CERN COURIER

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Contents

Cover photograph: Following the recent international seminar on 'The Great European Projects' held in Rome by the European Physical Society, Pope John Paul II received EPS President Antonino Zichichi and Council in special audience. Replying to Professor Zichichi's remarks on the cultural value of science in modern times, His Holiness expressed his firm support of the role that science should play in shaping the future of mankind. (Photo Felici)

San Francisco Accelerator Conference

The 1979 Particle Accelerator Conference was held in San Francisco from 12-14 March. It was in the USA national series of such Conferences which has, nevertheless, broad international participation and which has gained in importance since the International Accelerator Conferences (of which the last one was in Serpukhov in 1977) became less frequent. The USA series is also distinct in giving considerable emphasis to practical applications of accelerators.

With communications in the field so very good, the San Francisco Conference was not the scene of dramatic revelations but it was the scene of a most impressive demonstration of the quantity and quality of work now being done in the accelerator field. This is true both in relation to the high energy physics research programmes and to a broad spectrum of practical applications. It was reflected in the number of participants, which passed the 900 mark (some 100 up on the previous record) and in the number of submitted papers which reached 450 (usually around 300).

In high energy physics, simply listing the new and projected machines conveys the same message – PETRA has just come into operation, CESR and PEP are nearing completion. ISABELLE and the Energy Doubler are authorized. The CERN antiproton project is under way. LEP and UNK are on the drawing board. Construction of the Peking machine is starting. At the same time everyone now has a synchrotron radiation source in their back yard, intense neutron sources are round the corner, accelerators for diagnosis and cancer therapy are a matter of optimization rather than principle, radioisotope dating with acceleration is blossoming, the vital potential contribution of accelerators to heavy ion fusion and fission breeders is under serious study.

The big machines

The coming into operation of the electron-positron storage ring PETRA at DESY was given the number one spot in the programme with a report by Gus Voss. First stored beams were achieved in the summer of last year, within budget and within schedule (as usual in the accelerator field). Four interaction regions have been brought into action and the first physics results were published in January. They covered R measurements, QED tests, jet phenomena and photon production. The TASSO, PLUTO, JADE, MARK J and CELLO detection systems are in operation and decisions on experiments for two remaining interaction regions will be made during the next year.

Operating conditions for physics are good with low background. However, the behaviour of the beams is qualitatively different from what has been seen at DORIS and SPEAR and the present limitation on luminosity is a vertical instability from an unknown source which is very dependent on the beta value of the interaction regions. Injecting at high beta and manœuvring to low beta for the experiments helps. Bunch lengthening is small and there seems to be no trouble from higher order mode losses.

The ultimate design aim is a luminosity of 10^{32} per cm^2 per s at 19 GeV. More r.f. has been installed (32 out of the 64 cavities) in a shutdown which began in February to enable the peak energy to be taken to 17 GeV. The remaining 32 cavities for 19 GeV will go in at the end of the year. Injection at present uses the DORIS storage ring to achieve adequate positron intensities. This will be replaced by a new small storage ring called PIA (see October issue 1977, page 326) which is to be commissioned in the summer of this year.

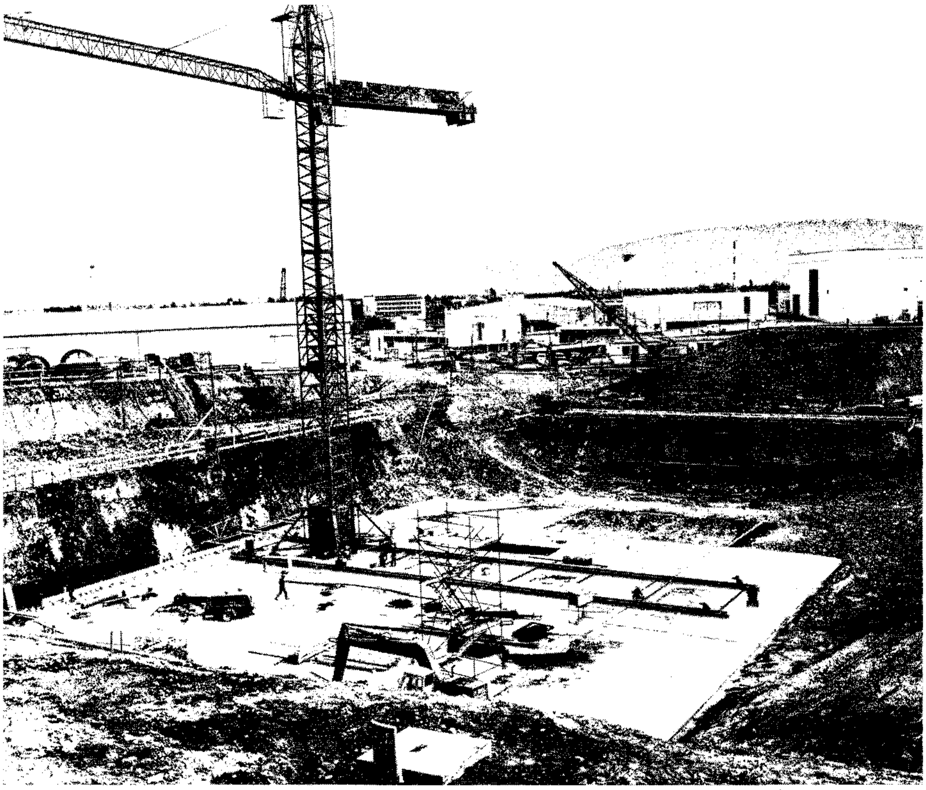
The remaining experimental halls will come into action in 1981 and there may then also be an attempt at experiments with polarized beams. Longer term, the use of superconducting cavities is being pursued in collaboration with Karlsruhe and CERN and the possibility of colliding electron and proton beams is under study in the project known as PROPER (see November issue 1977, page 364).

Number 2 spot at the Conference was given to the CERN proton-antiproton colliding beam facility (described in detail in the September issue 1978, page 291) for which construction is now well under way. Five experiments have now been approved for the facility; the two big ones UA1 and UA2 were covered in the September article and in the March issue of this year, page 16. In addition there will be a magnetic monopole search, a measurement of elastic scattering and total cross-section and a streamer chamber study of multi-particle production. Altogether these experiments involve 141 physicists drawn from ten of the Member States of CERN.

The antiproton accumulator ring is under construction and will use stochastic cooling exclusively, following the excellent results from the ICE experiments (reviewed at the Conference by Lars Thorndahl). It will accumulate 6×10^{11} antiprotons in 24 hours and distribute them in six buckets in the SPS ring. With these values it is hoped to achieve proton-antiproton collisions at an energy of 270 GeV and a luminosity of 10^{30}. The first AA ring tests are scheduled for mid-1980 at which time the SPS will begin an eight month shutdown to prepare for colliding beam physics

Construction work under way for the Antiproton Accumulator (AA) ring at CERN, as part of the project to use the SPS proton synchrotron as a proton-antiproton colliding beam facility.

(Photo CERN 103.3.79)



in 1981. Roy Billinge concluded his talk on the exotic machine physics built into the proton-antiproton facility by quoting, 'The impossible is what we have not tried yet'.

Boyce McDaniel covered the big new projects in the USA. At the time of the Conference there was feverish activity around the 8 GeV electron-positron storage ring CESR at Cornell with the aim of achieving first stored beams by 1 April. The hope of the Cornell physicists is that, with DORIS having to strain every muscle to reach the upsilon mass region and with PETRA and PEP more comfortable at higher energies, they will have upsilon spectroscopy pretty much to themselves.

CESR positron injection involves the vernier scheme of bunch slipping invented by Maury Tigner and it also has 'the most irregular lattice ever constructed'. It will be a nice feat of machine physics to bring it on the air and eventually to push to the design luminosity of 10^{32}.

The Berkeley/Stanford PEP project for 18 GeV electron-positron colliding beams is still aiming for completion in October of this year, 'despite civil contractors, uncivil contractors and the weather'. A sector of the ring is completed and installation of components is going ahead rapidly. Three detection systems are expected to be ready for the start up of the machine — Mark II, MAC and the free quark search. The High Resolution Spectrometer and Time Projection Chamber will probably follow some six months later. When construction of the machine is completed, PEP will become a regular part of the SLAC organization where a PEP Division will be created (looking after SPEAR also). At the same time a single Experimental Program Advisory Committee will combine the present SLAC and PEP Committees.

At Fermilab the Energy Doubler/Saver/Tevatron project has been much encouraged by the achievement of an intense proton beam through a string of 25 superconducting magnets installed under the Main Ring, albeit at comparatively low field (equivalent to 100 GeV as reported in our April issue). The beam behaviour through the magnets was as expected and could be controlled. Performance of the refrigeration system looked good.

This is an important step along the way to the Energy Doubler, which became an authorized project from October of last year. A small reduction in the bending magnet length has just been decided to give more room around the ring and this will be implemented on the magnets to be built from now on.

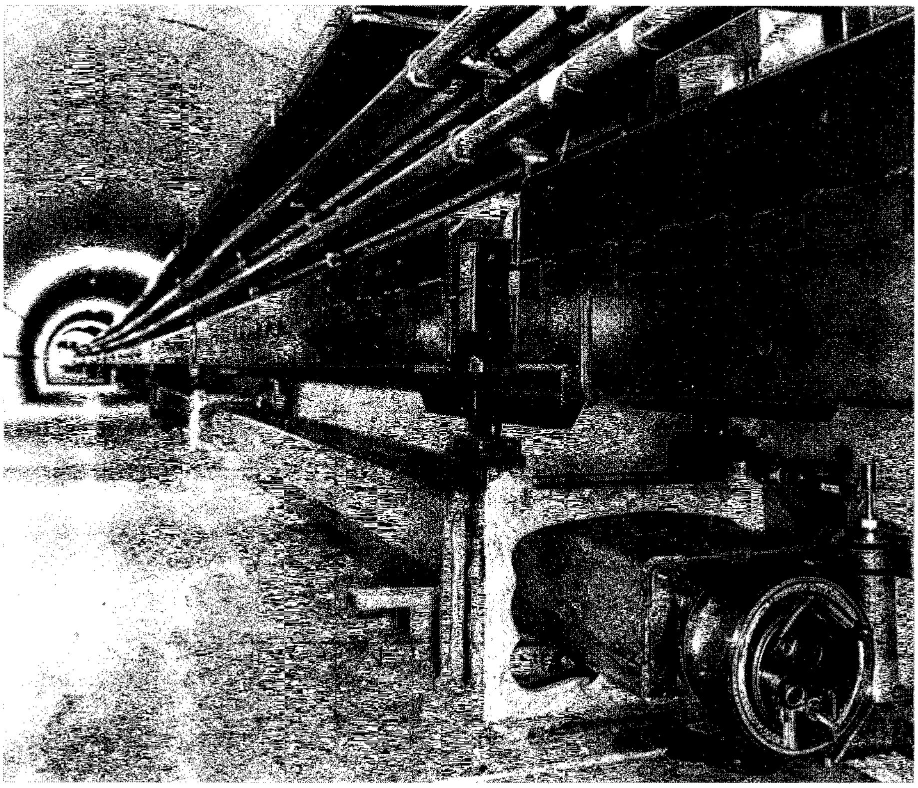
There are various colliding beam options open to Fermilab when they have the Doubler ring installed. Amongst them, the better vacuum in the Doubler should open up the possibility of proton-antiproton physics at acceptable luminosities and, to this end, electron cooling is being studied at the Laboratory (reviewed at the Conference by Fred Mills). Protons from the Booster have been stored in the electron cooling ring and cooling experiments are scheduled to start soon.

At the same time, the addition of stochastic cooling is being investigated in collaboration with Berkeley and Argonne and cooling at high energies with a small electron ring (see April issue 1978, page 109) is still being given some thought (reviewed at the Conference by Dave Cline).

The other big project involving superconducting magnets is the 400 GeV proton-proton storage rings, ISABELLE, authorized last year for construction at Brookhaven.

