CERN COURIER

NO. 10 VOL. 14 OCTOBER 1974

CERN, the European Organization for Nuclear Research, was established in 1954 to '... provide for collaboration among European States in nuclear research of a pure scientific and fundamental character, and in research essentially related thereto'. It acts as a European centre and co-ordinator of research, theoretical and experimental, in the field of sub-nuclear physics. This branch of science is concerned with the fundamental questions of the basic laws governing the structure of matter. The Organization has its seat at Meyrin near Geneva in Switzerland. There are two adjoining Laboratories known as CERN Laboratory I and CERN Laboratory II.

CERN Laboratory I has existed since 1954. Its experimental programme is based on the use of two proton accelerators — a 600 MeV synchro-cyclotron (SC) and a 28 GeV synchrotron (PS). Large intersecting storage rings (ISR), are fed with protons from the PS for experiments with colliding beams. Scientists from many European Universities as well as from CERN itself take part in the experiments and it is estimated that some 1500 physicists draw research material from CERN.

The CERN Laboratory I site covers about 80 hectares almost equally divided on either side of the frontier between France and Switzerland. The staff totals about 3100 people and, in addition, there are about 1000 Fellows and Scientific Associates. Twelve European countries contribute, in proportion to their net national income, to the CERN Laboratory I budget, which totals 391.1 million Swiss francs in 1974.

CERN Laboratory II came into being in 1971. It is supported by eleven countries. A 'super proton synchrotron' (SPS), capable of a peak energy of 400 GeV, is being constructed. CERN Laboratory II also spans the Franco-Swiss frontier with 412 hectares in France and 68 hectares in Switzerland. Its budget for 1974 is 227.1 million Swiss francs and the staff totals about 350 plus 10 Scientific Associates.

CERN COURIER is published monthly in English and French editions. It is distributed free to CERN employees and others interested in sub-nuclear physics.

The text of any article may be reprinted if credit is given to CERN COURIER. Copies of most illustrations are available to editors without charge.

Advertisements are published on the sole responsibility of the advertisers.

Editor: Brian Southworth
Assistant Editors: Henri-L. Felder
Michel Darbin
Advertisements: Micheline Falciola
Photographs: PIO photographic section

Public Information Office
CERN, 1211 Geneva 23, Switzerland
Tel. (022) 41 98 11 Telex 2 36 98

Printed by: Presses Centrales Lausanne S.A., 1002 Lausanne

Contents

CERN News

Around the Laboratories

Cover photograph: Niobium-tin finds its way onto our cover for the second time this year. This is a magnification (about 700 times) of a cross-section through a partially reacted sample of composite conductor. It shows many niobium filaments in a bronze matrix. The filaments are surrounded by a skin where tin has already diffused in to form the superconducting niobium-tin alloy. For the latest news on high field magnets using this alloy, see page 349.

Recent advances in particle physics

L. Van Hove

Professor Léon Van Hove has been awarded the Max Planck gold medal by the German Physical Society (Deutsche Physikalische Gesellschaft) 'for his important contributions to the foundations of statistical mechanics, his works in quantum field theory and his substantial investigations in the theory of elementary particles, in particular for the description of many particle reactions at high energy.' The presentation was made at the Annual Meeting of the Society in Nürnberg on 25 September. This article is a condensed version of a talk given by Van Hove to the CERN Council at the end of his three year mandate as Director of the Theoretical Physics Department.

Very important results obtained in high energy physics in the last three to four years have profoundly affected our conception of even such basic notions as the internal structure of the proton and neutron, two of the three particles out of which ordinary matter is composed. Our knowledge of the electron, the third of these particles, is much more advanced and has changed little in recent years.

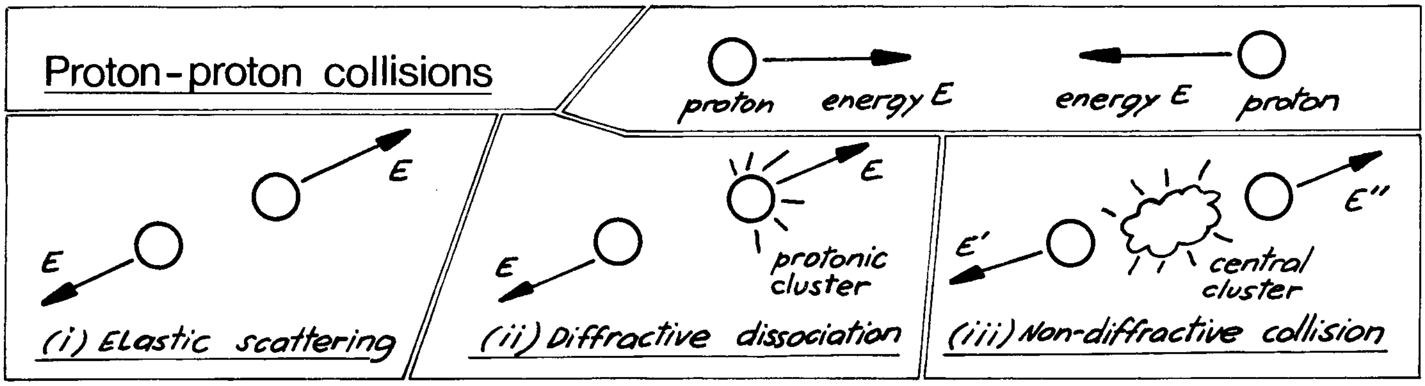
I will attempt to sketch what we have learned from recent experiments carried out on proton-proton collisions (at the Intersecting Storage Rings of CERN and at the American 400 GeV synchrotron of the Fermi National Accelerator Laboratory), on neutrino-proton and neutron collisions (mainly Gargamelle heavy liquid bubble chamber experiments at CERN) and on electron-proton and electron-neutron collisions (mainly at the 20 GeV electron accelerator of the Stanford Linear Accelerator Center). It is remarkable that a rather unified picture of proton and neutron structure begins to emerge from all these experiments and, although many aspects are still beyond our understanding, this picture reveals some form of basic simplicity.

