on the old Gargamelle external muon identifier), containing a thick iron/tungsten shield, makes additional downstream spectroscopy difficult.

Thanks to modern technology, the bubble chamber seems to have bounced back, and future experiments could, well see a lot more of these small 'disposable' detectors.

Lasers and chambers

Nitrogen lasers, radiating at 337 nm, have been developed at CERN with the aim of producing intense subnanosecond light pulses with small beam divergence and cross-section. The light beam ionizes the typical gas mixtures used in drift and streamer chambers with ionization densities similar to those created by minimum ionizing particles. Multiple photon excitation is believed to be responsible for this effect but the molecules involved (probably impu-

'Tracks' induced by the same laser in three different particle detectors at CERN. Top to bottom: Off-line display of drift times from the Jet chamber of the Axial Field Spectrometer at the ISR, photo taken in the BEBC hydrogen bubble chamber and photo taken in the 2 m streamer chamber of the European Muon Collaboration. The laser beam technique promises to have numerous applications, especially for surveying and calibrating large imaging chambers.



rities) are not yet known. However consistent results were obtained in several chambers and gas mixtures.

The advantages of the laser beam technique, especially for calibration and surveying, are: high spatial resolution (50 microns were obtained from drift time measurements in small chambers and 100 microns on long tracks in a jet chamber at the ISR), small variation of the ionization density (an order of magnitude better than the Landau distribution from particle ionization in thin gas samples), insensitivity to magnetic fields and the unique capability to produce well localized multiple tracks.

Narrow bubble tracks were induced by the same laser in a test bubble chamber filled with argon or nitrogen as well as in BEBC filled with hydrogen. The bubble nucleation probably occurs on tiny dirt particles heated by the laser beam. Further tests are in preparation. Among the applications being considered are event tagging and studies of chamber performance, for example of holographic and rapid cycling bubble chambers.

BROOKHAVEN
Studies of a phased ISABELLE

In a recent review of the ISABELLE high energy proton-proton storage rings project at Brookhaven, the possibility of a phased approach to attain the full potential of the machine (involving a 720 GeV centre-of-mass first phase with a luminosity of 10^{32} to 10^{33} per cm^2 per s) was presented. This would involve the use of Fermilab-type magnets with the addition of a booster in the second phase. A special task force headed by Kjell Johnsen is studying the feasibility of this approach. Additional options such as electron-proton collisions, heavy ions and polarized protons are also being considered. This task force will present a preliminary report on 1 September and a full report on 1 October. The Laboratory management decides on 1 September whether to adopt this scheme.

In July, a new superconducting magnet — a 5-foot dipole with full ISABELLE aperture and using two layers of Rutherford type cable — underwent a highly successful first test, reaching 5.35 T at 4.8 K. Initial results indicated that the magnet was operating at the 'short sample' limit imposed by the intrinsic properties of the superconductor. No eddy current effects were observed as the ramp rate was increased to well above the design specification.

The magnet was built by a group drawn from the Physics Department and the ISABELLE Project, led by Bob Palmer. It was designed with dimensions and specifications identical to those of the standard ISABELLE magnets. The main difference is the substitution of cable for braid. Other innovations include special low friction slip planes in critical bearing areas, split core yoke construction for high compression and special clamping of the coil ends for longitudinal restraint.

Further tests were carried out with the temperature reduced to 3.7 K, and resulted in a higher field — 5.9 T. A second 5-foot magnet will be tested soon and a full size 15-foot ISABELLE magnet will be built in the immediate future.

DUBNA/ SERPUKHOV
Streamer spectrometer

A Berlin / Budapest / Warsaw / Dubna / Prague / Sophia / Tiflis group has obtained first results from the RISC spectrometer (Relativistic Ionized Streamer Chamber). It is being used in an experiment on multiple production of charged particles from nuclei with 40 GeV negative pion and kaon beams at the Serpukhov accelerator.

The basis of the spectrometer is a

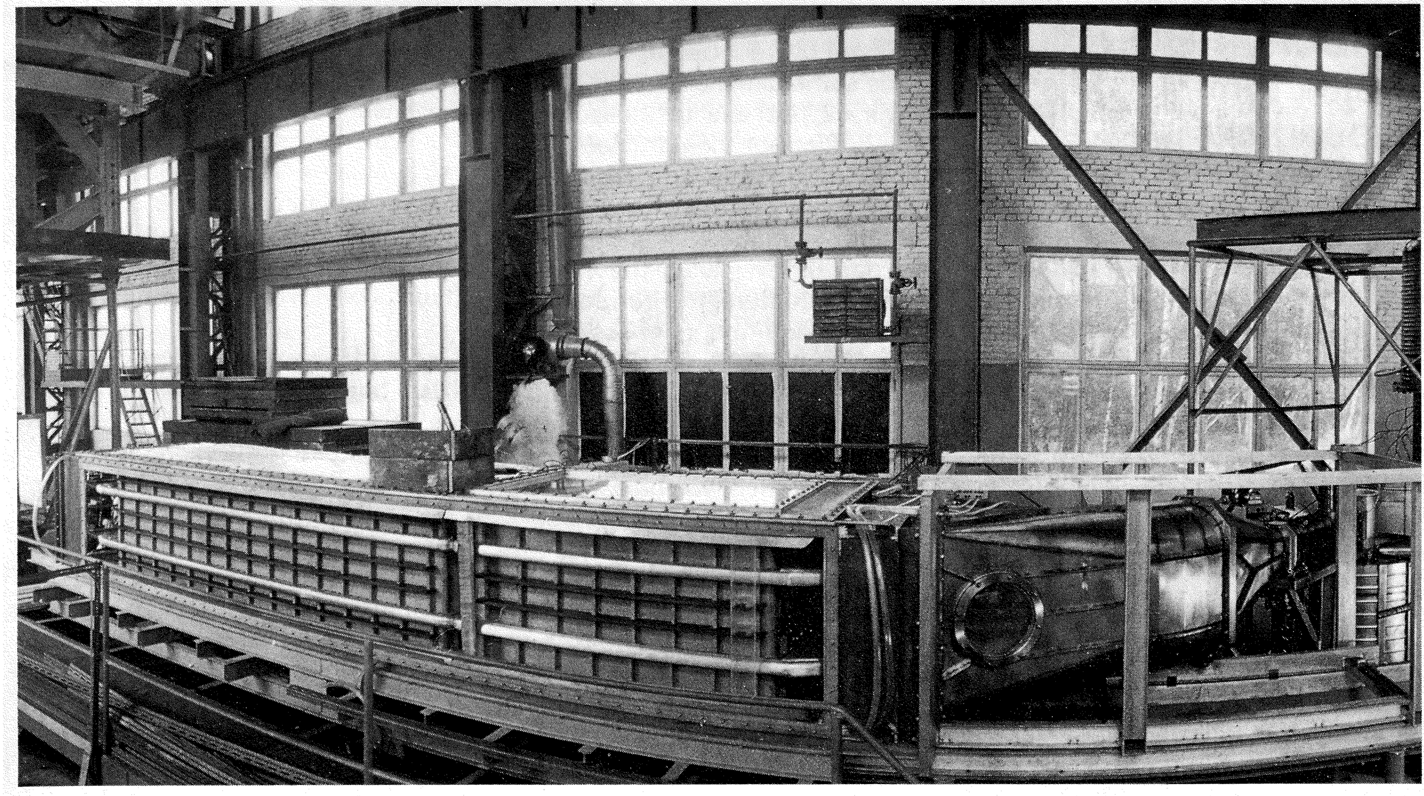
streamer chamber with a track-sensitive volume $0.93 \times 0.80 \times 4.70$ m^3 in a magnetic field of 1.5 T. The chamber differs from conventional streamer chambers in that it has a bipolar design. Instead of one high voltage electrode in the track sensitive volume, there are two, which are fed simultaneously with high voltage pulses. In this way it is possible to avoid having an electrode in the median plane of the chamber, thus freeing it for the installation of targets, detectors etc.

The chamber is monitored by an eight channel optical system (four stereoscopic pairs), with electrostatic image converter tubes which increases the brightness of the tracks in every channel 100-fold. The track sensitive volume is also viewed by a television system which makes it possible to keep a constant check on the quality of the tracks and the efficiency of the trigger.

Inside the chamber, there is a liquid hydrogen (or liquid deuterium) target of 20 mm diameter and 200 mm^3 volume. In the first experiment on multiple production of hadrons, up to ten separate nuclear targets were placed along the line of the beam in the chamber (from lithium to lead). Since it is possible to locate the interaction point very precisely and to have an efficient trigger, the targets used in RISC are very small (about one per cent of the nuclear interaction length). It is then possible to dispense with any basic corrections, related to the thickness of the target. The use of a streamer chamber which records all the charged particles being emitted from the target, and to distinguish charges over the entire solid angle, has yielded results on multiple production.

It has been found that the increase in multiplicity of charged particles in proportion to the atomic number relates mainly to the emission of positively charged particles. There are more positively charged particles, particularly protons, than negatively charged particles, even at energies over 500 MeV (far beyond the energies of evaporative protons). The average multiplicity value of negatively charged particles, in contrast to positively charged, increases slowly.

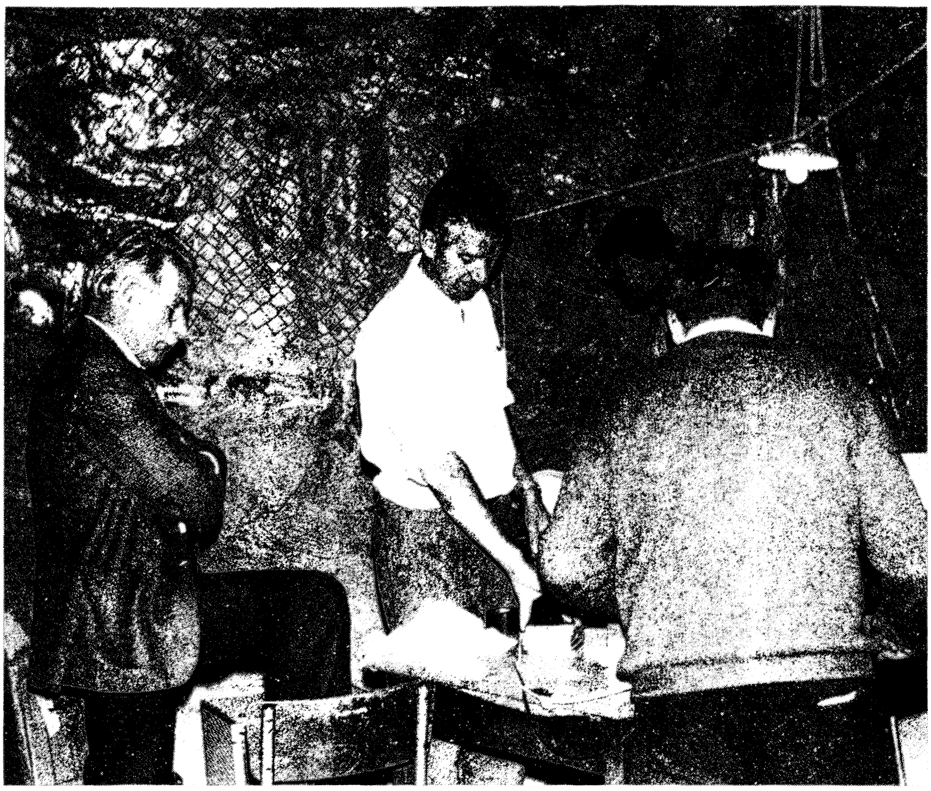
A programme is now in progress at the RISC spectrometer to investigate rare hadron-hadron and hadron-nuclei processes with a cross-section less than a microbarn and data on the production of charged particles in antiproton-nuclei interactions is being processed.