The string of superconducting magnets threaded through the support stand of the Main Ring Magnets at Fermilab. Beam has been taken through a string of twenty-five magnets at 100 GeV.

(Photo Fermilab)



Work on the site has started and the design of the experimental halls is under way. Detector development has been initiated in the group of Bob Willis and an AGS beam will be devoted to testing ISABELLE detectors.

On the superconducting magnet front, the story is not yet happy. The immediate aim is to build and test a full cell of the machine lattice but the latest magnet, assembled with coils produced in industry, did not perform well, exhibiting excessive training, and the causes are not clear.

Building a superconducting accelerator has proved far more difficult than could be anticipated when Peter Smith of Rutherford opened the door in the mid-1960s with his intrinsically stable pulsed superconductor. It has not been seriously pursued in Europe for some time and Berkeley, Brookhaven and Fermilab have all had a hard struggle.

We are left with the different approaches at Brookhaven and Fermilab which could prove very revealing. Brookhaven have a magnet design with warm bore and the magnet iron at liquid helium temperature (53 000 tons in all!). Fermilab have a magnet design with cold bore and warm iron. (In this situation Pief Panofsky could not resist the remark that the superconductivity community divides into two categories — cold bores and warm bores.) C. Benvenuti reported an interesting experiment at the CERN ISR with a cold bore insertion; under all the tested conditions the vacuum remained stable with currents to above 40 A.

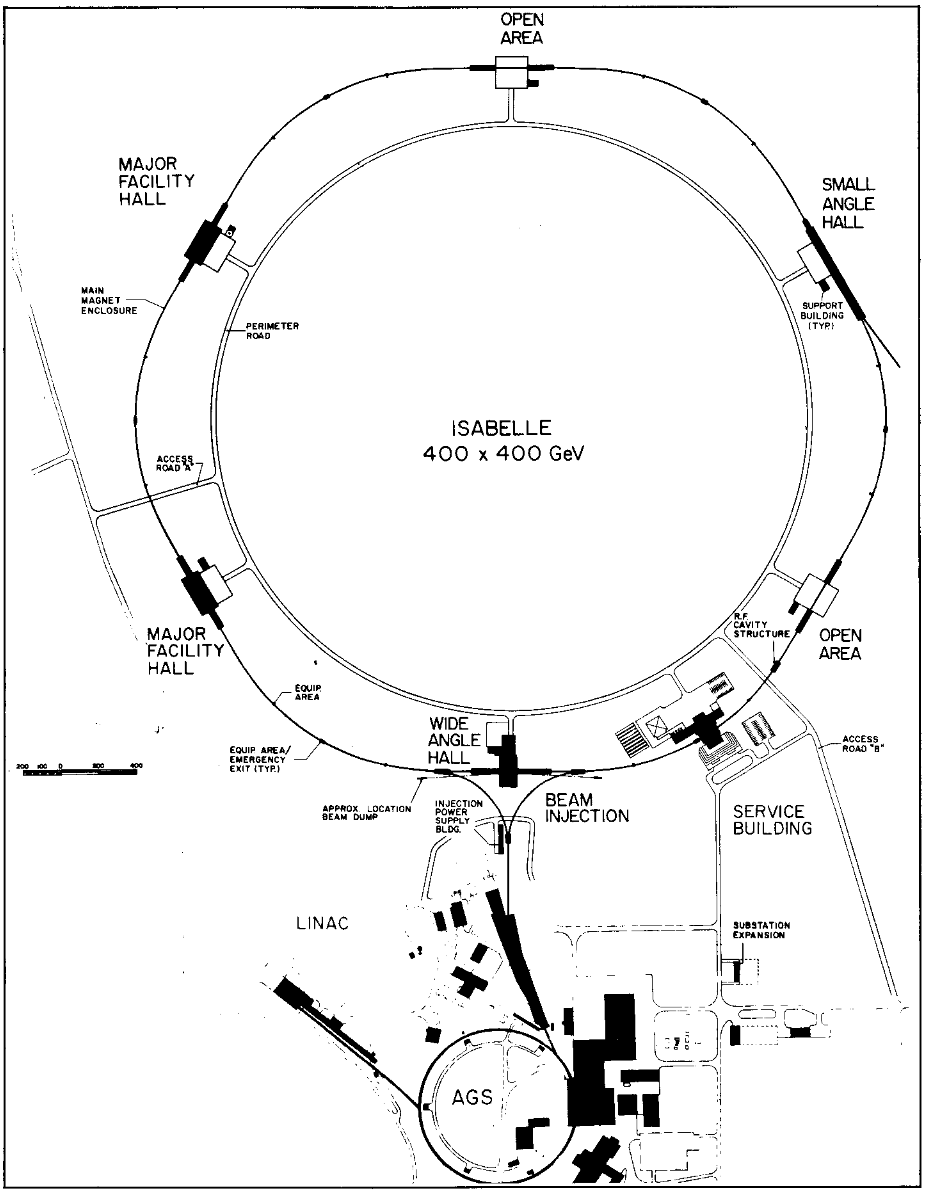
There was much talk about the LEP project (see December issue 1978) — the large electron positron ring which is being promoted as Europe's next step in high energy physics facilities and which was described at the Conference by Wolfgang Schnell. This talk was no doubt stimulated by the New York Times and San Francisco Chronicle reports headlined '12 Nations Approve Big Nuclear Device' (which we hope is only optimistic by two years).

Other papers at the Conference might well have a bearing on the LEP project. One of them was from Los Alamos (reported by Paul Tallerico) where they are pursuing the gyrocon technique to achieve higher r.f. amplifier efficiencies following the pioneering work at Novosibirsk. One of LEP's biggest problems (in terms of peak achievable energy, power consumption and cost) is the necessary r.f. power and any gain in amplifier efficiency would be of great interest. The Los Alamos work is concentrating on a 450 MHz, 650 kW gyrocon with a gain of 30 and a calculated efficiency of 82%. It is hoped to have the device ready for first tests in the Fall.

Another relevant paper, given by J. Spencer, came from SLAC and the Stanford Synchrotron Radiation Laboratory. On 28 February a 'wiggler' was operated to produce synchrotron radiation for the first time in the SPEAR storage ring. It is a small seven pole device, 1.25 m long, which can be powered up to fields of 1.8 T. It gave about a six-fold boost in radiation intensity and of course, due to the sharper bends which it introduces in the beam, gave higher frequency radiation. The synchrotron radiation users are delighted with its performance and that delight is shared by storage ring enthusiasts because, with the wiggler in operation, the luminosity in SPEAR rose by about 25%.

Which leads naturally into the topic of synchrotron radiation sources — a topic which is now so big that in no way can we do it justice

Layout of the 400 GeV proton-proton storage rings ISABELLE and their injection lines from the AGS at Brookhaven. Site work for ISABELLE has started.



in a general review article on the Accelerator Conference. Arthur Bienenstock covered major applications — the remarkably detailed atomic structure information coming from EXAFS, greatly improved and speeded X-ray diffraction work, microlithography for large scale high density integrated circuits, etc...

Arie Van Steenbergen reviewed the present major projects. The extensions of SSRL (soon to benefit from 50% dedicated use), the new machines — ALADDIN at Wisconsin, CHESS on CESR at Cornell, SRS at Daresbury, NSLS at Brookhaven and the photon factory at KEK, will all be in operation in a few years' time.

Among the newcomers is an 800 MeV electron storage ring, BESSY, now under construction in Berlin for research with vacuum ultra-violet radiation (leaving the higher frequency range to DORIS at DESY where the coming into operation of PETRA will liberate more dedicated time). Also in Europe, a Committee of the European Science Foundation is well advanced in a design of a major multi-nation facility described by Jerry Thompson. We will be coming back to this when the detailed feasibility study is published.

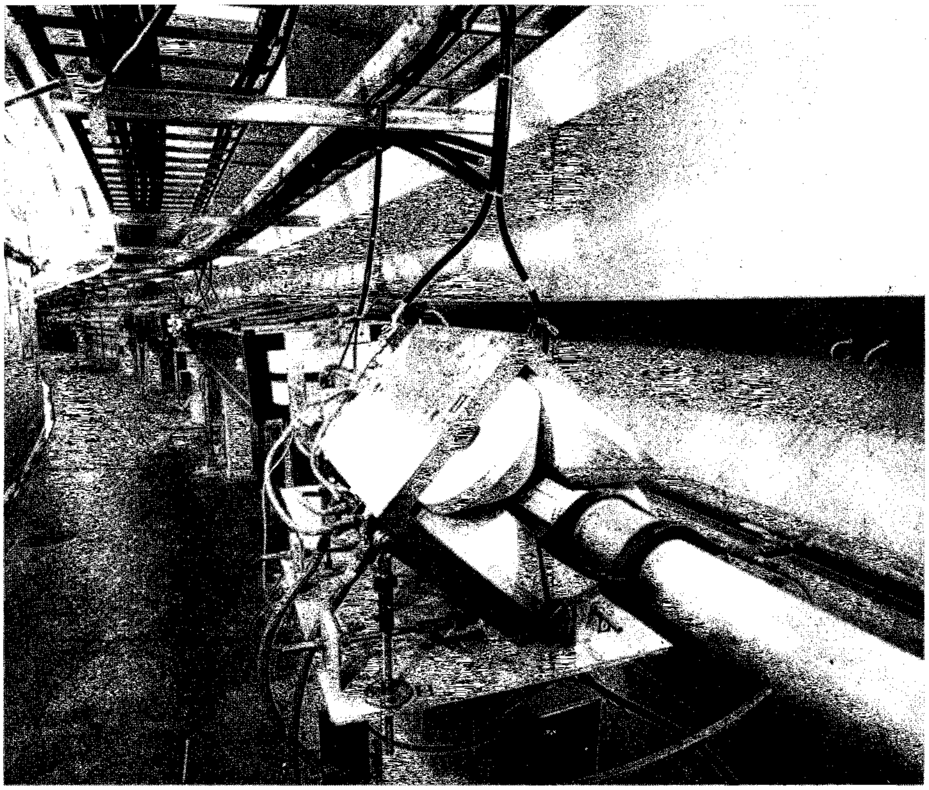
The new field of radioisotope dating had a very enthusiastic presentation from Richard Muller. Our very first article on this topic appeared only in the March issue of last year (page 81) but he threatened a growth rate in this research similar to that using synchrotron radiation with applications in archaeology, energy physics, geology, astrophysics, oceanography, climatology and theology. (The accelerator field has no need to worry for soon we will also have God on our side.) There are now groups working on accelerators in the USA, England, Canada and a strong team from Orsay and Grenoble in France.

The technique involves accelerating tiny quantities of matter, drawn from an ion source, to some tens of MeV and analysing it by mass spectrography. Only milligrams of a substance are needed to do 'accelerator dating', compared to grams for the traditional radiocarbon dating, and the analysis can be done much faster. The accuracy is not yet as good as radiocarbon dating and care has to be taken to eliminate background but, for a comparatively new technique, its applications are growing fast.

'Accelerators in medicine' has been on the programme for several years and J.R. Stewart reviewed the use in cancer therapy of photon, electron, neutron, proton, pion and heavy ion beams. Pions and heavy ions can be applied with better dose

The beam transport system installed in the south injection tunnel of the PEP electron-positron storage ring. First operation of PEP is scheduled for October.

(Photo SLAC)



distributions and have enhanced biological effects which has made their use worth pursuing despite the greater difficulties of producing beams. Los Alamos and Berkeley, for pions and heavy ions respectively, have played pioneering roles.

Stewart maintained that the USA is now ready for a coordinated national programme for the use of accelerated beams in hospitals rather than Laboratories. This could begin with neutron and proton beams and, after more research, be followed by pion and ion beams.