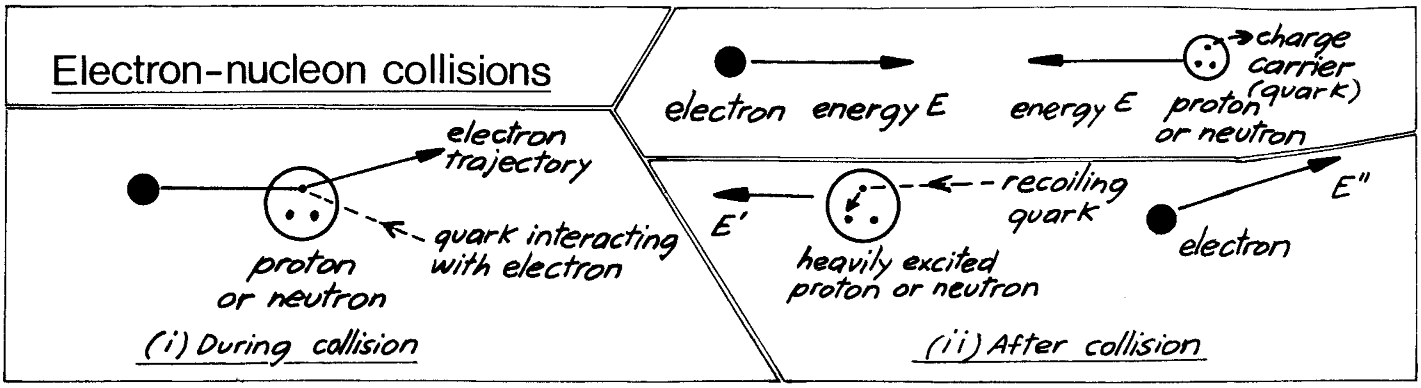
Classes of proton-proton collisions at high energies

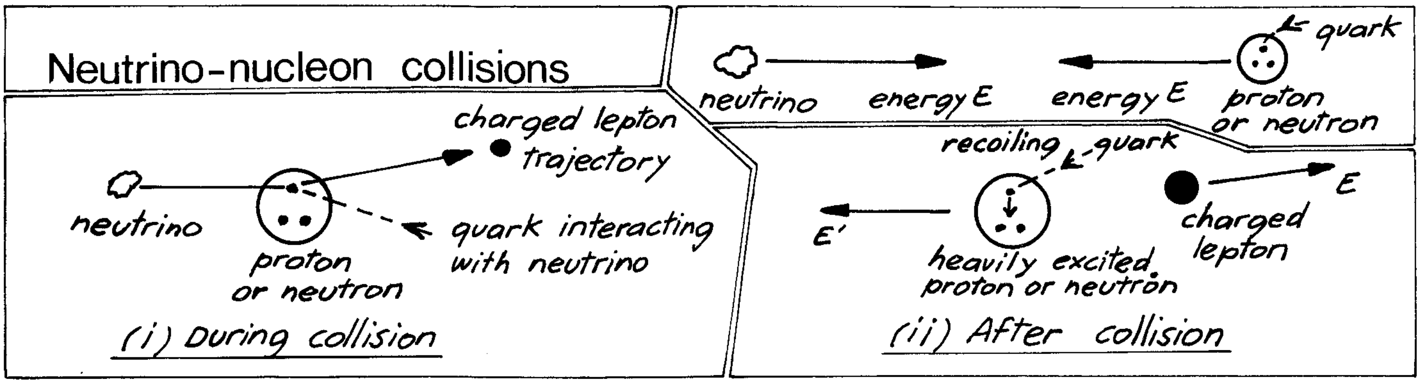
In a proton-proton collision, two protons fly towards each other and interact by the strong interaction, after which one of various things can happen. In the simplest case of elastic scattering, just two protons fly out after the collision and they have the same energy, E, as the incident protons. In all other cases (inelastic collisions) new particles are created.

At the very high energies available at the ISR and the FermiLab, these inelastic collisions reveal striking properties which were not clearly recognizable at lower energies and which lend themselves to simple phenomenological interpretation. The inelastic collisions neatly separate into two main classes. In the first class, called diffractive dissociation, either of the two incident protons gets excited into an object composed of a few particles; this group or cluster of particles is usually composed of a nucleon (proton or neutron) and of a few mesons all flying roughly in the same general direction and carrying in total about the energy E. The other proton flies out alone in the opposite direction also carrying about the energy E.