General view of the RISC spectrometer streamer chamber (with side cover removed) on its test stand at Dubna before it was sent for installation at Serpukhov. The chamber has an unusual bipolar design.

(Photo Dubna)

Background measurements in the initial excavation in the Fréjus tunnel.



UNDERGROUND

Frejus tunnel experiment

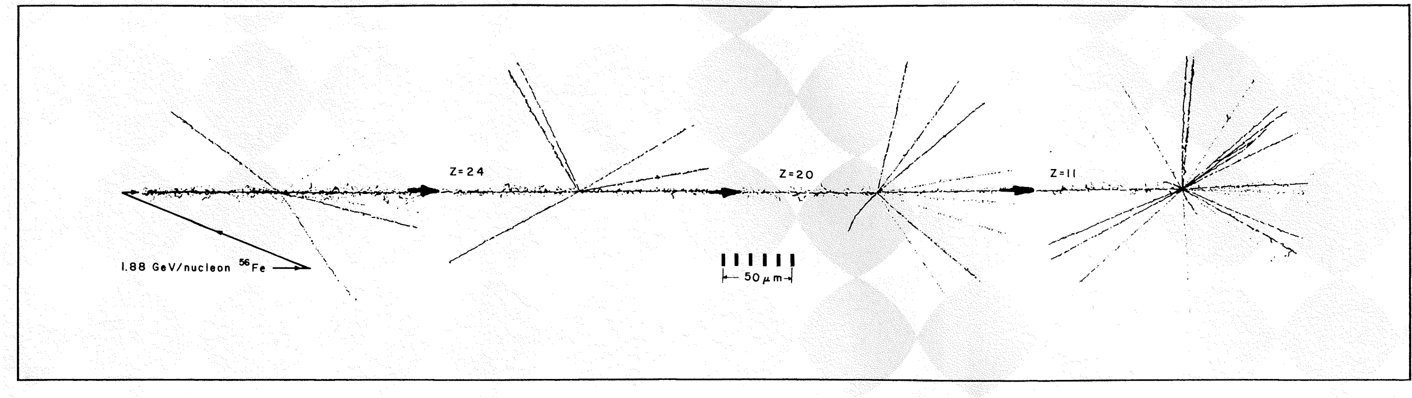
To search for proton instability and to measure the proton lifetime, an Orsay / Saclay / Ecole Polytechnique collaboration last year put forward a proposal for an experiment in the Frejus tunnel using a calorimetric detector with a fiducial mass of 1000 tons. A German group from Wuppertal added its support to the proposed experiment, which was approved in May.

The detector, which has a total mass of 1500 tons, measures 6 x 6 x 20 m. The nucleon source consists of iron plates 3 or 4 mm thick. The fine grain is provided by 1600 banks, measuring 6 x 6 m, of polypropylene plasma tubes 6 mm long, similar to those operating in a Fermilab neutrino experiment. These tubes are triggered by 185 Geiger tube banks of the same dimensions. With these it will be possible to measure the time of flight of the particles and to detect any particularly slow particles, such as monopoles. All these detector components are fitted in alternate array, giving the whole a modular structure. The iron sampling precision and the fineness of the grain will make it possible to discover the charge of the tracks and to measure their energy with a high degree of accuracy.

The experiment will be carried out in the Modane underground laboratory fitted out beside the Frejus tunnel linking Modane in France to Bardonecchia in Italy, and located on French territory some 100 m from the border. An initial excavation of 800 m^3 was made before the tunnel was completed in 1980 and background measurements were made. They showed that the muon rate was indeed reduced by a factor of the order of 10^6, as expected by the 1500 m of rock covering the chamber. This excavation will be enlarged at the beginning of 1982 to take a 3000 m^3 laboratory. A start will be made on installing the detector at the end of 1982. Since it is modular, it can begin operating before it is completed. It will be sensitive enough to allow the measurement of a lifetime of 10^{31} years in one year and to reach a lower limit of 10^{32} years in a few years.

Physics monitor

Although not evidence for quarks, heavy ion experiments at the Berkeley Bevalac have revealed signs of unusually short-lived states in nuclear emulsion. Here is an example of an incoming iron nucleus producing a chain of four successive interactions.



Quark search conference

In spite of (or perhaps because of) the present doctrine of total quark confinement held by the majority of particle theorists, experimental searches for free fractional charge and other anomalous stable particles in ordinary matter have been increasing in number during recent years, using a range of techniques of increasing sophistication and sensitivity.

As a result, researchers in this area had a conference to themselves in June. About 40 participants and 150 observers gathered at San Francisco State University to report progress and discuss future plans, with representatives present from almost every group involved in quark searches.

Direct accelerator searches have seen no fractionally-charged particles of mass below about 13 GeV. However possible candidates for new particles in this mass range have been reported from the Auckland cosmic ray experiment and some anomalous nuclear fragments appear to be present in emulsion experiments with heavy ions at Berkeley.

The majority of the current and planned searches in matter are based on one of three basic techniques — magnetic levitation, time-of-flight spectrometry and electrostatic droplet deflection. Other ideas under development include semiconductor and tunable laser techniques for the excitation and detection of anomalous atoms.

Inevitably, interest at the conference focused on the latest results from the Stanford group which has been reporting apparent fractional charges in over a third of their levitated 0.25 mm niobium spheres. In the opening talk of the conference, W. Fairbank claimed the continued observation of this effect in a further fifteen charge measurements on five spheres. One sphere gave zero residual charge, two gave measurements of $+^1/_3$ and two $-^1/_3$ of the electronic charge (in the experiment, $-^1/_3$ is indistinguishable from $+^2/_3$ or two $+^1/_3$ charges, and vice versa). One of the $+^1/_3$ values remained unchanged for eight levitations, while another sphere changed from $-^1/_3$ to 0 in successive levitations. Fairbank showed measurements of background, which remained constant during successive levitations, and concluded that the measured fractional charges represent a real effect. Nevertheless he has agreed to a 'blind' analysis of future data, incorporating in the computer program a random charge value which will not be known to the Stanford group until afterwards.

In contrast to the Stanford results, G. Morpurgo reported no fractional charges with his levitated iron spheres, obtaining a residual charge consistent with zero in a total of seventy spheres. Since the spheres are of different material and are prepared in different ways, the two results are not necessarily in direct contradiction, but Morpurgo feels that, since the Stanford fractional charges occur so frequently, and are apparently rather easily removed from the niobium spheres, we should expect a significant proportion in other materials also. He is now planning to test niobium-coated iron spheres, and spheres made from a niobium-iron alloy. It is not clear whether it will ever be possible to levitate the same spheres in both the Morpurgo and Fairbank systems.

A direct test of the Stanford claim may now be possible as a result of a new experimental strategy initiated by P. Smith and R. Bennett from the Rutherford Laboratory. The plan is to obtain a large number (ten thousand or more) of new niobium spheres, using the original Stanford material and the same manufacturer. Random samples will be tested by Stanford to confirm that fractional charges are still observed in the new batch, and the remainder will be tested in a series of experiments by a Rutherford / Imperial College / Queen Elizabeth College collabora-

People and things

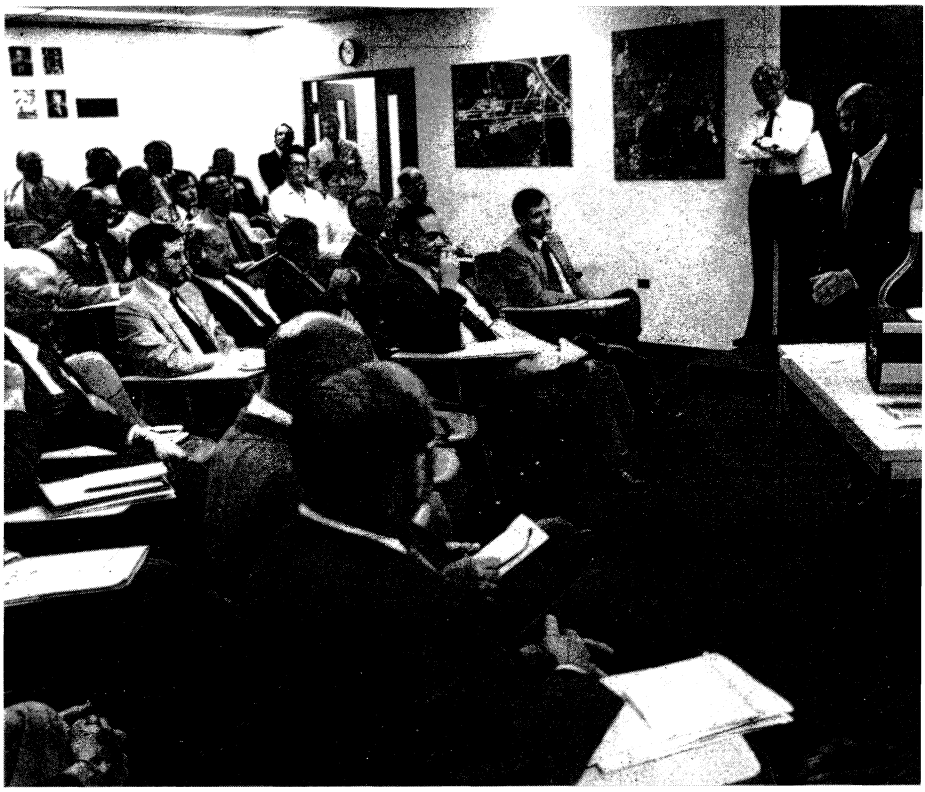
tion which will attempt to confirm and identify the source of the fractional charge. The experimental programme includes evaporation of the material into a time-of-flight spectrometer (see January issue, page 18) and a new electrostatic deflection experiment. The Stanford group is also attempting to develop an independent test in which the spheres are suspended in an air stream and induce a small alternating current in a rotating array of capacitor plates. The hope is that sufficient sensitivity will be achieved to measure the charge on each sphere to better than $\frac{1}{3}$.