On the increasingly desperate energy front, Pierre Grand talked about the latest thinking about the use of accelerators to breed fuel for fission reactors (see the article in the May issue 1978, page 152). A scheme known as LAFER (Linear Accelerator Fuel Enricher Regenerator) is being considered at Brookhaven. In principle with a linac giving some 300 mA at 1 GeV, a dozen reactors of the CANDU type could be kept fuelled. These accelerator parameters are frightening in themselves but the target problems look even more severe. Nevertheless, the implications of success with such a scheme are tremendous and it merits serious examination to see just how far the necessary technology can be taken.

Terry Godlove covered progress in the design of intense heavy ion beam systems to achieve fusion by the bombardment of deuterium-tritium pellets. Some 100 TW in 10 ns need to be delivered to a 2 mm pellet. Energy deposition requirements of about 20 MJ per gram limit the energy to around 20 GeV.

The proposed systems are now crystallizing out on two approaches — banks of r.f. linacs feeding accumulator synchrotron rings or r.f. linacs followed by induction linacs. The induction linac has much in its favour because of its essential simplicity but it requires more R and D to confirm its potential particularly with regard to space charge problems at injection.

It is now accepted that the concept of the heavy ion route to fusion has been validated and there is high confidence in the ability to master the accelerator technology problems which remain. Argonne, Berkeley and Brookhaven are involved in this work. It is hoped to launch a Heavy Ion Demonstration Experiment (HIDE) for some 20 to 100 kJ at 5 GeV fairly soon followed by an Engineering Test Facility (ETF) for 20 GeV around 1987. A decade later an Experimental Power Reactor could be built. Godlove finished his talk with the words that this is 'an extremely exciting application of decades of accelerator technology.'

The other big contributions to the fusion scene from accelerators are in the building of neutral beam injectors for Tokamak magnetic confinement systems and the building of a high intensity deuteron linac for the production of 14 MeV neutrons to study fusion environmental conditions. Wulf Kunkel described the multi-megawatt neutral beam injectors for the Tokamak Fusion Test Reactor at the Princeton Plasma Physics Laboratory.

Los Alamos are building a 5 MeV deuteron linac prototype for the FMIT (Fusion Materials Irradiation Test) facility to be constructed at Hanford and their work on sources, accelerator structures, r.f. etc. was reported by Bob Jameson. They are very interested in the novel structure with space uniform high frequency focusing, described at the Conference by N.V. Lazarev from the Moscow Institute for Theoretical and Experimental Physics. Such structures could achieve bunched

Around the Laboratories

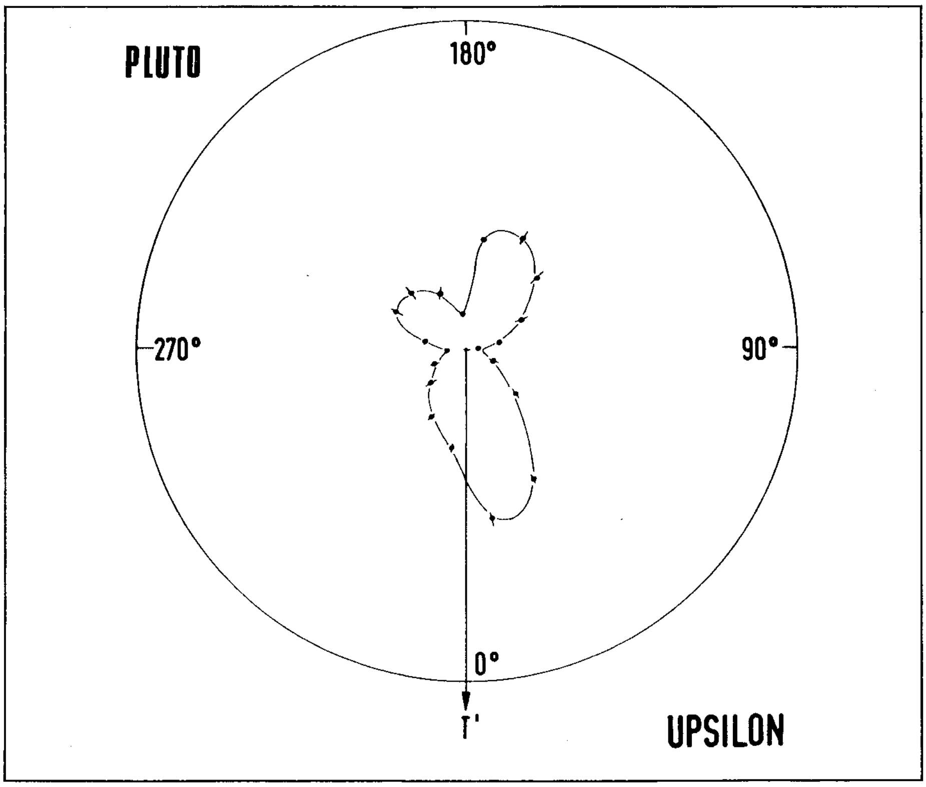
beams from d.c. beams ready for the subsequent accelerating cavities.

Yet another field where accelerators are now taking over is in the provision of intense neutron beams. Argonne are commissioning an Intense Pulsed Neutron Source (see September issue 1978, page 301) and have a more advanced project on the table. Rutherford are starting construction of a Spallation Neutron Source, SNS (see May issue 1976, page 170).

A participant at the Conference quoted Lord Rutherford's famous remark 'All science is either physics or stamp-collecting'. Well, accelerators are obviously contributing enormously to the advance of physics but it is gratifying that they are also enabling some very fine stamp-collecting to be done.

Decays of upsilon particles produced in the new PETRA electron-positron storage ring at DESY show a clear three-pronged pattern. This is vital evidence in favour of the colour picture of inter-quark forces, with gluons acting as the inter-quark messengers.

(Photo DESY)



DESY
Three jets in upsilon decays

There was considerable excitement at DESY on 30 March when the PLUTO group presented the results of a search for a three-jet structure in the decays of upsilon particles at the new PETRA electron-positron storage ring.

Theorists have been predicting that the upsilon, a bound state of a heavy quark and its antiquark, should show signs of the production of three gluons, in much the same way that positronium, a bound state of a positron and an electron, decays into three photons. Production of three gluons should produce a definite trident of hadronic matter in upsilon decays.

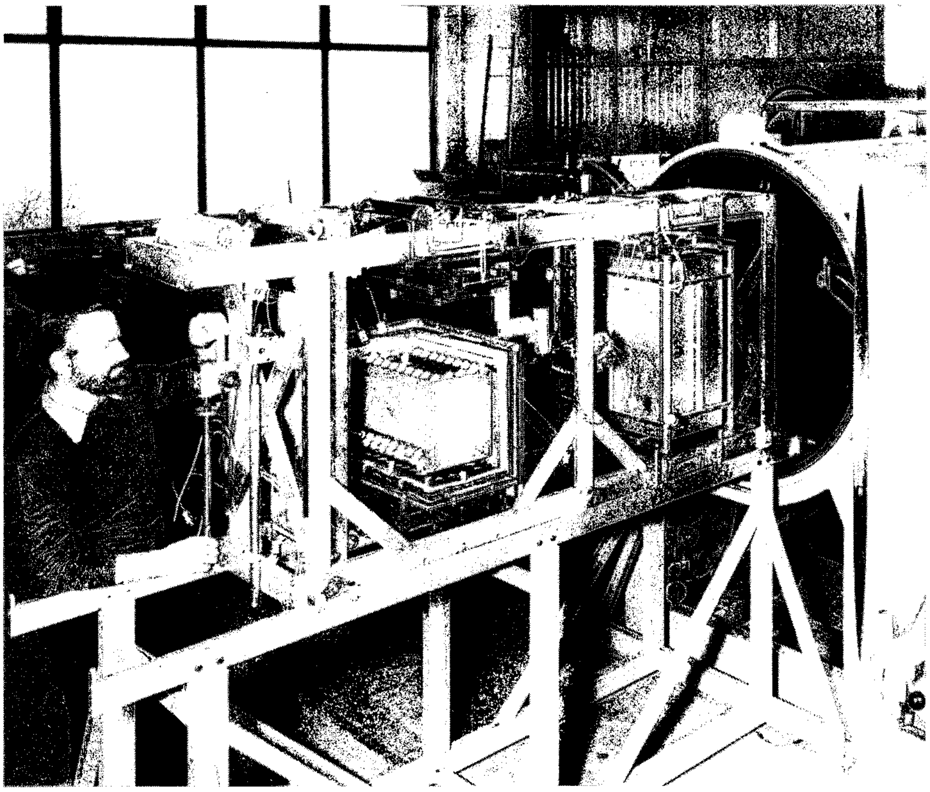
The PLUTO group saw the upsilon last year at DORIS (see June 1978 issue, page 202), and searched hard for evidence of three-jet structure in the decays, but the results were not conclusive. Now the new data from the detector, sited at PETRA, shows clear evidence for three jets.

If confirmed, this observation provides vital evidence for the colour picture of inter-quark forces where the gluons carry colour between the quarks. With quantum chromodynamics, the theory describing these inter-quark forces, currently in such good shape, this new observation could mark a great new step forward in our understanding of the structure of matter.

The key to these latest PLUTO results lies in the inclusion of neutral particles, such as the neutral pion and eta meson, which allows a more complete reconstruction of each event. The identification of the jet axis is made using high momentum particles, avoiding analysis difficul-

In the foreground, the two furnaces of the CERN niobium-tin production facility, seen removed from their vacuum tank (rear). To make the superconductors, a thin niobium tape is passed through a bath of liquid tin in a high vacuum. This process was not available commercially and had to be specially developed at CERN.

(Photo CERN 37.3.79)



ties with low momentum particles.

The results presented were of the polar angle dependence of the energy flux with respect to a jet axis and of the angular separation of the jets. The data agrees well with the pattern expected from a true three-jet decay, and is in clear disagreement with both a 'phase-space' model with no specific particle correlations, and a two-jet model.

CERN 6 Tesla superconducting persistent dipole

Shortly after the discovery of technically useful type II superconductors with high critical temperature and fields (such as niobium-titanium and niobium-tin), the idea emerged of using them to shield or trap high magnetic fields without any electrodynamic losses. Such losses can be avoided by inducing persistent currents in appropriately-shaped superconductors.

For example, normally a niobium-tin tube in an axial magnetic field is penetrated by the field over its whole structure. However if the tube is cooled below the superconducting transition temperature and the applied field is then removed, persistent currents are induced which trap the original magnetic flux inside the tube. In a normal conducting device (like a copper tube) the induced currents would die away quickly because of the finite ohmic resistance, but they persist if the device is superconducting. Alternatively, if the tube is already superconducting before the external field is applied, the induced currents will shield its bore from the external field.

This principle was applied at CERN, for example, using a shielding tube to give a field-free path for low momentum particles through the transverse fringe field of the 2 m bubble chamber magnet (see June 1972 issue, page 202). Niobium-titanium foils, forming a tube in two halfshells with dipole characteristics, were used. Subsequent work at CERN aimed at shielding and trapping higher fields gave unsatisfactory results, the critical problem being the electrodynamic stability of the niobium-titanium foils, which limited the maximum trapped field to about 2.5 T. Earlier work at Bell and RCA Laboratories showed that higher fields were attainable with niobium-tin, and at CERN a 50 mm long dipole using commercially-available niobium-tin tape had successfully shielded and trapped fields up to 4.2 T.

Niobium-titanium foil of large width is readily available but the small width of the commercial niobium-tin tape (up to 60 mm) limited its use to small diameter applications. Bending magnets require a minimum tape width of at least 200 mm. This was unobtainable in Europe or the USA and had to be produced at CERN.

Development of wide niobium-tin tape was started at CERN in 1976 by a small team led by F. Sernetz, using the 'liquid diffusion' technique in which a thin niobium tape is passed through a bath of liquid tin at about 1000° C in a high vacuum. Tin atoms diffuse into the tape creating a niobium-tin layer about 4 μm thick. To construct a larger facility, a great number of new technological problems had to be solved, but now a 220 mm wide niobium-tin tape can be produced up to 100 m long and down to 0.03 mm in thickness. Short sample critical current density is comparable to that of commercially available tape.