In the second and main class of inelastic collisions, called non-diffractive, the protons come out in opposite directions, excited or not, and with strongly reduced amounts of energy, E′ and E″ which are on average equal to about half of the energy E of the incident protons). In addition, a considerable number of other particles, mostly mesons of lower energy, come out. They show quite remarkable correlations which suggest that they somehow come out in clusters of three to four mesons each and there is evidence that the clusters are frequently neutral (the total electric charge of a cluster is frequently zero). These clusters, the average number of which may be itself around three of four per collision, are called central clusters to distinguish them from the protonic clusters occurring when an incident proton gets excited in the collision.







Electron-nucleon and neutrino-nucleon collisions

By studying collisions of high energy electrons on nucleons we can obtain information on the distribution of electric charge inside the nucleon. Similarly, collisions of high energy neutrinos on nucleons give information on the distribution inside the nucleon of what can be called the weak charge (a quantity controlling how the weak interaction acts on the nucleon, just as the electric charge controls how the electromagnetic interaction, i.e. the electric and magnetic forces, act on the nucleon).

Recent electron experiments at SLAC and neutrino experiments with the Gargamelle bubble chamber at CERN have concentrated on deep inelastic collisions, meaning collisions where the nucleon gets very heavily excited. In such collisions, we can measure the texture of the distribution of charges inside the nucleon at very short distances (in space-time).

The results of the experiments are quite remarkable. In a first approximation, it appears that the electric and weak charges of the nucleon are concentrated on three small grains. These grains have a radius which is at most about one-tenth of the nucleon radius. Their charges and spin appear to have the same values as those of the celebrated quarks. These are the conceptual building blocks of nucleons, mesons, etc., which were postulated in 1964 as a very simple but amazingly successful model for the classification of all hadrons (of all particles which partake in the strong interaction).

The resulting picture of deep inelastic electron and neutrino collisions on nucleons is sketched above. In both cases, one and only one quark is hit in the collision and by its recoil it heavily excites the nucleon. It does not escape however, (this is the big mystery about quarks) and the excited nucleon separates into many particles. We believe these to be in general a nucleon and many mesons but the very important experimental question of what they are and how they share the recoil energy has hardly been investigated up to now.

In the neutrino case, the collision converts the neutrino into another particle, which is an electrically charged lepton — electron, positron, negative or positive muon — depending on the nature of the incident neutrino. This is the normal case. As is by now well known, good evidence for an abnormal type of neutrino collision has been found in the Gargamelle experiment and, more recently, at the FermiLab and Argonne. In these abnormal collisions, the neutrino does not convert into a charged lepton. It is believed (although not checked experimentally) that it remains a neutrino. In the physicist's terminology, normal neutrino collisions are said to be of charged current type and the abnormal ones of neutral current type. Electron collisions are also of neutral current type. The experimental findings about the neutrino collisions of neutral current type, coupled with important developments in quantum field theory, have raised lively hopes for a possible theoretical unification of electromagnetic and weak interactions. It should be stressed, however, that the discovery of the new type of neutrino interaction is of great scientific importance in itself, quite irrespective of what its final theoretical interpretation turns out to be.

To return to the consequences of the SLAC and CERN experiments for the internal structure of the proton and neutron — not only did they show that the charges are mainly concentrated on three small grains, which can be identified with quarks, but their detailed interpretation leads to a determination of the fraction, x, of the nucleon energy, E, which is carried by a single quark. This quantity is found to have an interesting distribution with mean value of about 1/6, so that the energy fraction carried by the three quarks is about a half (three times 1/6). This result, which came as a surprise, means that the nucleon contains more than the three quarks and that the additional stuff which carries the remaining half of the energy must be essentially neutral (without

Professor Léon Van Hove, left, receiving the Max Planck gold medal from Dr. Otto Koch, President of the German Physical Society.

(Photo Peter Vrbata)

electric or weak charges). The name of 'glue' is often used for this additional stuff because it is believed to be associated with a very strong field which would be responsible for binding or 'gluing' the quarks together inside the nucleon.

The surprisingly large amount of glue as neutral component in the nucleon is probably related to the fact that the quarks are very strongly bound inside the nucleon, so strongly that all attempts to extract them have failed so far. It is therefore unlikely that quarks could be similar to ordinary particles. A further and very striking result in this direction has come out of the research programme of electron-positron storage rings (Frascati, Cambridge and SLAC). At the higher energies, the cross-section for annihilation of an electron and a positron with production of strongly interacting particles (mainly mesons) takes values which are much larger than what is calculated if quarks are treated as charged particles without strong interaction. Here also the very strong binding forces which prevent quarks from getting away from each other must deeply affect the physical situation. In these annihilation experiments, as well as in the deep inelastic collision experiments mentioned earlier, one can look forward with the greatest interest to the detailed study of the multiparticle system coming out of the process.

More about proton-proton collisions

It is natural to ask whether the recently discovered internal structure properties of protons and neutrons have anything to do with the processes taking place when high energy nucleons collide with each other. The answer seems to be positive in the sense that interesting, though still speculative, connections can be established for the main non-diffractive class of inelastic proton-proton collisions. The other classes are then automatically linked also to structure properties since they can be regarded as shadow effects.

In its simplest form, the picture is the following. In a non-diffractive proton-proton collision, the quarks of each incident proton fly through with their own fraction of incident energy, and they give rise to the outgoing protons (excited or not). The glue contained in the incident protons converts into the central clusters where it then decays into the particles finally observed (mostly mesons). There are two attractive features of this picture. Firstly, the property of the glue being mostly neutral is reflected in the fact that the total charge of the central clusters seems to be dominantly zero. Secondly, the property that the quarks inside a proton of high energy, E, carry on average about half of its energy is reflected in the fact, that the protonic energies E', E'' are on average one half of E.