Other workers favour a more general approach and plan to examine a wide variety of materials at sensitivity levels better than the Stanford result (10^{-17} per atom). This has been made possible in particular by the development of an electrostatic droplet deflection technique by R. Hagstrom (Argonne), G. Hirsch (Berkeley) and C. Hendricks (Livermore) using a stream of uniform size liquid drops (typically two thousand per second, 20 microns diameter) passing through an electric field. The drops separate into discrete integer charge clusters between which any fractionally-charged drops would be clearly detectable. Hirsch and Hendricks are constructing apparatus with a 10 foot vertical flight path, while Hagstrom plans to use a 70 foot tower and 50 micron drop size in order to increase the processing rate.

The remarkable features of the technique are its universality (since almost all materials can be put into liquid solution or suspension) and the quantity of material which can be examined (as much as 10^{-4} g per second or 10^{23} atoms per day, which makes new levels of sensitivity possible for the direct detection of fractional charge in all types of matter). With suitable enrichment procedures, concentration levels down to 10^{-30} or less may be attainable.

Professor Fairbank's son, W. M. Fairbank Jnr., presented a paper on the use of tunable dye lasers to excite and identify specific atoms at the 1 in 10^{19} concentration level. This technique could prove of importance in a variety of experiments requiring extreme chemical sensitivity (one example in particle physics being solar neutrino detection by chemical techniques).

The conference, conceived and organized by G. Fisher of San Francisco State University, was judged to be a success by both participants and observers and attracted considerable media coverage because of the novelty (and unusual simplicity) of the scientific objectives. The conference also produced the first-ever quark t-shirts!



Charles Percy, U.S. Senator from Illinois, addresses the Fermilab Industrial Affiliates first annual meeting and symposium on technology transfer. He stressed the importance of continued emphasis on research and development. More than seventy representatives attended the meeting on 27, 28 May at Fermilab. Participants included John Hulm of Westinghouse, who helped to pioneer the application of superconductivity to bubble chambers, and particle physicist Mel Schwartz who also has his company (Digital Pathways).

(Photo Fermilab)

At its June session the CERN Council appointed René Turlay from Saclay for a three year period of office as a member of the Scientific Policy Committee. It also extended the mandate of F. Herz as Head of the Health and Safety Division until the end of 1981. The Council also expressed its appreciation of the work of Italo Mannelli who is leaving the CERN Directorate, being succeeded by Robert Klapisch. Gregers Hansen

replaces Klapisch as Chairman of the Proton Synchrotron and Synchro-Cyclotron Committee.
From 1 July Fritz Niemann has taken over from Günther Ullmann as acting Head of Personnel Division. Günther Ullmann has been Head of Personnel at CERN for twenty years and has contributed greatly to the success of the Laboratory by his intelligent handling of the concerns of the personnel in CERN's unusually complex multicultural and multi-lingual community.

Frederick Reines, neutrino researcher from the University of California, Irvine, has been awarded the thirteenth annual J. Robert Oppenheimer Memorial Prize.

New fellows of the Royal Society in the UK elected this year include experimentalist Ian Butterworth of Imperial College, London, and theorist John C. Taylor of the University of Cambridge. In addition, Steven Weinberg of Harvard, currently on leave at the University of Texas, was elected foreign member.

The UK Institute of Physics Guthrie Medal and Prize has been awarded to J.C. Ward of Macquarie University, Australia. His accomplishments cover a wide range, including both field theory and statistical mechanics. In the domain of field theory and renormalization techniques, his contributions include the famous 'Ward Identities'. He has also made important contributions to the development of the unified theory of electromagnetic and weak interactions, particularly in collaboration with Abdus Salam.

Burt Richter (left) and Pief Panofsky in action during the annual Experimenters versus Theorists softball game at SLAC.

(Photos Joe Faust)

The 1981 Norsk Data Physics Award was presented to Kjell Johnsen on 23 June for his technological contributions to elementary particle physics. Kjell Johnsen headed the team which built the CERN Intersecting Storage Rings and is currently technical director of the ISABELLE project at Brookhaven.

Reorganization at Fermilab to take account of the advent of the Energy Doubler programme has led to a new Accelerator Division since 1 July. This merges the Energy Doubler and the 400 GeV Accelerator into a single Division. Division Head is Rich Orr and Helen Edwards is his deputy. Also since 1 July, William Bardeen has taken over from Chris Quigg (on leave of absence for a year at Ecole Normale Supérieure in Paris) as Acting Head of Theoretical Physics.

Brad Cox becomes head of Fermilab's Research Services Department succeeding Marvin Johnson.

Alick Ashmore retired in June as Director of the Daresbury Laboratory. He had successfully seen Daresbury through a difficult transition period when the Laboratory was transformed from a high energy physics centre based on the operation of the NINA electron synchrotron to a multi-disciplinary centre based on two very different frontline facilities - the Synchrotron Radiation Source (2 GeV electron storage ring) and the Nuclear Structure Facility (30 MV tandem Van de Graaff). He was made Commander of the British Empire (CBE) in 1979. He is succeeded by Leslie Green.

Max Delbrück died in California earlier this year. His important early contributions to quantum mechanics and field theory have been immortalized in the term 'Delbrück scattering', describing the electromagnetic interaction of photons with nuclei. In 1938 he turned his attention from theoretical physics to genetics, where he went on to become an authority of world renown.

News from China

The King of Belgium recently paid a state visit to the People's Republic of China and invited four Belgian scientists to accompany him — M. Engelborghs-Bertels, P. Melchior (Royal Observatory of Brussels and Louvain), J. van der Veken (Louvain) and Y. Goldschmidt-Clermont (Brussels and CERN). Yves Goldschmidt-Clermont provided us with the following report.

From 11-20 May, the Academy of Sciences (Academia Sinica) held the first meeting of its 400 strong Scientific Council since 1960. The importance of this meeting was emphasised by the fact that Deng Xiaoping, Peng Zhen and Zhao Ziyang attended the opening session. Though formerly only an advisory body, the Council has now been given management functions. It elected Yang Jici (nuclear physics) as Chairman and several Vice-Chairmen, including Li Xun and Qian Sanquiang, and it will in future be responsible for defining the Academy's working programme. The stress was laid on applied research, especially in economic fields (particularly agriculture), defence and social progress, but without neglecting fundamental research.

The former Chairman has resigned, but Fang-Yi remains a Vice-Premier and Chairman of the State Committee for Science and Engineering. Chinese scientists welcome this greater and more useful independence of the Academia Sinica's scientific institutions.

Economic readjustments have forced the Institute of High Energy Physics to abandon the proposed construction of a 50 GeV proton synchrotron (see April 1979 issue, page 59). Other projects are being examined, especially one for electron-positron colliding beams with sufficient energy to reach the production threshold of particles containing a charmed quark and capable eventually of reaching that of particles containing a beauty quark. The first research stage would be devoted to charmonium spectroscopy and the production and decay mechanisms of charmed particles.

The Chinese scientists showed great appreciation of the fact that a Head of State had invited representatives of his country's scientific circles to accompany him, and that he spoke with them during a long conversation in which Li Xun (Vice-Chairman of the Academia Sinica), Zhang Wenyu (Director of the Institute of High Energy Physics) and Peng Huangwu (Director of the Institute of Theoretical Physics of Academia Sinica) took part.

GUD – Giant Underground track – Detector

Italian physicists are presently developing a large modular track detector to be installed in the future Gran Sasso underground laboratory. Such a 'Giant Underground track-Detector' (GUD), up to 10 Kt in mass, should be capable of investigating nucleon decay and the interactions of high energy cosmic neutrinos.

A Workshop is being organized to gather the experts in the fields of interest and the physicists working or willing to work on the projec to study the range of applications of such a detector to fundamental problems of subnuclear physics and astrophysics. At the same tim the Workshop should promote discussions on the technical aspects and compare the proposed track detector with alternative technique Participation will be by invitation and limited to about 70 physicists and astrophysicists. For further information please write to Ms. G. Fascetti, Istituto di Fisica dell'Universita di Roma, P.le A. Moro 2, 00185 Roma, Italy.

International Conference on Nucleus-Nucleus Collisions

An International Conference on Nucleus-Nucleus Collisions will be held at Michigan State University from 26 September to 1 October, 1982. Sponsorship by the International Union of Pure and Applie Physics has been requested and is under consideration. The Conferen will aim to survey developments i the field of nucleus-nucleus collisions at low, intermediate and rela tivistic energies. In addition it will coincide with the inauguration of the National Superconducting Cycl tron Laboratory at Michigan State University. Further information ca be obtained from David K. Scott, National Superconducting Cyclotr Laboratory, Michigan State University, East Lansing, Michigan 4882 USA.

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Nominations or applications should be sent to Dr. Edmond L. Berger, Chairman Search Committee, Box 10, High Energy Physics Division, Argonne National Laboratory, 9700 S. Cass Avenue, Argonne, IL 60439.

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Letters of application, together with a curriculum vitae and a list of publications should be addressed to:

Prof. Dr. K. Strebel
Dekan der Phil. Fakultät II
Universität Zürich
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Applications should arrive not later than December 31st 1981.

Those wishing to draw the faculty's attention to potential candidates are invited to write to the same address.

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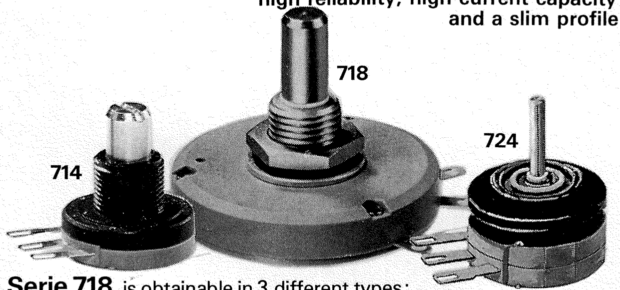
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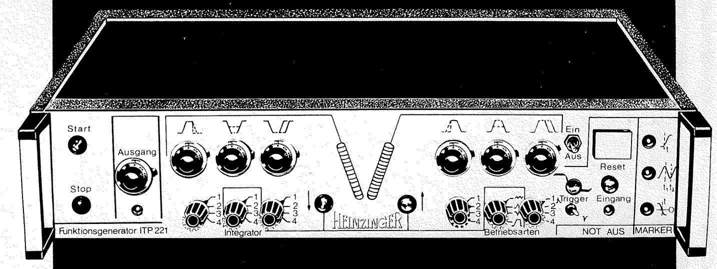
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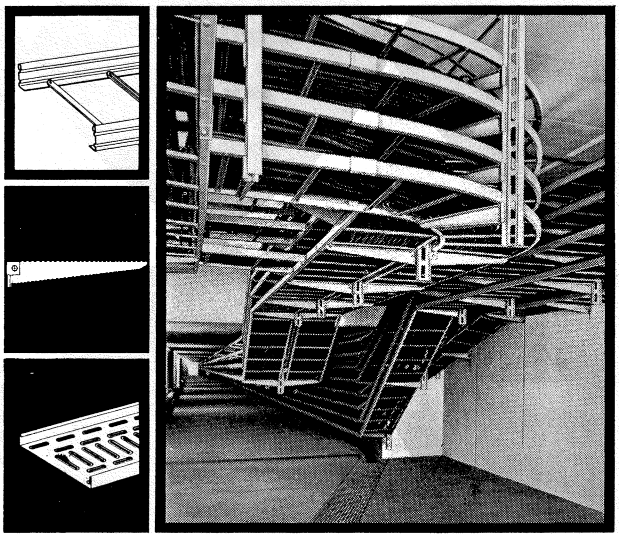