The BBC/Open University film crew prepare to shoot the first sequences for their film of an experiment at the SPS proton-antiproton collider.

(Photo CERN 249.3.79)

To check the quality of the tapes for large-scale applications, several small model dipoles with 25 mm bore and 180 mm long were made. In the tests, for example, a dipole with 176 layers of niobium-tin foil 0.035 mm thick and interleaved with copper for stabilization shielded 4.9 T and trapped 5.9 T, both at 4.2 K. The results agree with predictions based on a short sample critical current. The maximum allowable charge rate was dependent on the stabilization technique applied. The maximum trapped field was limited only by the field available in the 6 T charging magnet.

These tests show that the quality of the CERN niobium-tin tape will allow the production of large and simple high field persistent magnets for a variety of applications.

Filming an experiment

Particle physics tries to answer the basic questions on the ultimate composition of matter and must be considered as an integral part of our culture, but because many of the concepts are difficult to explain in simple terms for the uninitiated, the subject often remains shrouded in mystery.

Some noble attempts have been made to break down these barriers and make the subject more comprehensible to a general audience. One notable example is the Open University in the UK, a novel education project which enables the general public to follow university-level courses in a wide range of subjects in their own time.

Besides specially-written texts, the courses make wide use of BBC radio and television, and special units have been set up to produce Open University broadcasts. Programmes introducing particle physics form part of the Open University's basic science courses, while others are also aimed at a more general audience. BBC/Open University teams have been frequent visitors to CERN to compile material for these broadcasts.

Following a suggestion by Roger Anthoine of CERN's Press and Visits Service, a BBC/OU film unit has now embarked on a major new project to film a single experiment and document its progress from initial proposal and planning right through to final results, giving a glimpse of all the behind-the-scenes work required these days to discover new things in physics.

The experiment which has been chosen is the UA1 collaboration at the SPS proton-antiproton collider, in which an Aachen / Annecy / Birmingham / CERN / London / Paris / Riverside / Rome / Rutherford / Saclay / Vienna group is building a large detector to look for new phenomena (see September 1978 issue, page 291).

The film project is being supported jointly by CERN and the Open University, and several final versions are planned. Four different language editions are to be produced of a film for showing at CERN to general interest visitors, while a more scientifically literate full-length documentary version will be produced both for CERN and for transmission on BBC Television.

In March, the film crew visited CERN to film the first sequences, including earthmoving for the new underground hall to house the experiment. This will be followed up by visits to the collaborating Laboratories where apparatus is being built, and by further trips to CERN to monitor assembly and testing before data-taking begins in earnest.

With the SPS proton-antiproton

collider opening up a new range of energy and with the intermediate bosons of weak interactions looming on the horizon, the filmmakers could also find themselves in on one of the biggest scientific discoveries of the Century.

Synchrotron radiation from protons

In the September issue of 1978 (page 294) we reported the first ever observation of synchrotron radiation from an orbiting proton beam in the SPS. Though the proton mass and energy (even in the SPS and Fermilab machines) indicate negligible radiation according to classical theory, R. Coisson deduced that effects could be seen at field discontinuities, such as at the edge of a magnet. This was shown to be true in the first qualitative experiments at CERN last August which saw a radiation spot on a TV screen at energies above 350 GeV and intensities above 6×10^{12} protons per pulse, increasing with energy and intensity.

Since then the observations have been refined. Synchrotron light has been detected at intensities as low as 10^{11} and it has been shown that the light has a 23 μs amplitude modulation corresponding to the beam structure. In addition, the light is highly horizontally polarized as expected of synchrotron radiation. The quantitative measurements, using a photomultiplier, on the variations of the radiation with the characteristics of the proton beam, are in agreement with the theory.

These observations are encouraging for the proton-antiproton projects which could use synchrotron radiation at magnet edges for profile measurements on the two orbiting beams. More detailed information will appear in a paper by R. Bossart, J. Bosser, L. Burnod, R. Coisson, E. d'Amico, A. Hofmann and J. Mann to be published in Nuclear Instruments and Methods.

FERMILAB
Operation successes

A major reliability campaign is under way at Fermilab and since 1 February the accelerator has averaged 10^{18} protons per week. A new single pulse intensity record of 2.7×10^{13} protons was set on 21 February. These impressive records result from a combination of a seven second duty cycle resulting from 350 GeV operation, high reliability and high injection intensity.

Recently, Russ Huson, Head of the Accelerator, has subdivided the Division into three parts. One group, headed by Rolland Johnson, is concerned with the 400 GeV programme. Rich Orr is in charge of another group handling installation of the Tevatron. Don Young heads the third group studying accelerator aspects of colliding beam physics (including the operation of the new 200 MeV cooling ring).

The 400 GeV programme group has to satisfy the goals of the high energy physics programme regarding operation of the present accelerator; it includes the Linac, (headed by Curt Owen), Booster (Chuck Ankenbrandt), Main Ring (Frank Turkot), External Beams (Roger Dixon) and Operations (Jim MacLachlan and Jeff Gannon).

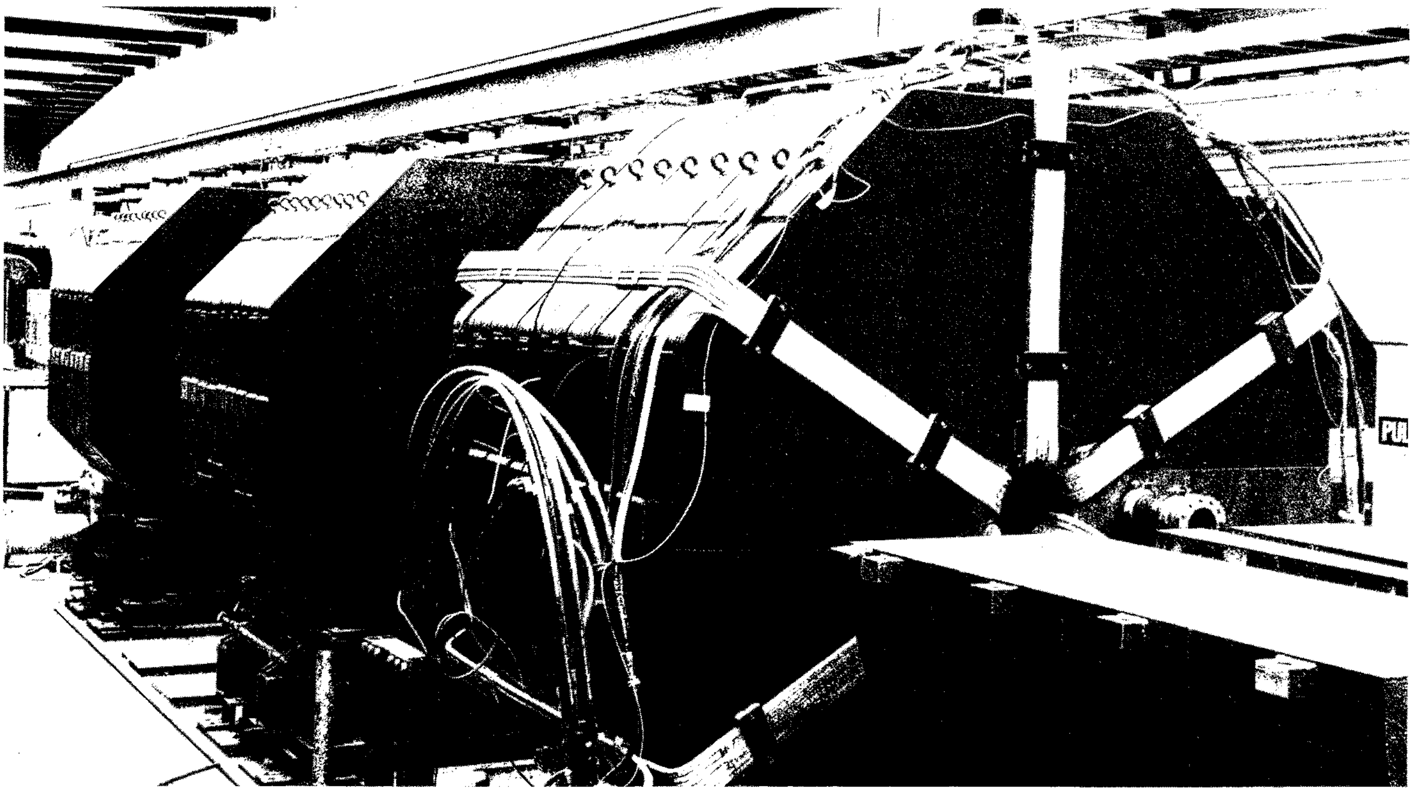
From mid-November last year to mid-March the accelerator has operated at 350 GeV for certain neutrino experiments needing lower muon backgrounds. The lower energy operation has also allowed a short cycle time. This, combined with higher reliability, has allowed record numbers of protons to be delivered to experiments. At the beginning of the year, operation changed from a three-week cycle to a weekly cycle. In this mode, the accelerator has operated with a 7.5 s cycle and 1 s flat-top to give the average of 10^{18} protons per week from the beginning of February through the first week in March when a two month shutdown began.

At the beginning of the shutdown an eighty hour period was devoted to studying accelerator operation at 450 GeV. The machine was off for only ten hours due to equipment problems almost entirely unrelated to the increased energy. For the 450 GeV run the beam intensity reached 2.1×10^{13} protons per pulse. Consideration is now being given to some operation at energies above 400 GeV in the near future.

For some time, the beam intensity provided to the experiments has been principally limited by beam instabilities during resonant extraction which result in uncomfortable levels of radioactivity in the transfer hall. The understanding and cure of this limitation continues to have the highest priority of the conventional accelerator programme.

Another serious limitation is funding constraints on the power bill. Operation of the machine is now normally keyed to the reduced cost of electricity at night and on weekends. Thus, typically, the average power used in the main ring changes from 47 MW to 30 MW on weekday mornings and back again in the evening. Operation in this mode has an impact on reliability. Work is in progress to facilitate the day-night changeover and diminish the perturbations on operations. For 350 GeV there is essentially no change in the day-night power level because of the reduced operating power required.

There have been notable accom-



The resurrected magnets of the Brookhaven Cosmotron in use for a muon experiment at Fermilab.

(Photo Fermilab)

plishments in the Linac and Booster in the past year also, including the implementation and development of negative hydrogen ion injection into the Booster.

The ion source has turned out to be extremely reliable with an output of 50 to 60 mA. It also provides great flexibility for the needs of the Cancer Therapy Facility and the electron cooling ring.

At the Booster end of the Linac, the ions are stripped in a carbon foil which seems indestructible by the beam. This method of injecting by charge exchange allows virtually any number of protons to be injected into the best phase space of the Booster. Other improvements to the Booster combined with negative ion injection have produced the intensity record of 3×10^{12} ppp. This, in turn, corresponds to a potential of 3.9×10^{13} protons which could be injected into the Main Ring.

Old accelerators never die

One feature of the technology associated with high energy physics is the re-use of the magnets of retired accelerators in the form of magnetic spectrometers. Examples include the Chicago cyclotron magnet being used in the Muon Laboratory at Fermilab and the yoke of the Carnegie Mellon cyclotron which currently dominates intersection region 1–2 at the CERN ISR. The latest example is the first synchrotron magnet to be used in this manner — the magnet from the Cosmotron, which operated in its previous incarnation as a 3 GeV accelerator at Brookhaven which began operation in 1952.

The Cosmotron magnets are being installed as elements of a toroidal muon spectrometer by members of a Chicago-Princeton collaboration studying muon pairs of high invariant mass including upsilon, other heavy resonances and the di-muon continuum. The experiment will be fed by an intense pion beam with 10^9 to 10^{10} negative pions per pulse in the High Intensity Laboratory. Muons will be identified and their momenta measured as they pass through the octagonal shaped iron yokes of the Cosmotron magnets.