Another phenomenon discovered at ISR is that, as we go to higher energies, proton-proton collisions produce a small but rapidly increasing number of high energy particles flying off sideways. (Sideways means that these particles fly off in directions very different from the direction of flight of the incident protons.) This so-called large transverse momentum phenomenon is one of the most interesting under study.

Two types of explanation have been proposed. The phenomenon could result from occasional processes where quarks of the two incident protons collide with each other, or perhaps are interchanged with each other, producing a strong sideways deflection (the latter property could naturally result from the small size of the quarks). Alternatively the phenomenon could result from occasional production of an exceptionally massive cluster, the decay of which would naturally give rise to energetic particles flying off sideways. The careful study of the large transverse momentum phenomenon may well become an important source of progress for a better understanding of internal proton structure.

Finally we mention the finding that total cross-sections of protons and mesons on protons show an increase as the incident energy becomes sufficiently high (this was first found at Serpukhov for positive kaon-proton, then at the ISR for proton-proton and at the FermiLab for other cases as well). Many possible causes can be invoked for explaining this phenomenon. Progress in finding the correct explanation will probably require very good knowledge of how the various properties of inelastic collisions vary with energy. It is therefore not surprising that this class of problems has become central in the activity of experimentalists and theorists alike.

CERN News

Final touches to the central region of SC2, the revamped 600 MeV synchro-cyclotron, before it was buttoned up for the start of commissioning. Protons were accelerated for the first time at the end of September and machine performance during these initial tests looked good.

Synchro-cyclotron has protons again

On 1 October the refurbished CERN synchro-cyclotron (now known as SC2) accelerated protons to the full energy of 600 MeV in a very successful start to its recommissioning.

The SC was the first of CERN's machines, giving protons in 1957. By the early 1970's it had been overtaken, in terms of proton beam intensity, by several comparable machines in its energy range and had to confront the advent of the 'meson factories' at Los Alamos, Vancouver and Villigen. To revitalize the experimental programme, by making higher intensity and better quality beams available, a series of improvements were planned for the accelerator. These have been carried out during the past year.

The improvements have included replacement of the open arc ion source by a hooded arc type, replacement of the heavily irradiated magnet coils, installation of a new vacuum chamber housing the accelerating system, installation of a new extraction system and, particularly, replacement of the radiofrequency system based on the famous tuning fork modulator by a system based on a rotary condenser capable of providing higher voltages at an increased pulsed repetition rate. (More detail on the improvement programme can be found in vol. 13, page 35.)

Reassembly was completed in mid-September and acceleration tests began on the night of 29-30 September. Very quickly, protons were detected out to a radius of 30 cm where a thermocouple probe was located. This was comfort number one because it meant that the central region of the machine, which can be a difficult source of trouble, was behaving as predicted at least as far as could be gathered in the first crude measurements.

On 1 October, it was decided to go for acceleration out to the full radius of the machine. This was moving into less well known territory. The central region geometry had been checked in practice using a central region model; from there to full radius, the machine was the product of calculation. However, the beam spiralled out to full radius without any problem. This could be seen on two detectors (scintillators and ion chambers) out in the SC hall and by watching the signal corresponding to the voltage on the Dee which dipped a little because of beam loading for as long as the beam survived. Comfort number two.

There has, of course, to be at least one story about something which did not go as expected. In SC2 commissioning, it concerned the thermocouple probe which was pushed into the machine aperture on a long cantilever arm so that it sat in the median plane at the 30 cm radius position. As it was withdrawn to watch the beam at greater radii, the signal disappeared despite the other two detectors and the Dee voltage saying that all was well. This led to much head scratching until the light dawned. The force of gravity is not highly regarded at high energy physics Laboratories because it seems to have very little effect on the behaviour of individual particles. It does, however, have considerable effect on a long arm in close proximity to Mother Earth. The arm bowed over to put the probe in the correct position at 30 cm radius but as the arm was shortened the probe lifted above the median plane and was no longer hit by protons. Alert men draw information even from the unexpected — the absence of the probe signal at larger radii said that the vertical spread of the beam was less than 1 cm as had been hoped!