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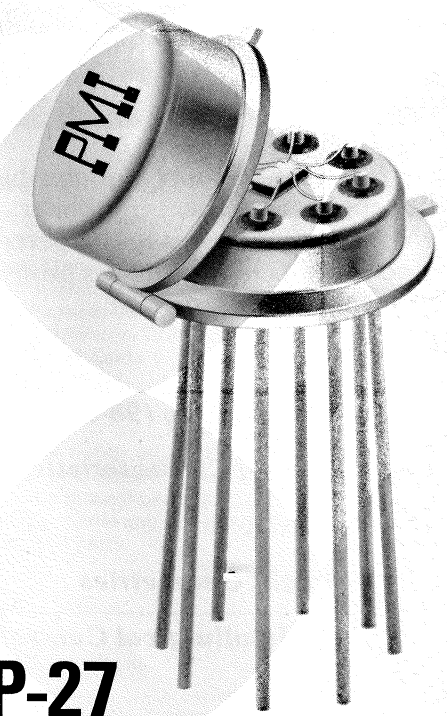

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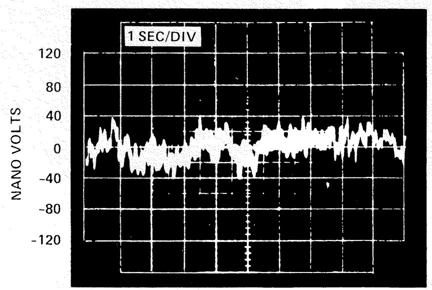

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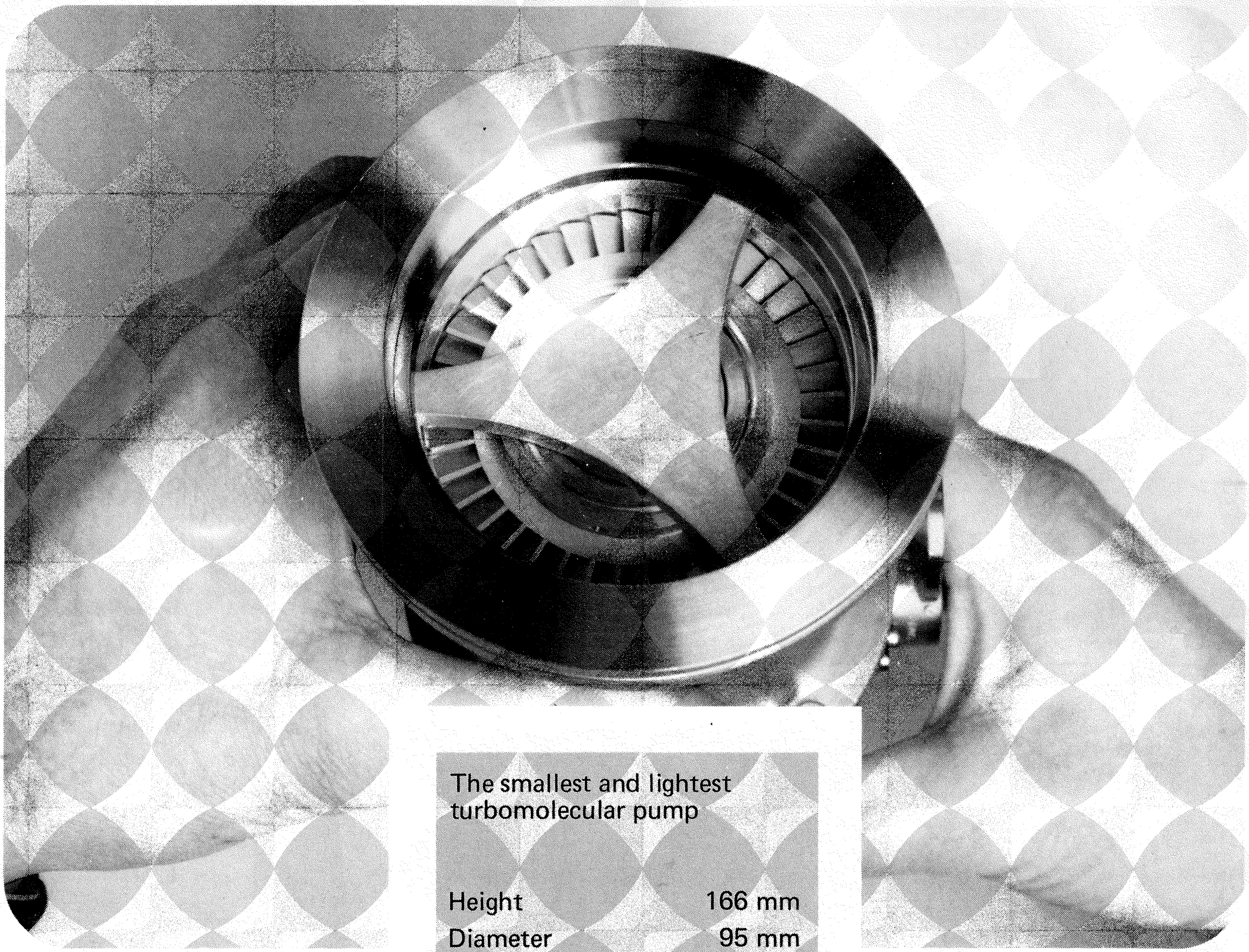

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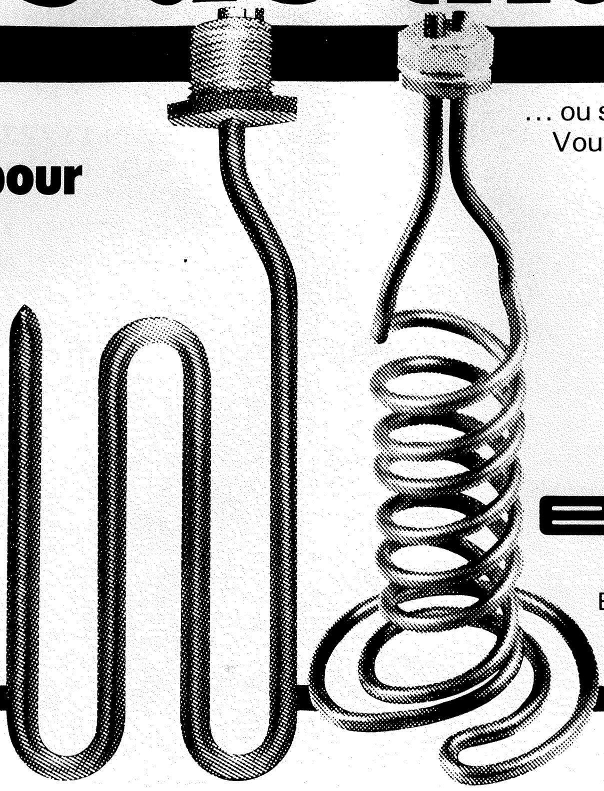

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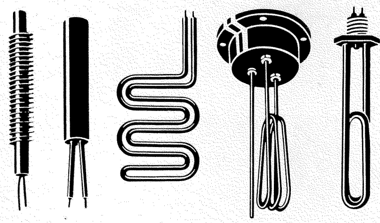

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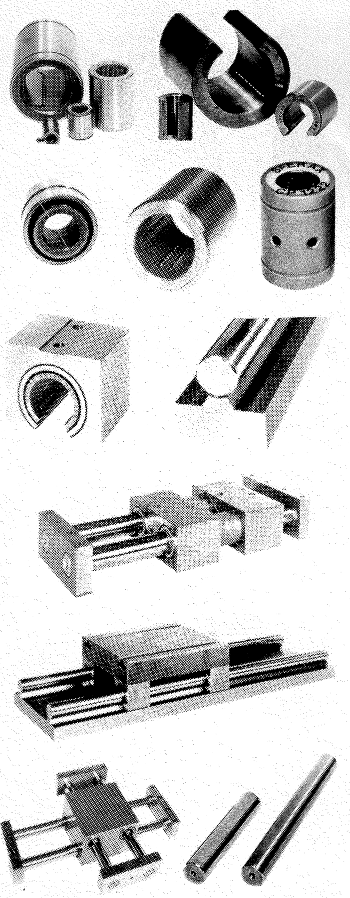

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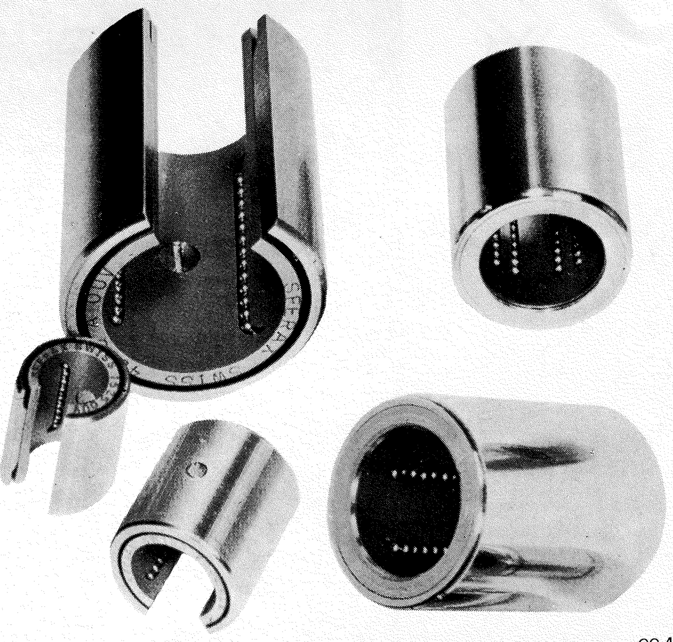

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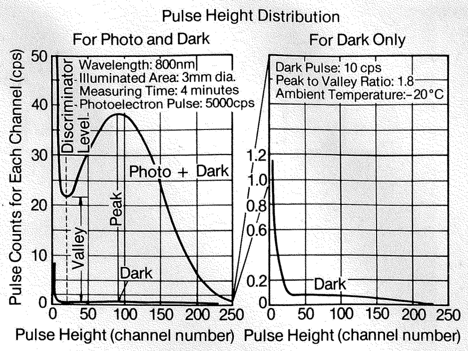

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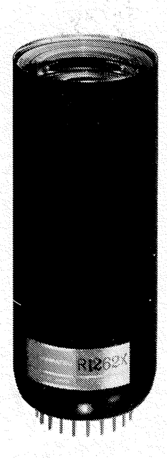