The pole pieces of the old accelerator have been reshaped and plugged with iron in order to complete the toroid. Five toroids are to be used; each 1.5 m thick, 2.4 m in diameter. In addition, two smaller toroids and a hadron absorbing wall make a total thickness of over 11 m of iron.

Particle trajectories are measured with seven planes of drift chambers, one after each toroid. The old vacuum chamber gap in the Cosmotron has been a particularly convenient feature permitting easy coil installation. Non-interacting beam and much of the unwanted hadrons produced in the target pass unobserved through the apparatus. The gap has also facilitated the installation of a small, iron-free passage for precision observation of particles produced at 90° in the centre of mass.

LOS ALAMOS Meeting on neutron sources

Accelerator technology has developed beyond particle and nuclear physics to cover newer research areas — solid state and atomic physics users of synchrotron radiation sources — muon beams for muon spin rotation — biomedical users of electron, proton, heavy ion and pion beams — and now nuclear engineering materials science and other users of intense pulsed Spallation Neutron Sources (SNS).

The activities reported at the International Collaboration on Advanced Neutron Sources meeting at Los Alamos in March illustrate this growth. This ICANS meeting was the third in a series which appears to be becoming a regular feature in this vigorous new field.

SNS representatives came from Canada, the UK, Japan, Switzerland, Germany and the US to share information on designs for accelerator-based neutron sources. Some facilities are in the early stages of operation while others are in various stages of design or construction.

The typical SNS facility consists of a 500-1000 MeV proton accelerator, a target station which is both beam stop and neutron moderator, and neutron flight tubes and spectrometer systems. Among the important design options are the type of accelerator, peak proton current, the proton beam time structure (affecting the usable time-of-flight range for neutrons), and the neutron intensity and spectrum.

The proton source may be an existing accelerator, as with the meson factories LAMPF, SIN and TRIUMF — or an existing booster synchrotron as at Argonne and KEK. New accelerators are planned at Rutherford and Karlsruhe.

The KEK neutron source KENS, described by M. Sasaki, will use the existing 500 MeV booster machine to deliver 6×10^{11} protons per pulse at an effective average of 15 pulses per s, time-shared with beam headed for injection into the 12 GeV accelerator.

The Rutherford project, reported by J.T. Hyman, is an 800 MeV 200 μa synchrotron concentric with the decommissioned Nimrod ring. The Argonne Booster II runs at 500 MeV delivering 8×10^{11} protons per pulse at 15 pulses per s. A high intensity synchrotron proposed for a later stage would deliver up to 500 μa. A 10 ma 500-1000 MeV linac is being considered by a Karlsruhe-Jülich team.

The Karlsruhe accelerator would deliver 5 Megawatts average beam power. J.C. Vetter reported that a pair of sector-focused cyclotrons is a design alternative to the linac. However with 100 ma pulsed current, the linac may be the safer design. The beam loading factor would be high, so it would take little more r.f. to power a linac in comparison with cyclotron.

The target design work, described by G.S. Bauer, is the responsibility of the Jülich team. Target power densities obviously exceed anything experienced at present. A storage ring at the end of the Karlsruhe linac is being considered for changing pulse lengths and rates, as is the case in the storage ring at Los Alamos.

The three meson factories use the primary beam stop as a neutron source. The beam stop facility is highly developed at SIN and TRIUMF. The principal use of the beam stop area at LAMPF is for radiation damage experiments. The WNR facility at LAMPF has two large stations and is designed for 20 μa. An upgrade is planned to permit 100 μa operation in conjunction with a storage ring which is now being designed.

Among the laboratories with operating experience is Argonne with the Zing-P' test bed. N. Swanson described work on targets and instrumentation. The instrumentation developed is on various neutron spectrometers and on provisions for proton and neutron radiography. Swanson also drew attention to the reactor-like construction of the targeting facilities.

All ring machines, including the LAMPF-WNR storage ring, use or will use H^- stripping injection. Thus intense H^- source technology is an important component of the design picture. Fast cycling machines with 15 pulses per s minimum are the rule for pulsed neutron sources. This is a challenge for the synchrotron designs. The 50 Hz Rutherford synchrotron must use a non-conductive beam tube to eliminate eddy currents from the magnet ramp.

A more speculative field is electronuclear fuel enrichment, a possible project discussed by J. Fraser from the Canadian Chalk River National Laboratory. Los Alamos has made a systems study of an enrichment facility.

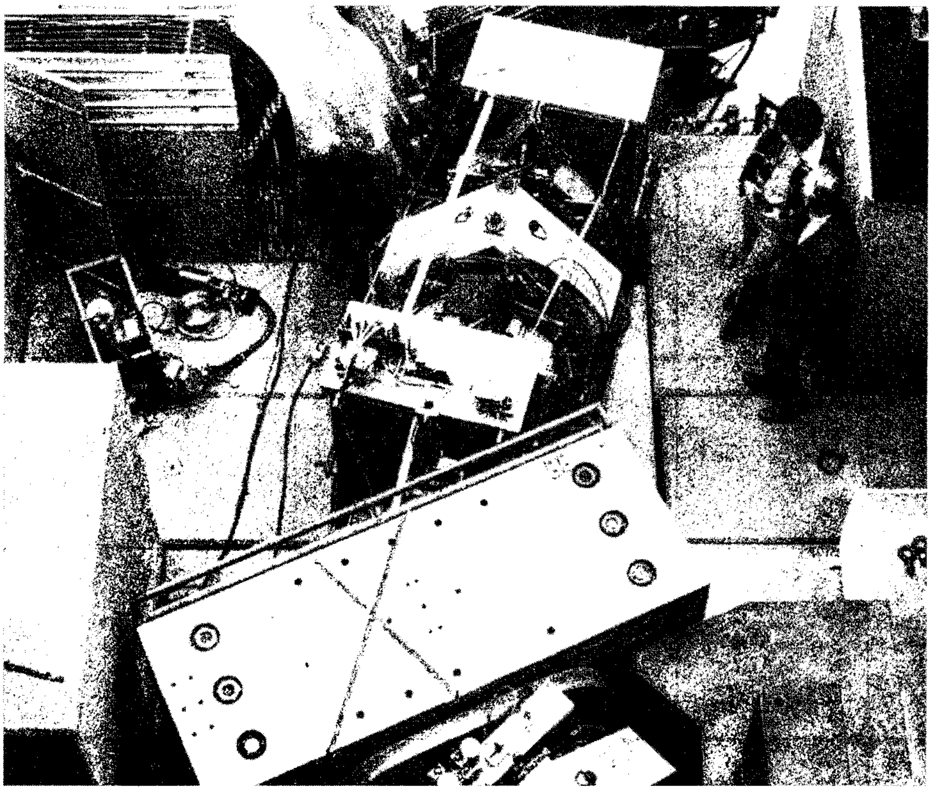
Each medium-energy beam proton yields 20-30 spallation neutrons. Typical thermal neutron fluxes available at the experimenter's end of the beam pipe are 10^{14} neutrons per cm² per s. This is claims to exceed the flux available from fission reactors.

Ironically there are certain to be SNS experiments to study reactor material radiation damage. The useful energy range may include quite energetic neutrons, and a likely use would be cross-section measurements. Other advantages of accelerator neutron sources include minimal handling of radioactive material and instant shut-off. SNS is a field which in a brief period has definitely entered the big machine stage. The ICANS collaboration plans additional timely meetings, with the next tentatively scheduled at Rutherford in September.

TRIUMF New beamlines commissioned

The new slow and stopping pion/muon channel M13 at TRIUMF seen before the installation of shielding.

(Photo TRIUMF)



In a six-week shutdown at the end of 1978, several major projects were completed. Three of them are associated with the high intensity proton line (1A) an additional (thin) target station (1AT1), a slow pion/muon channel (M13) and a low intensity proton branch line (1B). Work in the cyclotron itself has resulted in improved r.f. operation and stability and in the extraction of single turns at 200 MeV, giving reduced energy spread (0.2 MeV rather than the usual 1.0 MeV).

After the shutdown, beam was delivered to lines 4A and 4B in the Proton Area while work continued around line 1A in the Meson Area. The new 1B ('Peanuts') low intensity proton line branching off 1A was completed and received beam by the end of January. In the course of three shifts, beams at 200, 250, 300 and 350 MeV were successfully commissioned with final spot sizes less than 5 × 10 mm²; higher energy beams will be run when a delayed power supply becomes available. The line was designed and shielded for 10 nA currents; 15 nA have been run without detectable radiation fields in the Meson Area.

The purpose of 1B is to provide a branch off 1A, the high intensity line dedicated to pion, muon and neutron production, where experiments on proton-induced reactions can be performed when intrinsically low-intensity beams are being accelerated (e.g. polarized or high energy resolution beams). Besides its primary role as a meson factory, TRIUMF has a second important role to play as a source of variable energy proton beams between 180 and 520 MeV; indeed it is at present the only accelerator producing protons directly over this energy range without degradation.

Experiments requiring unpolarized protons and regular energy spread can be mounted on lines 4A or 4B and run simultaneously with pion or muon experiments fed from targets in line 1A. A polarized source is available and slit-selected beams of higher energy resolution are being developed (the fraction of beam delivered to line 4 can be varied between unity and one ten thousandth by suitable choice of the shape and height of the extraction foil).

The Lamb shift polarized source provides a 200 nA extracted proton beam with more than 70 per cent polarization at all energies. The slit-selected beams have comparable intensities. These beams are too weak to be useful for pion production, so that when they are run (20-30% of the scheduled time, depending on demand) line 1A is effectively shut off. Previously this meant that only one of the two extracted beams was utilizable. With 1B operational both beams can now be utilized, whether they are of high or low intensity.

The first experiment mounted on line 1B is a continuation of earlier studies of the pion production reaction by a University of British Columbia group (see March 1978 issue, page 66). They have recently assembled a new magnetic spectrograph based on a 65 cm Browne-Buechner magnet, to replace their previous 50 cm spectrometer. The new magnet is designed to handle pions of up to 110 MeV along the central ray, with an angular range of 35°-145°, momentum resolution of about 0.1 per cent, and acceptances of 30 per cent in momentum and about 9 msr in solid angle. The spectrometer is currently being commissioned with beam.

In 1A a new thin pion production target (T1) has been installed. As in the thick production target T2 there are five target positions on a vertical ladder. Three thin targets are available at present — 0.3 cm carbon, 0.3 cm vanadium and 2.5 cm beryllium. T1 is designed to feed the M11 high resolution fast pion channel (scheduled for completion early in 1980) and the M13 slow pion/muon channel. M13 takes off at 135° in imitation of M9, which has relatively low electron and fast neutron contamination. The channel is designed for beams below 130 MeV (50 MeV pions) and is 9.5 m long with two opposing 60° bends.

Tests with an alpha source showed that the channel properties are very similar to those predicted (solid angle acceptance 30 msr, momentum resolution 0.8 per cent with slits closed and a small source). The T1 target first received beam on 5 March and the M13 channel was first run the same night. The pion flux at 91 MeV using the 0.3 cm carbon target was about 10^5 positive pions per s per μA protons, in agreement with expectations. Work continues on optimizing the channel parameters and studying its performance.

Line 1A was brought back into operation for pion and muon production from the thick target T2 in February. The normal proton current continues to be 10 or 20 μA, with an increasing frequency of 100 μA shifts. During 1979 just over 10 per cent of the high-current running is being scheduled at 100 μA. The integrated charge delivered will be about 75 000 μA-h, a factor three greater than in 1978 (27 000 μA-h — itself a factor three greater than for 1977). The longest 100 μA run so far occurred in March when 100 μA was run successfully for three days.