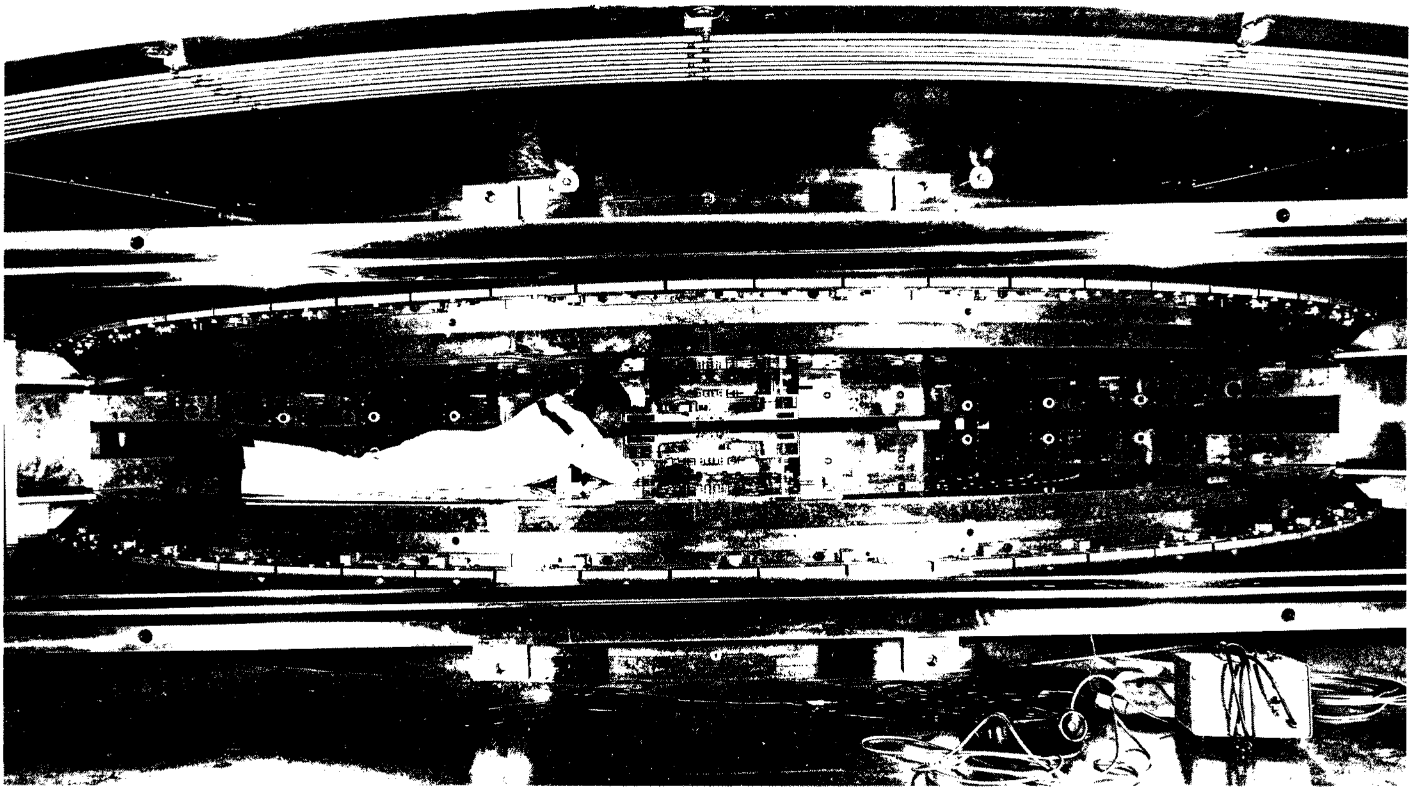
For the tests, the r.f. was pulsed at just one sixteenth of the design repetition rate so as to avoid unnecessary irradiation of the machine before the beam was brought fully under control. After some juggling with source position, the thermocouple (back at 30 cm) indicated that it was receiving a 0.6 μA beam. Doing the sums, this indicates that, already, the 10 μA design current is within easy reach when the r.f. is going full blast. Comfort number three.

After this successful start-up comes the painstaking process of optimization. The machine people will be playing with source position, working up the r.f. system, matching the frequency programme to the magnetic field parameters, bringing on the extraction system (which has to be very efficient in view of the high intensities) and optimizing beam quality. Also some things will need further attention — for example, the Dee is leaky and the r.f. reliability and servicibility is a worry. Nevertheless, it is intended to launch the experimental programme again before the end of the year.

Autumn Study on storage rings

The first two weeks of October have seen storage ring people from accelerator Laboratories throughout the world at CERN to study the fundamental problems of very high energy proton-proton colliding beam machines.

CERN obviously has a responsibility to anticipate the possible future needs of high energy physics research in Europe and to study the potential abilities of accelerator and storage ring systems to meet these needs. With the remarkable success of the ISR under our belts, it is natural that proton-proton colliding beams figure prominently in this thinking about the future. A 'Long Term Development'



CERN 112.8.74

branch has been set up in the ISR Department and they have been taking a first look at what could be done.

Many ideas have received attention. For example, one possibility is to uproot the present ISR and replace them with superconducting rings to store beams of about 100 GeV. This is not being pursued further, for the time being, since the advance in energy is not sufficiently attractive and the ISR tunnel would not house the rings comfortably. Another possibility is to have accelerator/storage rings like the ISABELLE project at Brookhaven where injection at some hundreds of GeV would be followed by acceleration to say 1000 GeV. However, with the imminent availability of 400 GeV protons from the SPS, work has concentrated on 400 GeV proton-proton storage rings.

It is obviously recognized that high field superconducting magnets could condense the size of the project considerably and there are practical and theoretical steps being taken to advance the advent of such magnets. On the practical side, superconducting magnets are being built for installation in a high luminosity (low beta) intersection of the existing ISR so as to examine their performance under the stringent conditions of an operating machine. On the theoretical side, the features of a machine based on magnets capable of 4 T fields have been considered.

Nevertheless it is 400 GeV storage rings based on the use of conventional magnets which have received most attention so far. This has enabled the study group to get their teeth into the problems of higher energy machines based on technology that is thoroughly known. The study has indicated that there is no apparent reason why luminosities of 10^{33} per square centimetre per second should not be achieved.