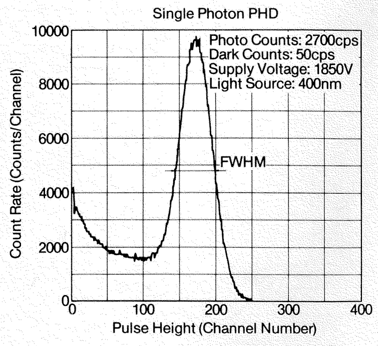

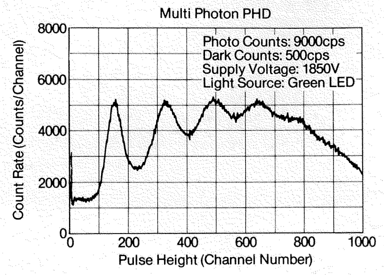

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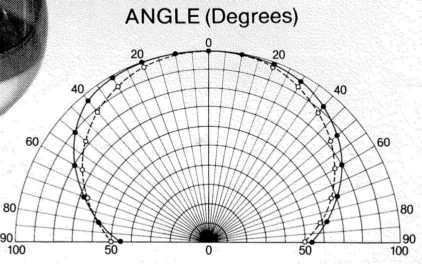

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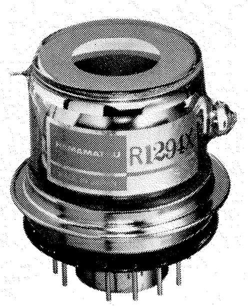

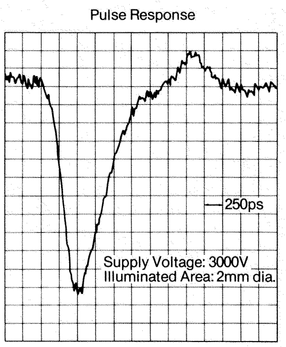

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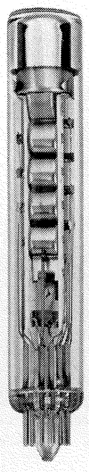

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Preparation of Nuclear Targets for Particle Accelerators
edited by **Jozef Jaklovsky**
New England Nuclear Corporation, Boston

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European Physical Society, Geneva, Switzerland

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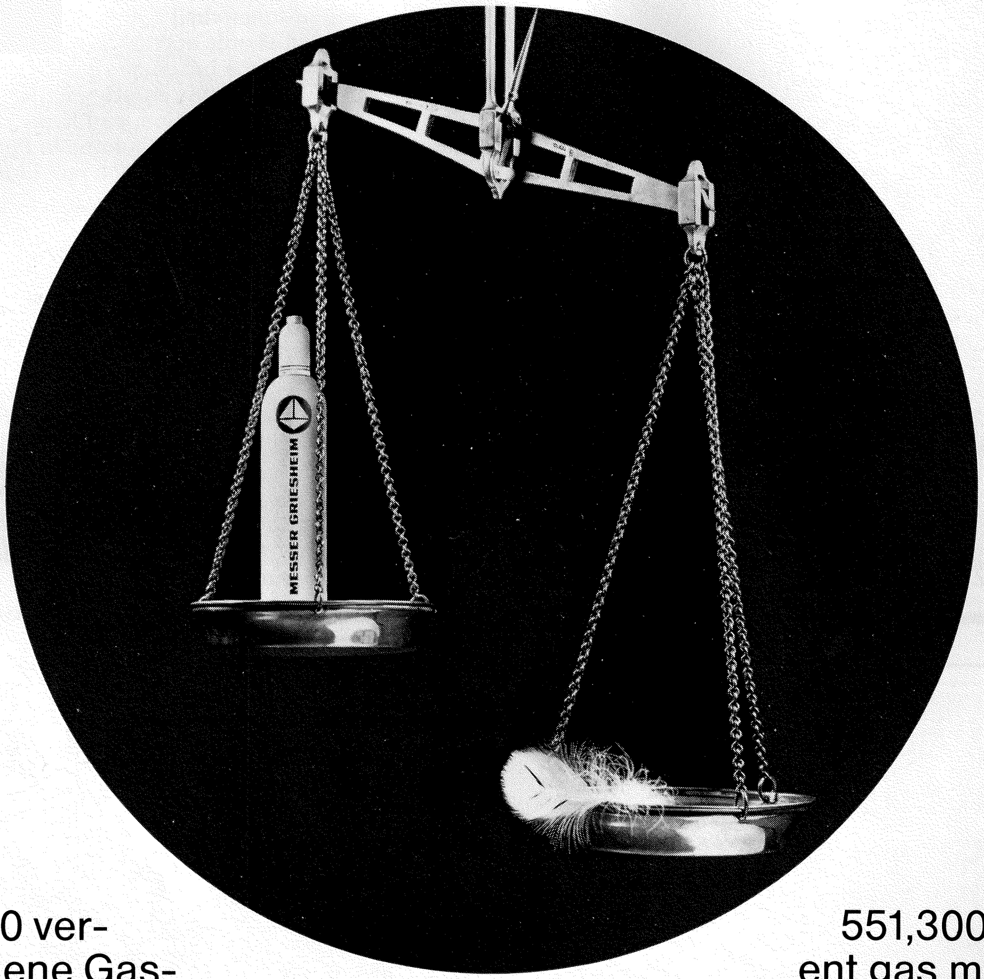

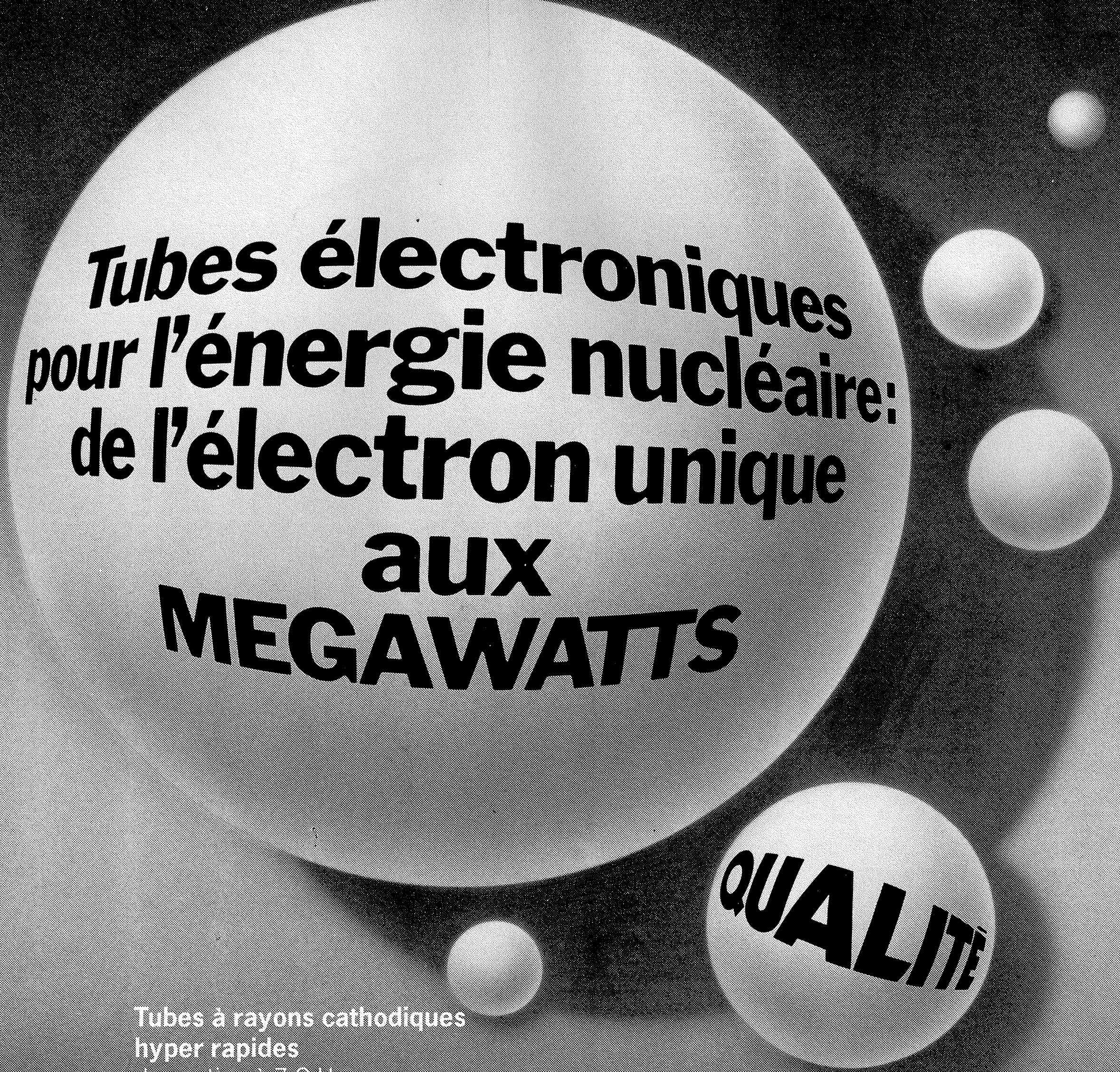
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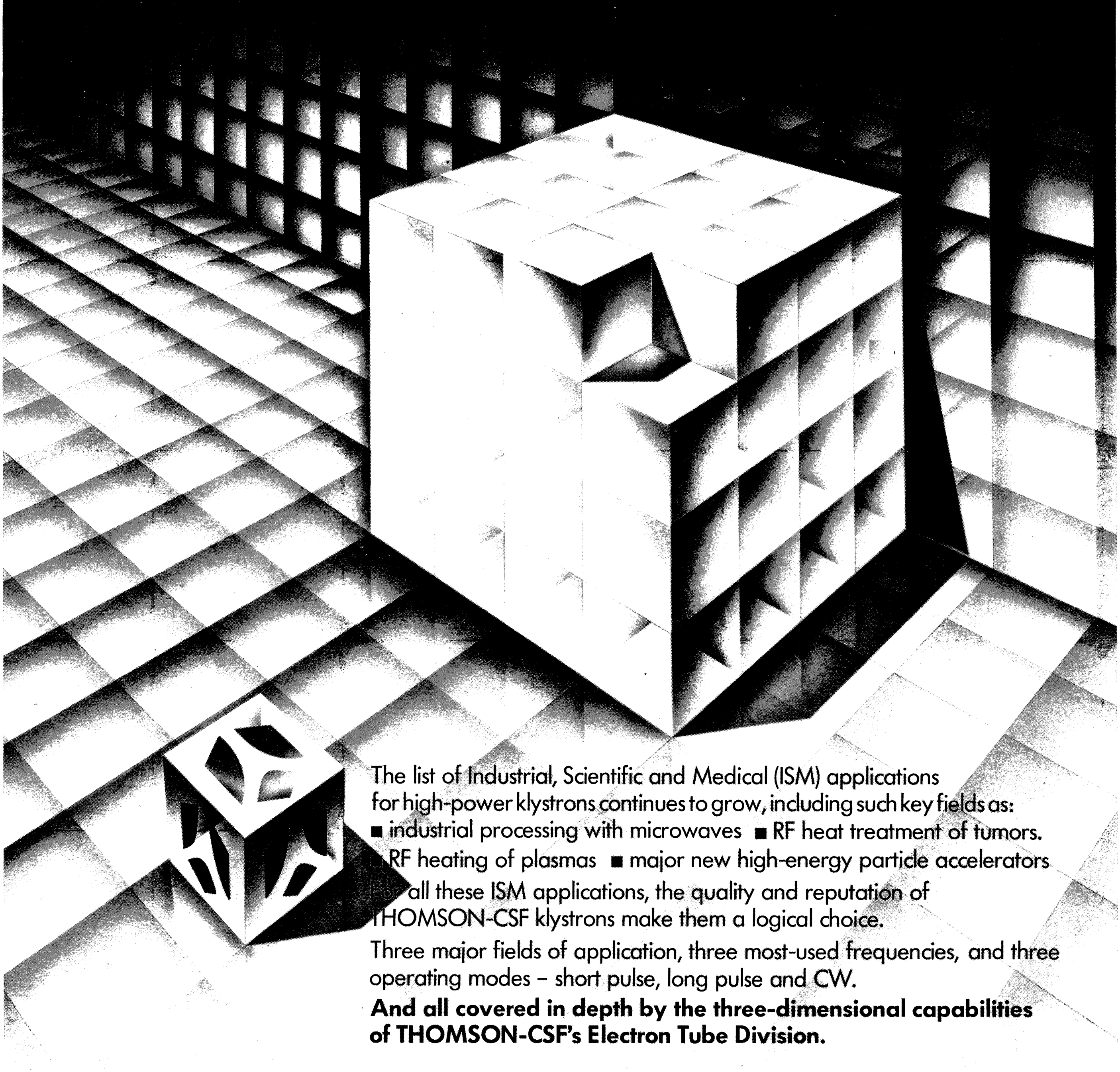