Physics monitor

Parity violation in real life

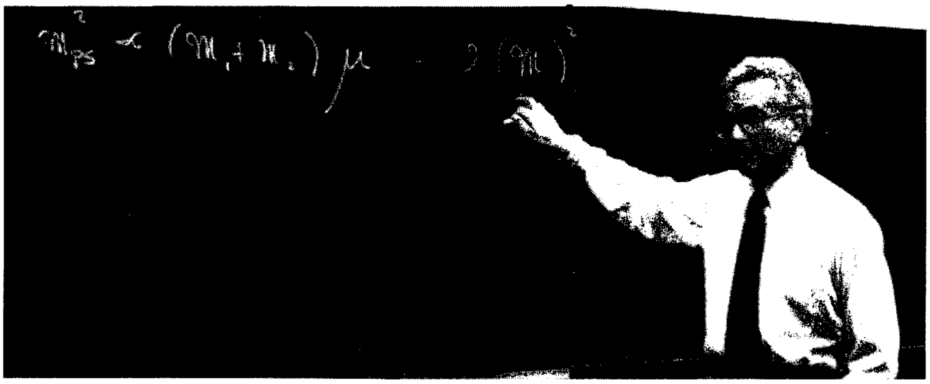
For some twenty-five years, it has been well known that when the weak force is in action, Nature cares about the direction in which things happen, so that there is an asymmetry between left and right. As a result of this parity violation, the electrons given off in natural beta decay tend to be 'left-handed', spinning anticlockwise when viewed along their direction of motion.

Another left-right asymmetry in Nature has been known and studied for much longer. Many organic substances rotate polarized light to the left, while substances capable of rotating polarized light the other way are somewhat rarer. The origins of this asymmetry have long been a mystery, but recent attempts have been made to link the macroscopic asymmetry of large molecules to the microscopic parity violation of beta decay.

One naturally occurring beta-active substance is carbon-14, formed by the bombardment of atmospheric nitrogen by cosmic ray neutrons. During their evolution, complex molecules were continually bombarded by the preferentially left-handed electrons from the decay of this isotope, and the left-right asymmetry now seen in organic substances could be the footprint of these early interactions.

To test this hypothesis, experiments have been carried out at Stanford with low energy polarized electrons. A target containing an equal mixture of optically left-handed and right-handed leucine (an amino-acid) was bombarded with a beam of 180 eV polarized electrons, and the results analysed using a gas chromatograph.

It was found that for left-handed



Murray Gell-Mann describes ideas on the 'grand unification' of strong, weak and electromagnetic forces. One by-product of this unification is the prediction of an unstable proton.

(Photo CERN 254.3.79)

electrons, like the majority of those seen in beta decay, the right-handed proportion of the sample decomposed much more than the left-handed. When the incident electrons were polarized right-handedly, the reverse effect was seen.

Quantitative measurements were difficult, but the experiment showed clearly how beta-decay could be responsible for the buildup of optically left-handed varieties of molecules in Nature. Further progress seems to depend on making these polarization measurements more precise.

The unstable proton?

During the past few years it has become increasingly probable that we are on the verge of a major breakthrough in our continual quest to simplify our description of Nature.

As a result of the theory usually called the Weinberg-Salam model (but in fact due to the efforts of many other physicists as well), the forces of electromagnetism and weak (radioactive) decay appear to be two aspects of the same fundamental 'electroweak' force (see July/August 1978 issue, page 245).

Spurred by the remarkable success of this electroweak unification, and by the achievements of quantum chromodynamics as a candidate theory of strong interactions, many theorists have begun to build more ambitious unification schemes which encompass the strong as well as the electromagnetic and weak interactions. The aspirations behind these theories are apparent from the term 'grand unification'.

Quantum chromodynamics tells us that the forces between quarks, although intense on the nuclear scale, appear to decrease as the interaction volume decreases. This means that at extremely high energies, the strengths of the apparently highly dissimilar strong and electroweak forces could converge (see November 1978 issue, page 399).

The basic particles in the electroweak theory are quarks and leptons, arranged in distinct 'generations'. The up and down quarks are traditionally associated with the electron and its neutrino, the strange and charmed quarks with the muon and its neutrino. Heavier quarks and the new tau lepton also fit nicely into the picture. While in principle the number of these families can be continually increased, cosmological arguments can limit the possible number of different types of neutrino, offering a tempting glimpse of a closed set of basic particles.

Although the quarks and leptons are grouped together in the electroweak theory and interact with each other, they are nevertheless immutable. Quarks cannot be changed into leptons and vice versa (other than by particle-antiparticle annihilation).

In widening the model to incorporate strong interactions, the leptons and quarks remain as the basic particles, but no longer remain aloof from each other. In grand unification an additional mechanism links the quark and lepton varieties of matter.

Just as the electromagnetic and weak interactions come about through the exchange of intermediate particles (photons and weak bosons respectively), so this quark/lepton mixing force requires a carrier.

Theory estimates the mass of this carrier to be of the order of 10^{15} GeV, corresponding to some 10^{-9} grams — a weight detectable even by mechanical means and about a million times heavier than a small bacterium! Such a gigantic mass (by particle physics standards) makes the quark-lepton link very feeble at today's energies (some physicists refer to it as the hyperweak force). However this does not mean that it is totally absent, and there is still a small probability for quarks to interact and produce leptons.

This would mean that nuclear matter as we know it is gradually eroding away. Calculations attribute the proton, traditionally regarded as the only stable hadron, with a lifetime of some 10^{31} years, give or take a factor of a hundred or so. This means that one proton in the body of a centenarian might decay during his lifetime.

The instability of the proton would also mean the end of baryon number as an absolute conservation law. Exact conservation laws, such as those of energy-momentum and electric charge, are the result of basic invariance principles, and al-

The baryon family of ten particles ornamenting the physics courtyard of the University of Wisconsin at Madison (brought to our attention by Robert Morse).

though it has become traditional to think of the proton as a stable particle, no invariance has ever been found to account for the apparent conservation of baryon number.

Trying to measure the proton lifetime

Further progress with this grand unification of strong and electroweak forces lies in confirming the prediction of the unstable proton. Experiments have been mounted before to search for decaying protons, but none have reached the sensitivity required by the latest predictions.

If the proton indeed has a lifetime around the 10^{31} year mark, then a tank containing 1000 tons of water should produce about 60 decays per year. To pick up such rare events, the sample would have to be carefully shielded from cosmic ray background by veto counters and some 2000 metres of earth or rock.

Only cosmic neutrinos may produce similar effects, and the detector must be able to distinguish between the two. One possibility would be to detect the Cherenkov light produced in the water. Protons would be at rest when they decay and give two opposite cones of Cherenkov light, while neutrinos produce a single cone along their direction of motion.

In principle such an experiment is simple, the difficulty being to find a cave both deep enough and sufficiently large to house the sample and detecting apparatus.

The creation of baryons

The model also has deep implications for our picture of the evolution of the Universe. At an early stage, we can picture the Universe as a hot 'soup' of quarks and leptons with zero net electric charge and baryon number. Under these conditions, the superheavy particle of the hyperweak force played an important role and lepton/quark conversion was commonplace.

As the Universe subsequently cooled down and expanded, the rate of hyperweak interactions slowed down so fast that lepton/quark conversion through the hyperweak force was not in thermal equilibrium, and the number of quarks was no longer equal to the number of antiquarks.

This initial soup of particles was electrically neutral, however the presence of a CP-violating mechanism could have made the condensation process produce an excess of nuclear matter, rather than matter and antimatter in equal proportions. CP violation occurs naturally in theories involving a sufficient number of different types of quark, although its magnitude is not fixed.

The dominance of matter in our Universe, where antimatter appears to be confined to rare high energy interactions, has long puzzled cosmologists, and the emergence of this matter/antimatter asymmetry in a natural way seems to provide further stimulus for the grand unification scheme to be considered seriously.

One of the main aims of physics is to understand as much as possible of the world around us from a minimum of initial assumptions. While the grand unification of strong, electromagnetic and weak interactions is still in its embryonic form as a theory, it seems to have a lot to offer.

People and things

The URA Board of Trustees at their March meeting in Fermilab.

(Photo Fermilab)

On people

After thirteen years in office, Norman Ramsey has retired as President of Universities Research Association (URA), which operates Fermilab under contract from the USA Department of Energy. He will be succeeded by Milton White, now chairman of the URA Board of Trustees. Norman Ramsey is Higgins Professor of Physics at Harvard and last year was President of the American Physical Society. He was also Chairman of the advisory panel on high energy physics which in 1963 proposed the construction of what was to become Fermilab. Milt White has been with Princeton University since 1946 and was Director of the Princeton-Pennsylvania Accelerator.

It was also announced during the March URA meeting that former Director Robert R. Wilson becomes Director Emeritus of Fermilab, and Harry Woolf, Director of the Institute for Advanced Study at Princeton, becomes Chairman of the URA Board of Trustees.

Joseph Cerny has been appointed Head of the Nuclear Science Division and Associate Director of the Lawrence Berkeley Laboratory for a five year term with effect from 1 July. He succeeds Bernard Harvey who 'looks forward to resuming his research career'.

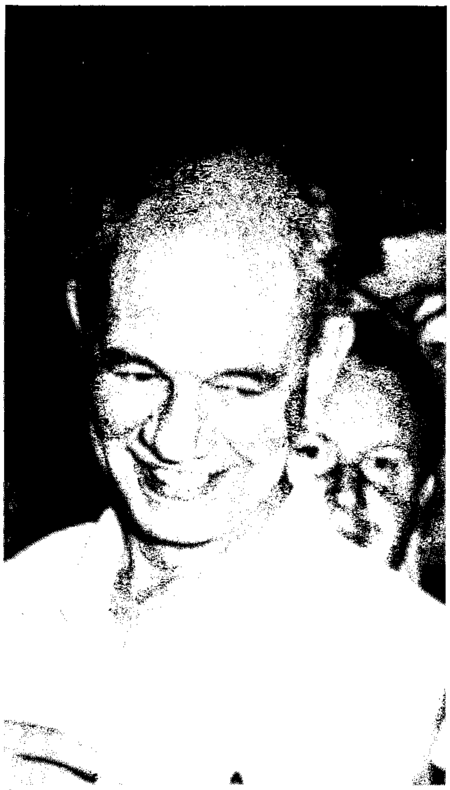
Leland Haworth, long associated with the Brookhaven Laboratory, died in March. It was his five page letter to the Atomic Energy Commission which served as the 'proposal' which led to the building of the Alternating Gradient Synchrotron.

Gary Feldman was appointed Associate Professor at the Stanford Linear Accelerator Center at the Stanford University Board of Trustees meeting in February. Gary Feldman is well known for his contributions to experiments at SLAC on electron scattering and electron-positron collisions in the SPEAR storage ring.

BNL HEDG

The annual meeting of the High Energy Discussion Group will be held at Brookhaven on 24–25 May. There will be reports of recent work at the AGS and for ISABELLE and future plans in these areas will be reviewed. One of the main areas of activity of the HEDG ISABELLE Subcommittee has been its interaction with Jim Sanford on the procedures for submitting and acting on proposals for experiments and facilities at the storage rings. At the annual meeting, these procedures will be presented to the entire HEDG community with a period of discussion to follow.

1. Leland Haworth on the night of the first operation of the AGS.
2. Garry Feldman.
3. Norman Ramsey.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Professor Weisskopf, always amongst the most articulate and cultured of the proponents of particle physics, concluded a lecture at Fermilab in March with the words: 'I have described the developments in physics in my lifetime. It was tremendous and I must say it has filled my life and the lives of my contemporaries with an enormous amount of excitement, interest and greatness. In spite of the fact that the same period also witnessed the worst things in human character, it also witnessed the best things in human character and this — the remarkable developments in high energy physics — is the example.'

USA-USSR scientific collaborations restricted

Over 2400 American scientists, including thirteen Nobel prize winners and many prominent figures in the high energy physics world, have pledged to restrict severely their cooperation with their Soviet colleagues because of the prison sentences imposed on Yuri Orlov and Anatoly Shcharansky. The curtailing of contacts is being done 'with the deepest reluctance'.