Related questions such as the storing of antiprotons, deuterons and polarized protons or the storing of electrons or positrons in a separate ring, so as to extend the physics programme that the project could accommodate, have been considered but not in much detail up to now. In particular it is felt that other centres have more familiarity with handling electron beams and electron-positron physics should be left in their hands. If the interest in electron-proton physics continues to grow, the question of whether to bring electrons to a proton machine or protons to an electron machine will have to be confronted.

The 'Autumn Study' brought expertise from other Laboratories to bear on the work that has begun at CERN. This enabled the assumptions and preliminary conclusions to be checked independently at a very early stage. The discussions were concerned with the basic features of high energy storage rings and not with detailed technical desine. It is likely to be a long time before, if the physics interest is sustained, a project emerges from the studies.

CERN on film

Inside CERN — Dévoiler l'inaccessible — Grosse Maschinen für kleinste Teilchen — Centro europeo della fisica delle particelle — are the titles which have been given to a new 20 minute film in colour on CERN which has been made in English, French, German and Italian editions, by Tattooist International of London.

Aimed particularly at the visitor to a high energy physics laboratory, notably CERN, who has no knowledge of the way in which the research is carried out but who nevertheless has an interest in finding out, the film adopts a direct descriptive approach.

In the beginning it recognizes the problem posed by the inaccessibility not only of the subject itself but of many of the machines because of fire precautions, high voltages, high magnetic fields as well as radiation, and so concentrates on those areas which remain for the most part enclosed in concrete. A short animation sequence introduces the audience to the essential steps in a particle physics experiment and then takes it in turn through

A delegation of the Norwegian press visited CERN from 15-17 October. They were received by the two Directors General, W.K. Jentschke at Lab. I and J.B. Adams at Lab. II. The journalists had a lengthy tour of the CERN installations accompanied by CERN experts; the photograph shows them in I-2 of the ISR with their compatriot K. Johnsen, former Director of the ISR department.

CERN 107.10.74

the SC, the various stages of acceleration in the CERN PS, the ISR which is followed by a look at BEBC, Omega and Erasme.

The scene then moves to the construction work on the SPS and includes a dramatic sequence when the mole bursts through into one of the long straight sections previously excavated by conventional techniques. This later part of the film will be brought up to date as the work on constructing the SPS proceeds and installation of the main elements in the tunnel gets under way.

As befits a research establishment, the film itself has an experimental element: that of using a laser beam as a visual pointer in indicating the details of the machines the commentary is describing. There are still difficulties to be overcome in using this technique but it seems clear that this is not the last time it will be seen on cinema screens.

A limited number of copies have been printed in each of the four languages and may be borrowed from the PIO, CERN. Any university or laboratory which would be sufficiently interested to have a copy permanently may purchase one from CERN at print cost price.

Commissioning the 380 kV line

The first on-load tests of the 380 kV line connecting the EDF (Electricité de France) power station at Génissiat to CERN Laboratory II took place on 4 October. The tests checked various parameters such as impedance, earth circuits, interference with the Post Office system, etc. The line brings power to feed the 400 GeV SPS. Two giant transformers, which arrived at CERN in June and August, are ready to receive the power and from the end of October they will come progressively into action to supply the SPS installations at 18 kV.

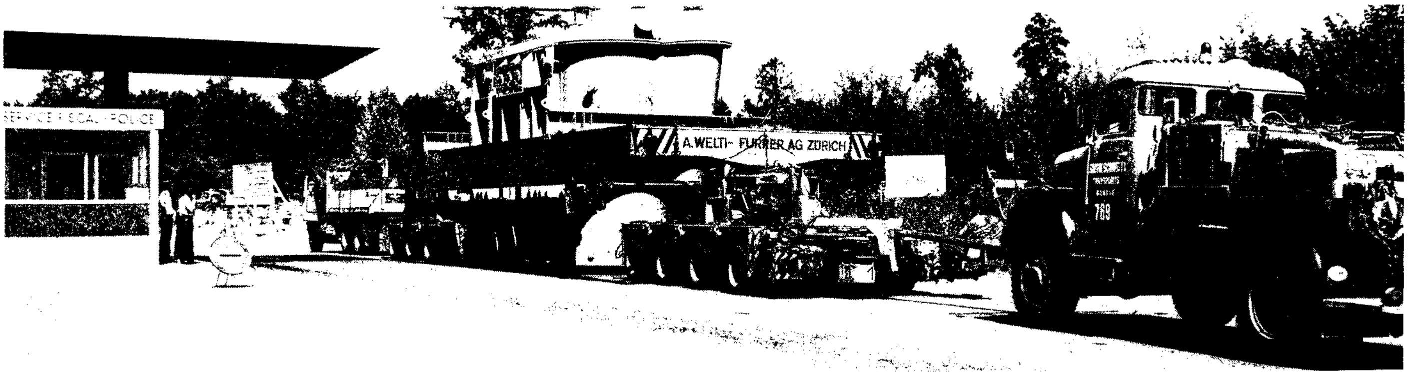
The design study for the SPS tackled the problem of linking the EDF mains, which is the only local system capable of coping with the high fluctuating power load, with Laboratory II. It became clear that two conditions had to be satisfied so that the mains could take the SPS pulses without troublesome disturbance:

a) the power cycle of the accelerator had to be limited with regard to minimum cycle time and instantaneous peak power

b) to carry the high power, a high voltage (380 kV) line had to be built between Laboratory II and Génissiat, the nearest point to the site (33 km away).

Now the link is completed and almost ready for action.