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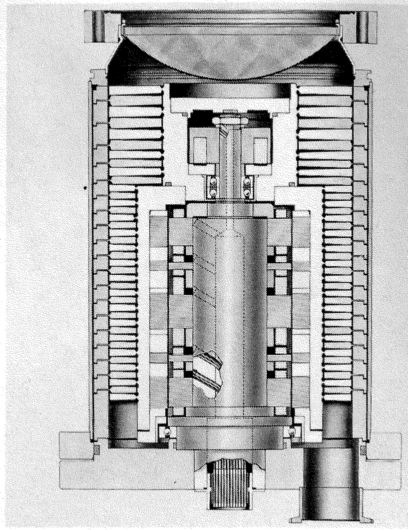

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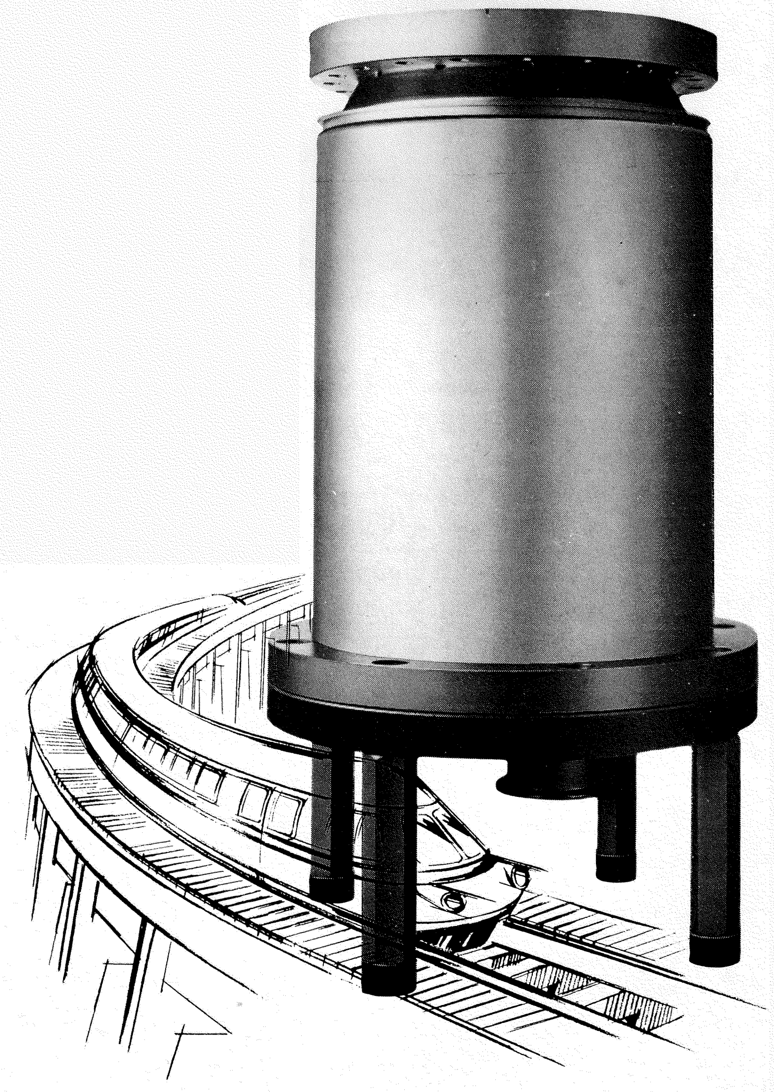

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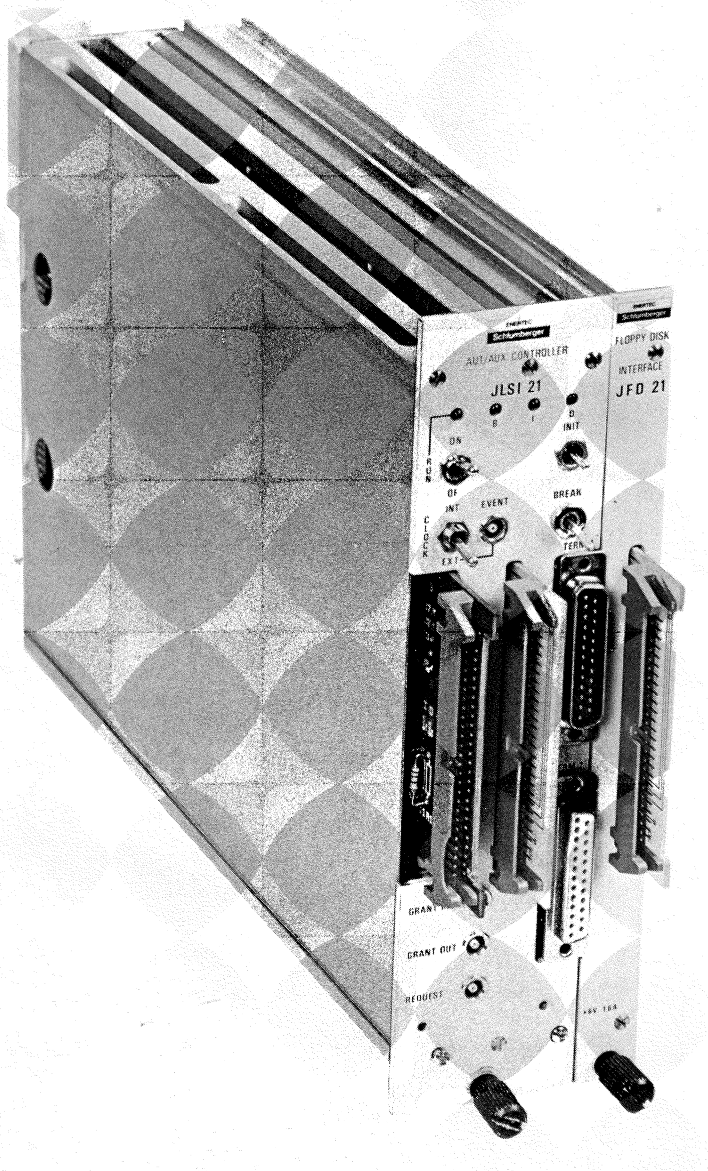

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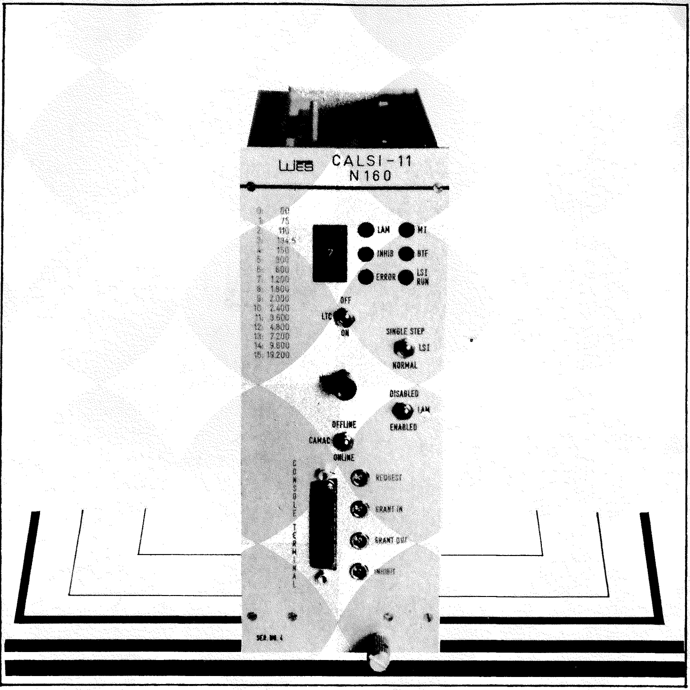
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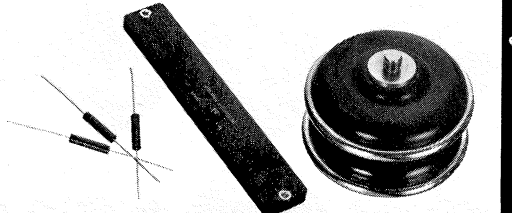