Beams from superconducting linac

In December the superconducting linac sections developed at Argonne were used to boost the energy of a beam of sulphur ions emerging from a Van de Graaff from 85 to 146 MeV. We reported progress on the linac last year (September issue, page 305). It uses split ring resonators made of niobium, designed to produce effective field gradients eventually reaching 4.25 MV/m. Two sections accelerated oxygen ions in September and, with the successful December tests, the linac is now being used in nuclear physics research. The great immediate advantage of the technique is seen as the ability to increase energies from Van de Graaffs at comparatively modest cost.

Medical Van de Graaff

Another example of the use of accelerator technology in the treatment of cancer is a 4 MV Van de Graaff which started operation at Mount Vernon Hospital, London, in November. It will be used to produce neutron beams for tumour irradiation and can also be switched to electrons, including pulsed electron beams. This last ability will be used in pulse radiolysis where chemical reactions in biochemical systems can be observed at the various stages of rapid change. The work at the new facility will be led by Jack Fowler.

TRIUMF

a Nuclear Research Laboratory at the University of British Columbia, Canada

Beam Development Group

A post Doctoral Fellowship or Research Associateship is available for a physicist to be responsible for the design and to assist in the commissioning of pion and muon channels for the TRIUMF 500 MeV cyclotron. Previous experience with the design of low energy meson channels, and a background in nuclear or elementary particle physics, are required. Salary will be commensurate with experience.

Send resume and the names of three referees, before May 31, 1979, to:

M. K. Craddock
Beam Development Group, TRIUMF
University of British Columbia
Vancouver, B. C. V6T 1W5.

Physicists/Engineers

The Cyclotron Institute at Texas A & M University has openings for physicists and engineers for facility and accelerator development. Experience in accelerator operations / maintenance / diagnostics / design, high power rf systems, or computer-based data systems is desirable. The responsibilities of the position and the salary are dependent upon qualifications and experience.
A vigorous program aimed at improving the characteristics of the AVF cyclotron and its associated beam-handling system is under way. Improvements in the center region, the extraction system, and the rf system and further development of internal heavy-ion sources and polarized-ion sources are planned. A new computer system is being acquired. It is our desire to maintain a strong and continuing program of accelerator development.

Send complete resume to:

D. H. Youngblood
Director
Cyclotron Institute
Texas A & M University
College Station, Texas 77843

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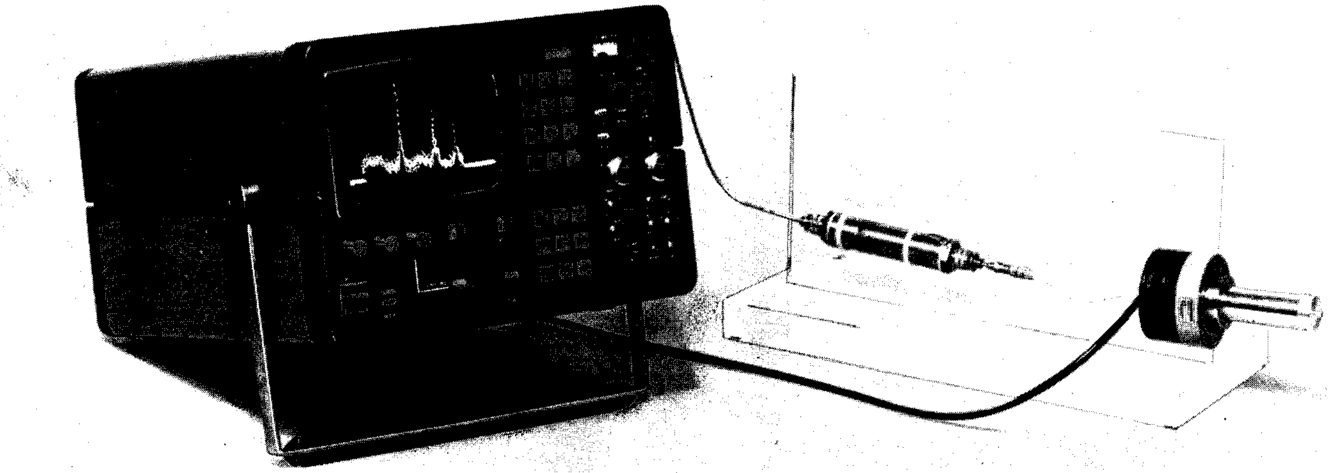

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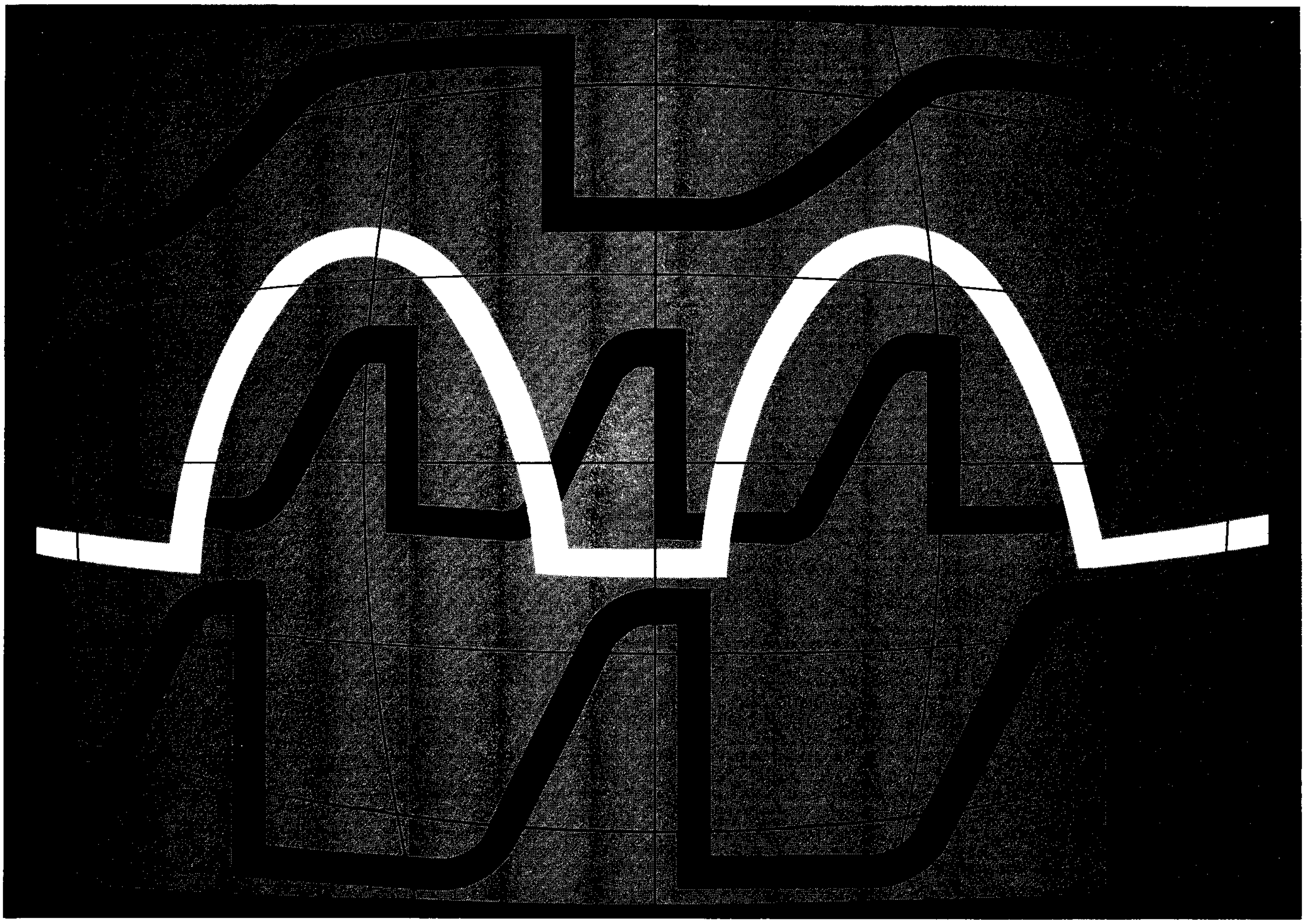
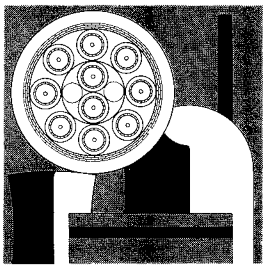
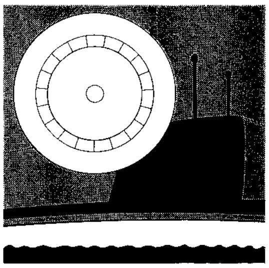
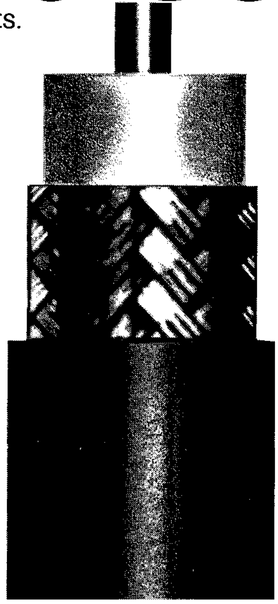
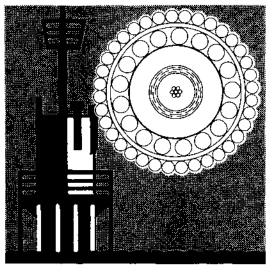
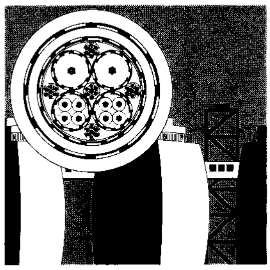