The transporter carrying the second large transformer for Laboratory II passes through the Meyrin customs post. The transformer sits at the end of the 380 kV line from the EDF power station at Génissiat which begins supplying power to Laboratory II at the end of October. It was built by Hawker-Siddeley and shipped directly to Basle via Rotterdam and the Rhine. The 220 ton transporter and load came by road from Basle via a devious route avoiding tunnels, bridges, hairpin bends and steep hills. During the journey the base of the transformer sat only 7 cm above the road surface.



CERN 44.8.74

Experimental Programme at the PS and ISR

We are aware that, for some of our readers, it is useful to have, from time to time, a run-through of the current research at CERN. Covering the whole programme in this way, it is not possible to give the full story of each experiment.
They are listed here according to the Experimental Hall in which they are located.

The CERN proton synchrotron (PS) continues to be the cornerstone of the experimental programme of Laboratory I. The tasks it is called upon to fulfil are many and varied. It has not only to supply protons and secondary particles for the experiments around the machine but also to fill the Intersecting Storage Rings (ISR) with particles. At the same time it is being adapted for use as an injector for the SPS.

Depending on the type of experiment concerned, the beam characteristics may vary considerably e.g. type of beam (primary or secondary), pulse length, intensity and energy, and transverse beam dimensions.

In order to satisfy these various requirements, a series of extraction systems has been set up around the ring. The accelerated beam is used in three ways: a) on internal targets to produce secondary beams; b) fast ejected primarily for beams to bubble chambers; c) slow ejected producing long beam pulses for counter experiments. Beams are fed to four experimental halls.

East Hall

Two ejection systems supply beams for the experiments in this experimental hall. A fast ejection system in straight section 58 supplies a primary proton beam-line e6 which can be directed to any of three different targets in order to supply particles to the 2 m bubble chamber via three beam-lines — u5 is an r.f. separated beam supplying the particles of the highest energy (e.g. 16 GeV/c positive kaons); m6 and k8 are beams electrostatically separated for lower energies.

A slow ejection system, from straight section 62, gives the primary proton beam e9 which is divided into three branches, with one target on each branch. Five secondary beams emerge from these.

The experiments in the hall are as follows:

2m bubble chamber is very active with about ten teams taking photographs since the beginning of 1974. Among the experiments are those which use pion or kaon beams with the highest available energy (16 GeV/c) to study interaction mechanisms, diffractive dissociation, quasi two body reactions, the distribution of particles in high multiplicity interactions, the production of resonances and their various decay modes, reactions with quantum number exchange. Other teams have been working at lower energies studying, for example, reactions with hypercharge exchange. The number of photographs taken since the beginning of the year is almost 3 million with a variety of incident beams K^0_L, K^-, π^-, π^+, p, $\bar{p}$.

Turning to electronic experiments: *S 129* is an Orsay/Ecole Polytechnique/Strasbourg collaboration studying elastic scattering and the production of resonances in hyperon-proton interactions with a specially tailored hyperon beam incident on a hydrogen target. The aim is firstly to measure the differential cross-section for $\Sigma^- p$ interactions for momentum transfers between 0.065 and 0.45 $(GeV/c)^2$ and, secondly, to study the diffractive production of Y^* resonances similar to the N^* resonances observed in pp interactions. There are forward and backward detectors around the target. The backward detector consists of multiwire proportional chambers (3000 wires) and 32 scintillators to measure the angle and momentum of the recoil protons. A DISC counter, located in front of the target, serves to measure the incident hyperon. The forward detector consists of a magnet and two 1.7 m streamer chambers. To complete the installation there is a neutron detector consisting of optical chambers interleaved with thick plates. This impressive detection system enables measurements to be made of the directions and momenta of the Y^* decay products. It is expected that 6000 elastic events and about 100 Y^* events have been recorded.