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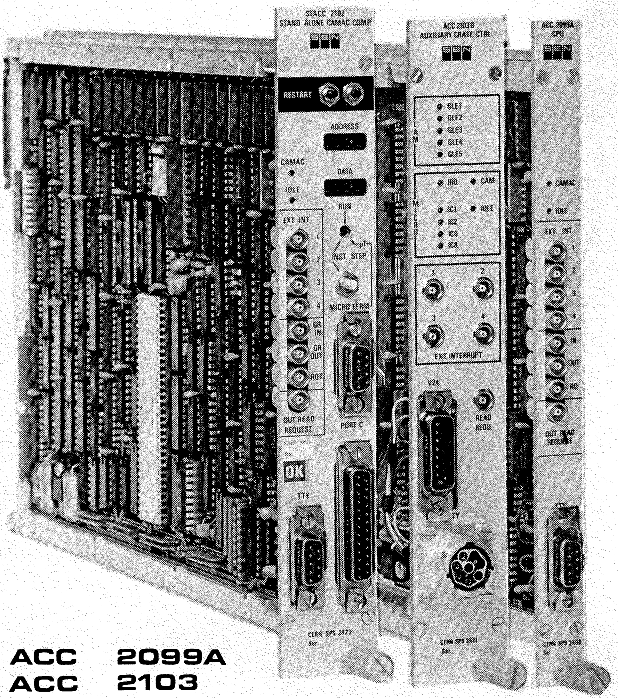

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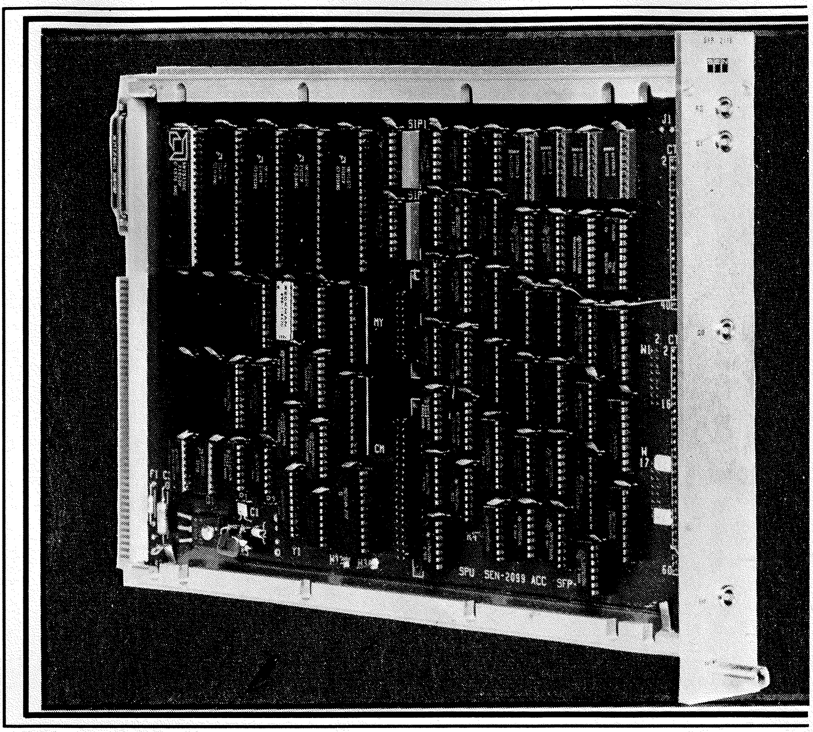

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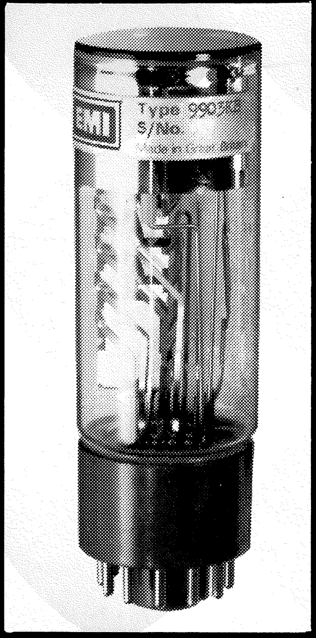

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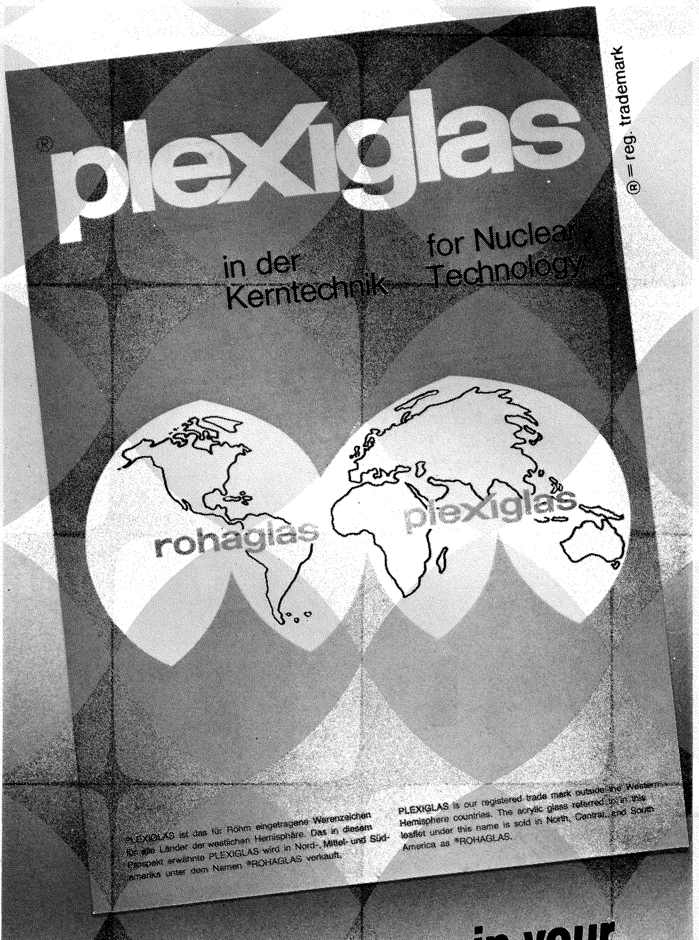

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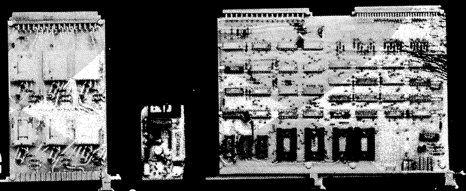

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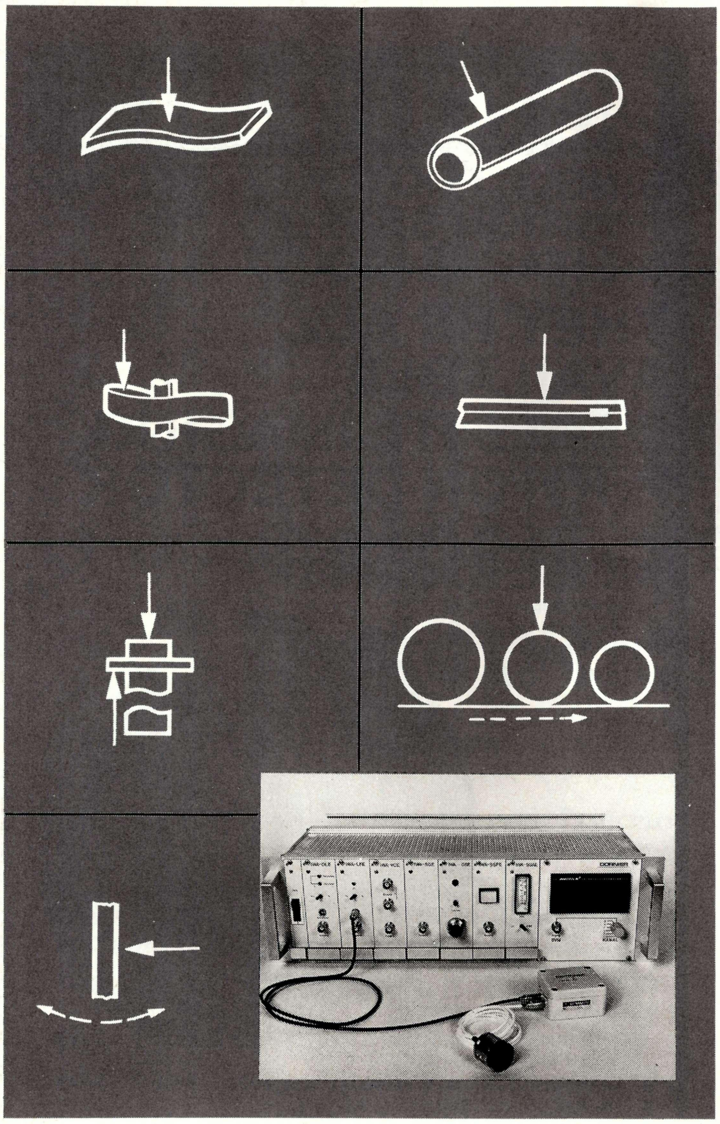

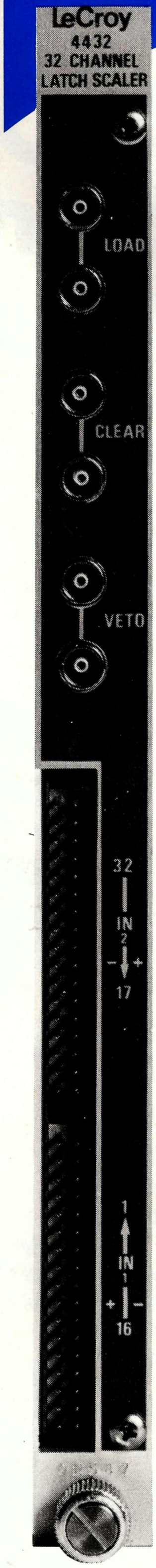
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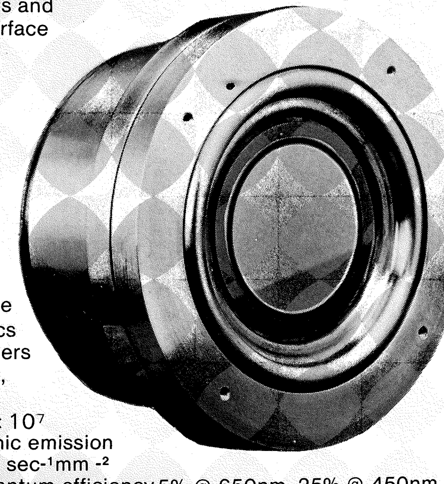