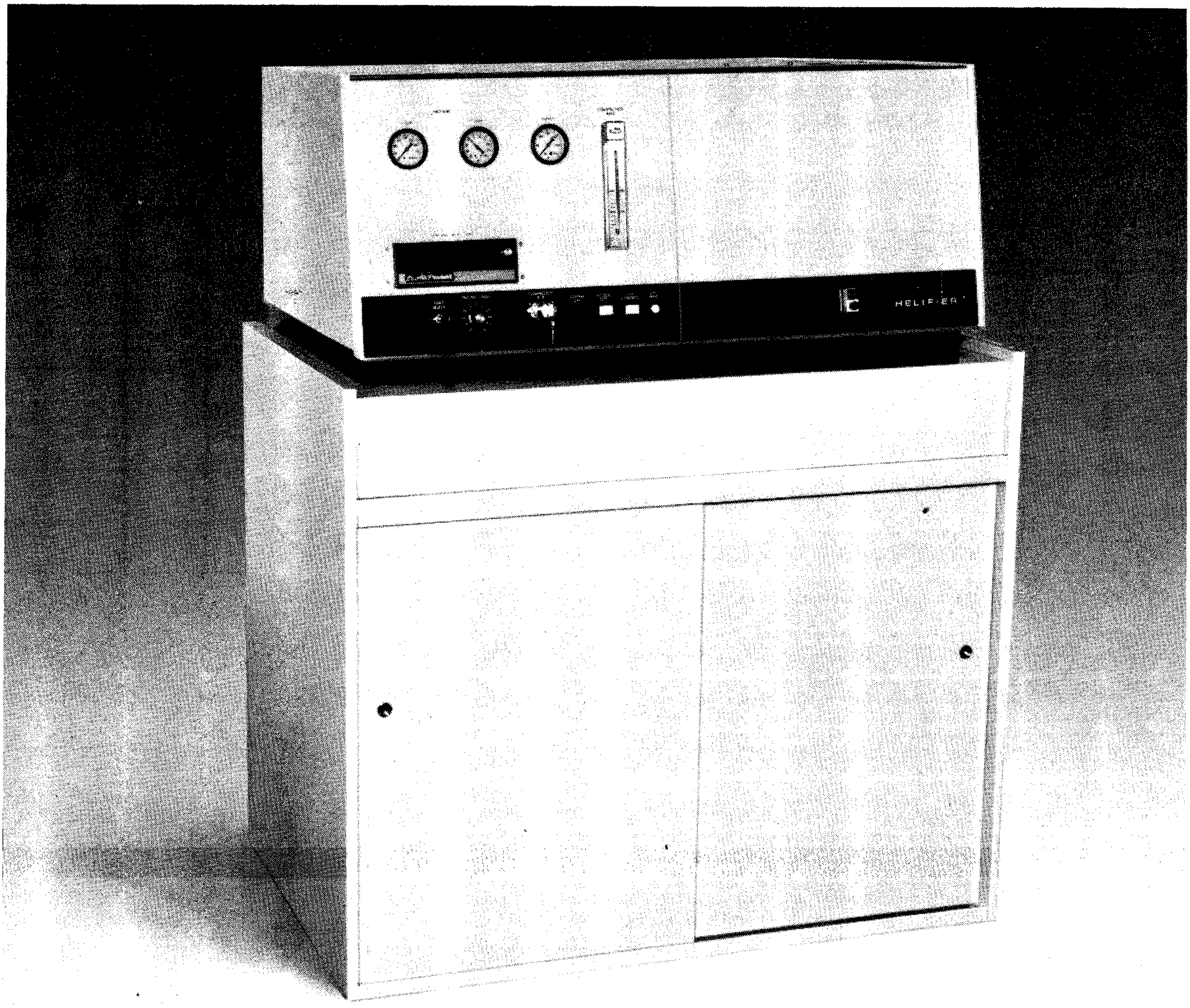


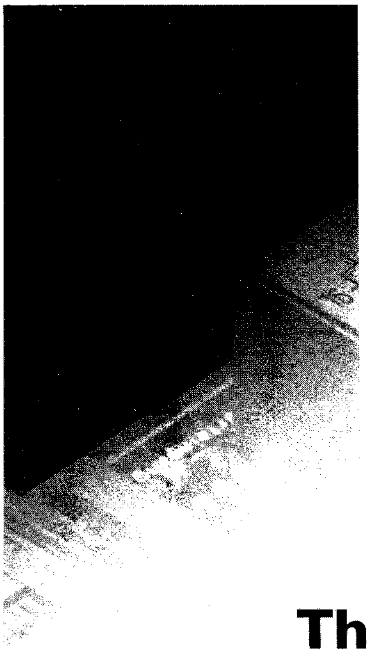


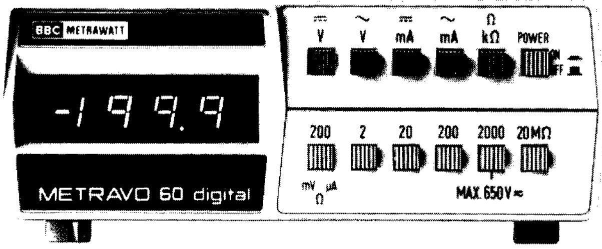


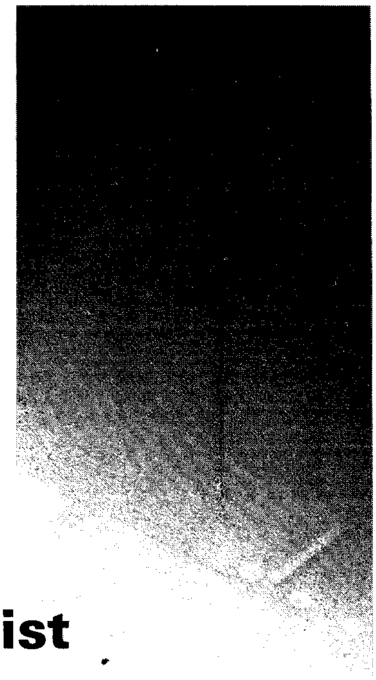








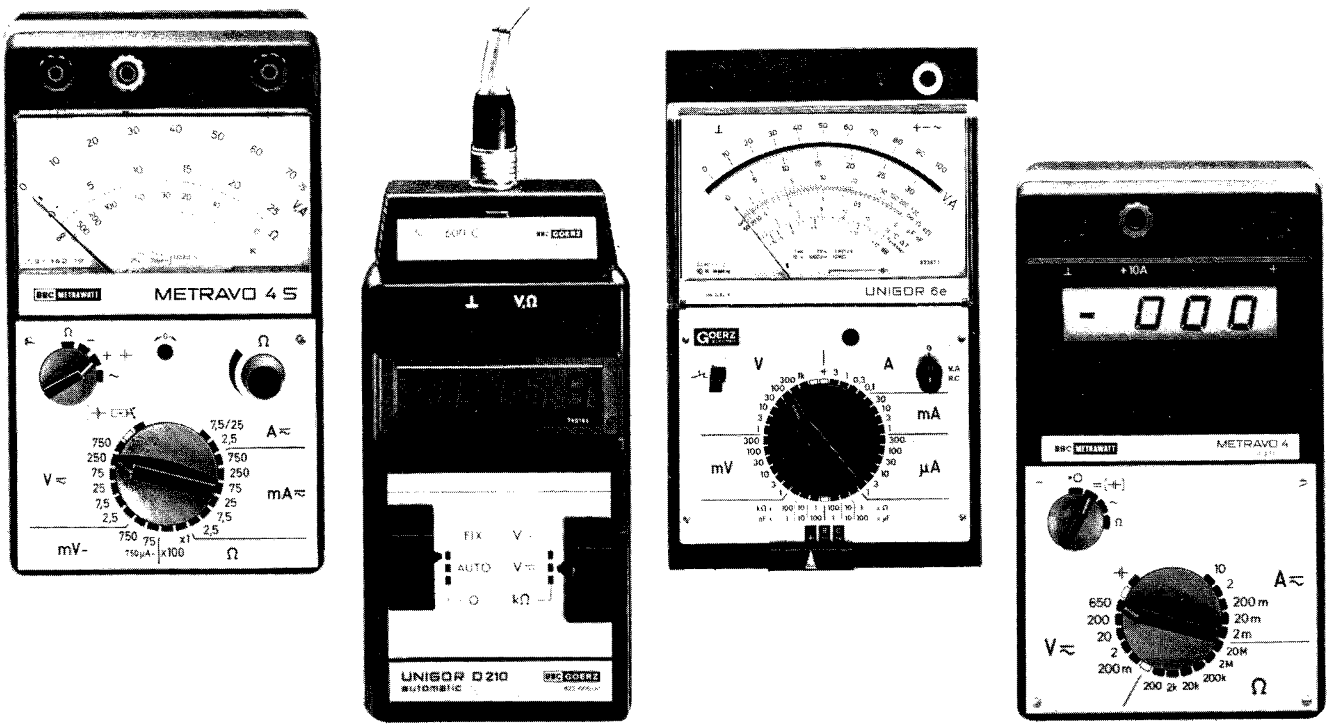




NEW

Digital display METRAVO® 60 D multimeter with 26 ranges for a.c., d.c. and resistance measurements. 10 Mohm input, overload protection and indication, automatic zeroing, 8 hours' continuous operation on no-maintenance, rechargeable NiCd cells.

The hallmark of the specialist
The BBC METRAWATT and BBC-GOERZ instrument



BBC-METRAWATT's and BBC-GOERZ' wide range of carefully designed instruments makes it easy to find the most suitable multimeter.

These instruments are backed up by two kinds of know-how: in circuit technology, controls and design, and in the selection of measuring ranges and channels. Nothing is left to chance in our multimeters. Take this opportunity of finding the ideal measuring instrument for your purposes. Ask for details — a phone call will do.

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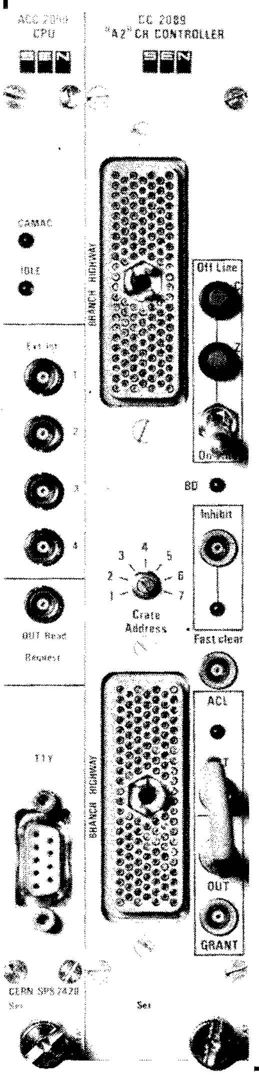
HCP

CAMAC

Introducing the most powerful intelligent CAMAC controller system: ACC 2099/CCA2 2089

This combination provides all the facilities of the host computer through a parallel branch with sophisticated Front-end processing through a fast 16 bit microcomputer.



ACC 2099: Auxiliary Crate Controller.

- 16 bit Texas TM 9900 microcomputer
- single width multilayer CAMAC unit
- 16K-16 bit RAM memory of which up to 4K can be replaced by ROM for fixed program storage
- Teletype interface
- 4 Front-panel Real Time Interrupts
- easy software with CAMAC modules addressed as memory positions
- 10 μs CAMAC Read/Write cycle
- Also SCCL2 and Nord 10 PIO controller compatible

CCA2 2089: A2 Parallel Crate Controller

- Fully conforms to the new EUR 6500e specs.
- single board construction
- fast clear input

SYSTEM OPERATION

The A2 Crate Controller is a parallel Crate Controller and includes all the same functions plus new control logic for local data handling using a microprocessor module (as ex. ACC 2099). The A2 provides access to the N and L lines via a rear panel connector for the Auxiliary Crate Controller placed in any normal station. It also handles the remote/local access request conflicts. Front-end data processing is governed by the ACC 2099 just as long as the main computer does not require access to this particular crate: However, when this occurs, the local processor is released, its status saved and the Branch Demand processed. Once the Branch Demand has been filled, control returns to the ACC 2099.

Next month:
The new ACC 2103 – an extended version of the ACC 2099 with additional EPROM for high-level languages.

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SEN ELECTRONIQUE

LeCroy's revolutionary photomultiplier high voltage system

LeCroy's new Model HV4032 revolutionizes photomultiplier high voltage by providing microprocessor control and monitoring of an economical 32-channel rack-mount power supply and distribution system.

Think of the advantages!

Intelligent

Each supply can be remotely monitored or set, permitting continuous on-line gain control. The outputs are repetitively compared with the 32 voltage set-points stored in memory; any defective channels are identified for on-line disengagement. The microprocessor permits digital control via CAMAC or TTY, as well as manual control via front-panel switches. Internal microprograms even check the battery backup system.

Complete

The HV4032 provides not only high voltage, but also distribution to 32 independent outputs, manual and remote control and monitoring of each output, front panel display, internal error-checking, and battery backup in case of power failure.

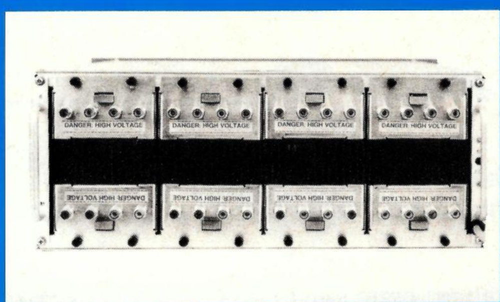
Economical

Compact packaging puts both high voltage and distribution into one convenient rack-mount assembly. Remote control and monitoring **eliminate long high voltage cable runs.** Ease of internal supply shutoff or replaceability saves down time.

THE HV4032 PROVIDES . . .

- 32 complete channels per single rack-mount package.
- >2 mA at up to −3 kV per output.
- Remote settability and monitoring to <1 volt per step.
- Optional positive voltage operation.
- Manual, TTY, or CAMAC control.
- Microprogrammed safeguards and error-checking subroutines.
- Easily accessible and interchangeable internal supplies.
- Ultimate sophistication at a low cost.

Consider LeCroy's one-stop solution to your high voltage distribution requirements. Write or call us for more details.



LeCroy
RESEARCH SYSTEMS

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