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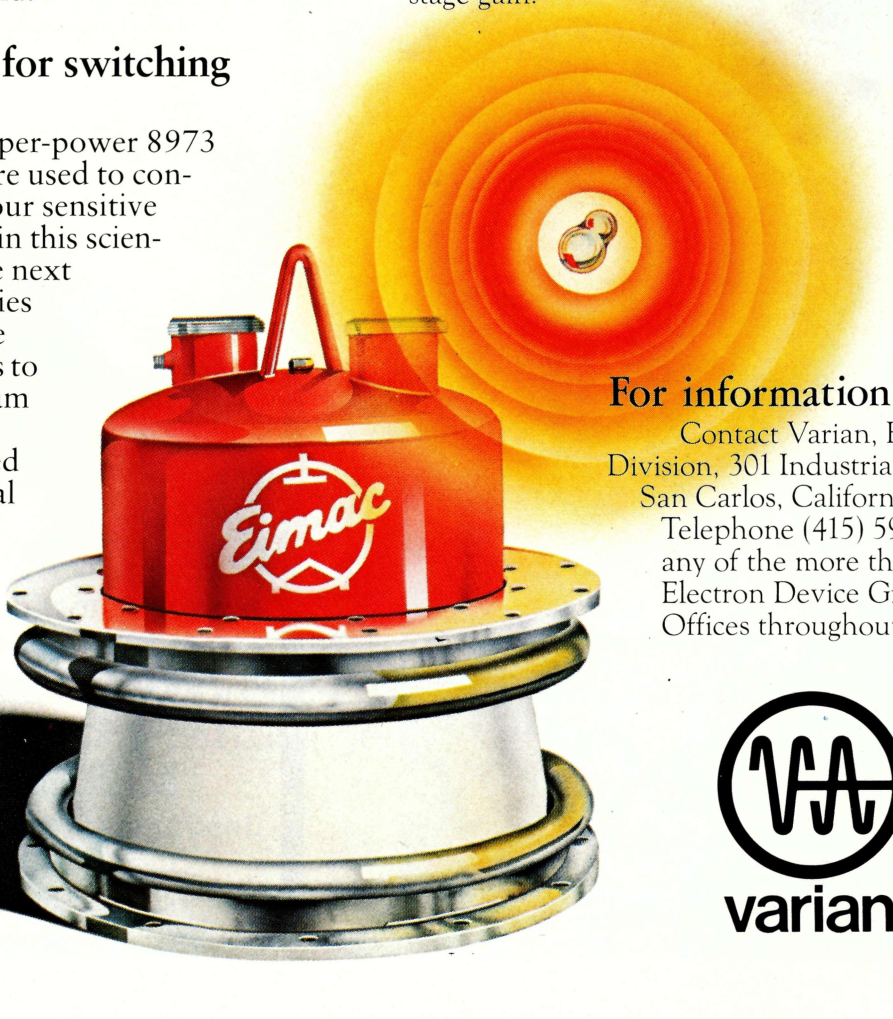

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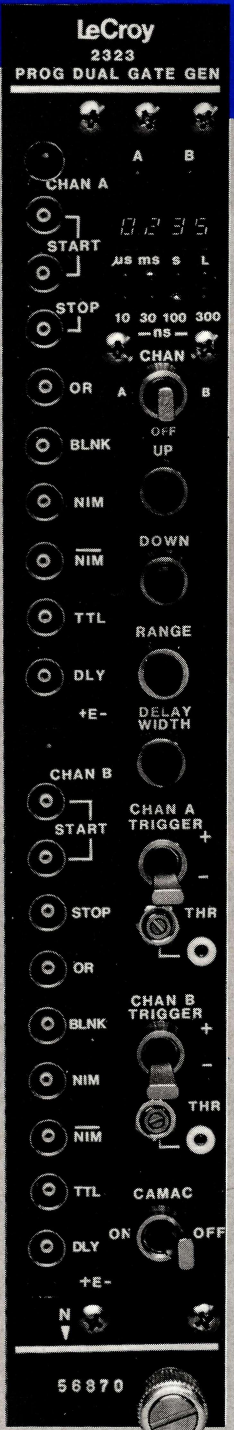
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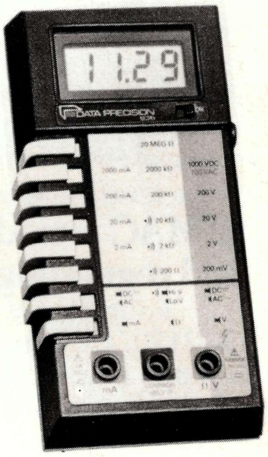
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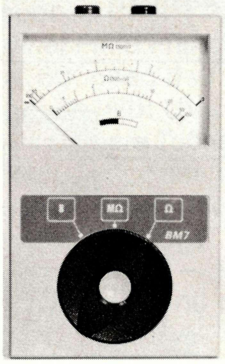
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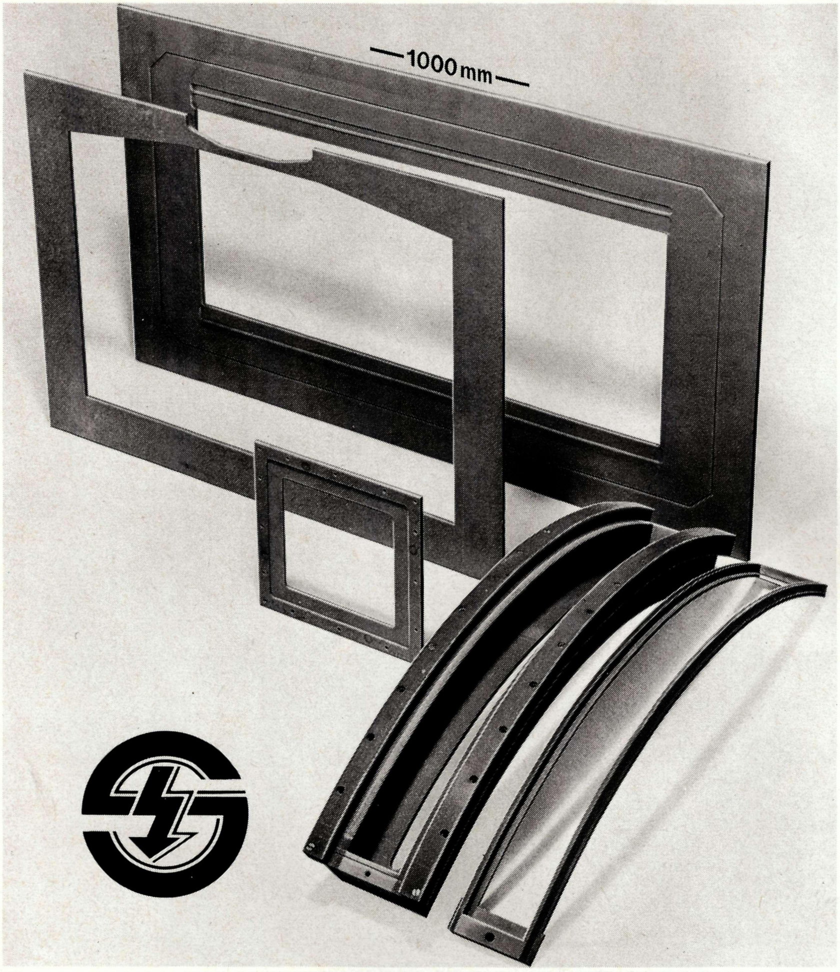
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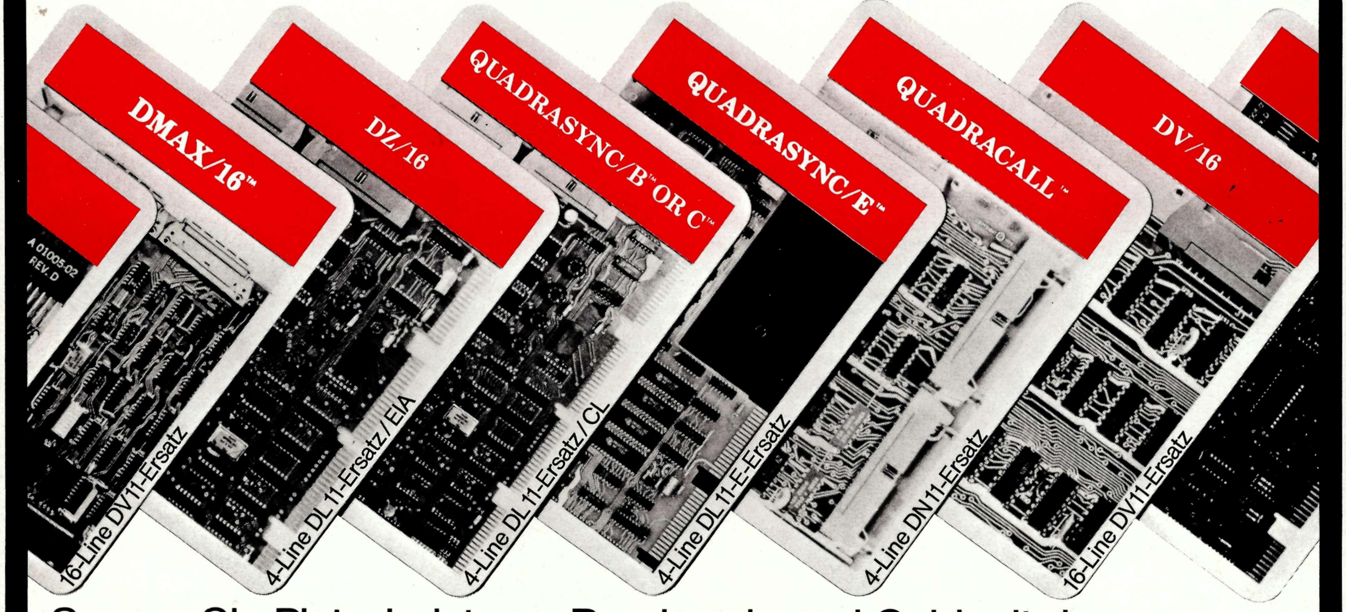
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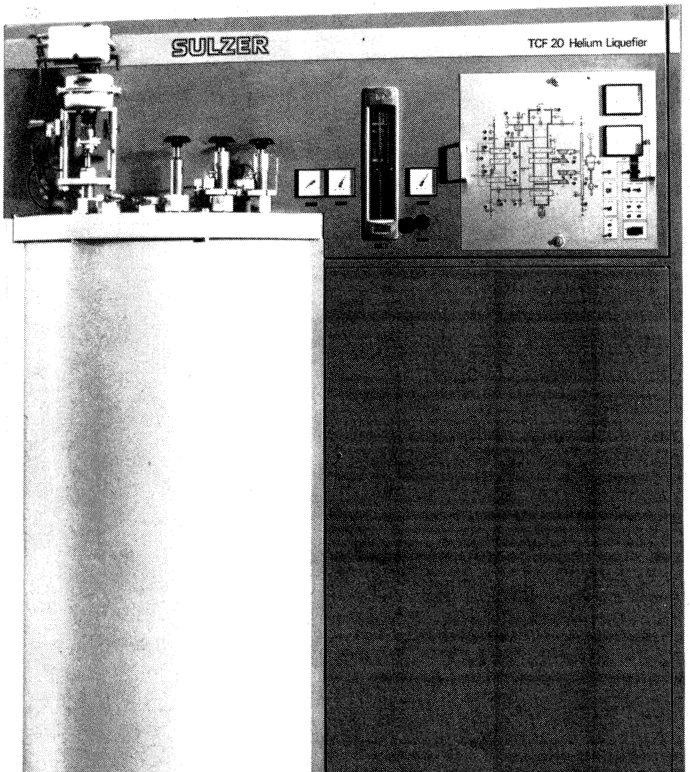

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