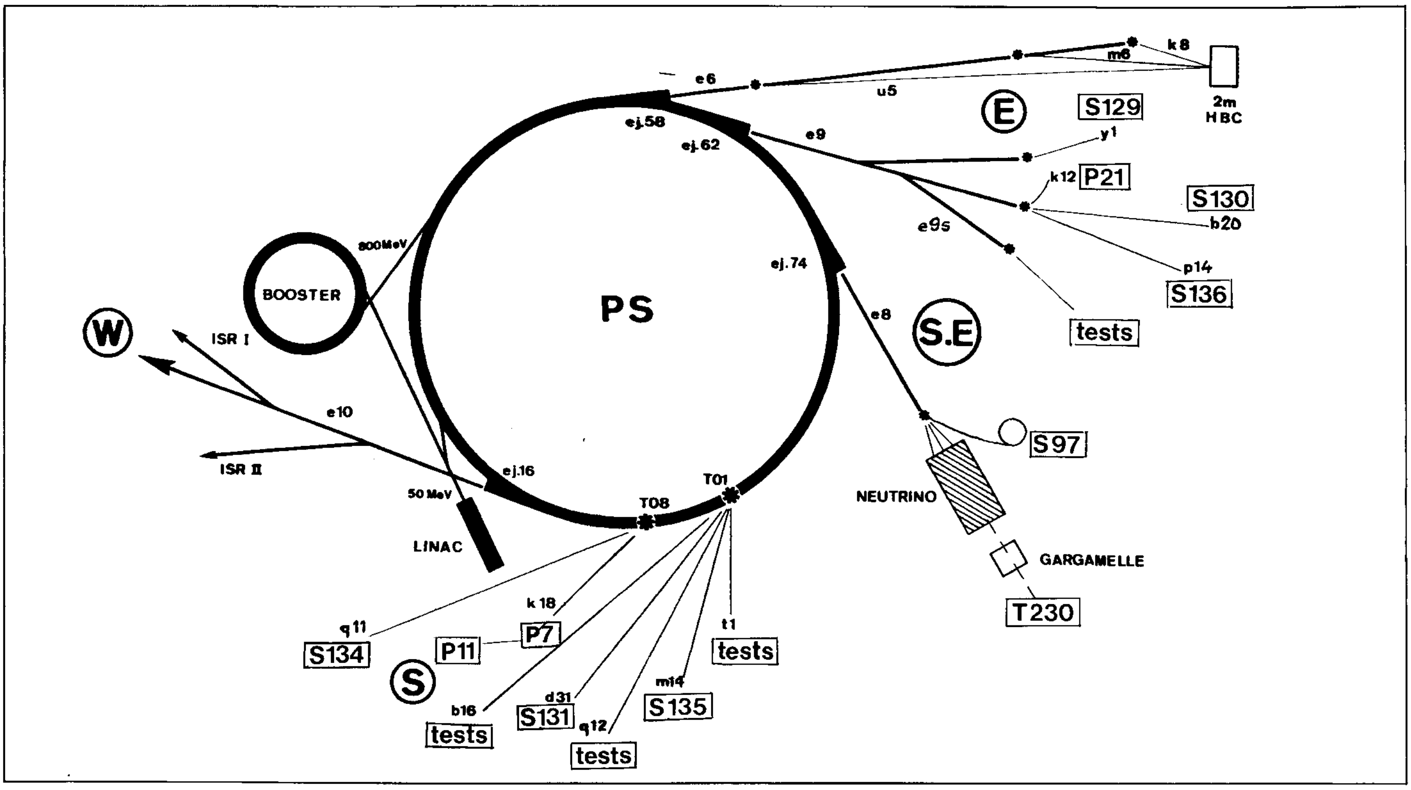
S 130 is a Collège de France/Padua collaboration to study the reaction $K^0_L + p \rightarrow K^0_S + p$ to verify high energy exchange theories. The incident beam consists of neutral particles, the main difficulty is to avoid recording other interactions such as those caused by the large number of neutrons.

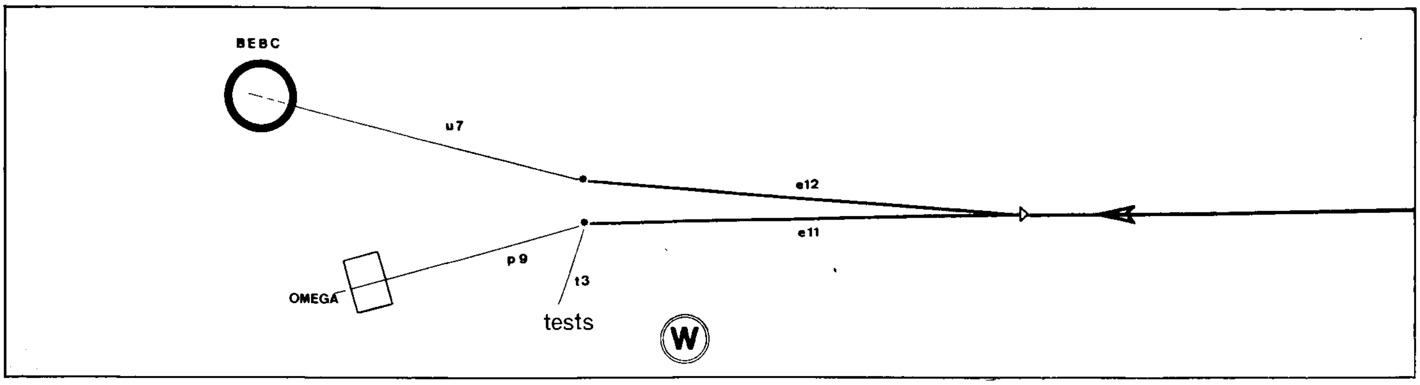
The installation consists of a detector for forward ejected particles and a detector for particles ejected at a wide angle. The forward detector is a spectrometer consisting of the 'Venus' magnet (on loan from Saclay), magnetostrictive spark chambers and a muon detector. It is used to identify characteristic K^0_S decay into two pions. The muon detector serves to measure the muons from K^0_L decay (about 30 % of the decays go this way) and provides an accurate means for measuring incident beam intensity. The wide angle detector consists of magnetostrictive spark chambers and is used for recoil proton detection.

The cross-section of the interaction of interest is small. Data is acquired at the rate of about two to three events per PS pulse but only a small percentage relate to the interaction; the rest relate to calibration and background.

A team from Freiburg im Breisgau also works on this beam testing a spectrometer to detect backward-ejected pions in the reaction $K^0_L\, p \rightarrow \Lambda^0 \pi^+$.

S 136 is a CERN/Munich collaboration to study the production of resonances which decay into two pions in the $\pi^- p \rightarrow \pi^+ \pi^- n$ interaction. They use a polarized butanol target surrounded by a counter array which eliminates





events other than those in which a neutron is produced. The detection system is a spectrometer consisting of an analyzing magnet, spark chambers and two large gas Cherenkov counters. The spectrometer is used for studying the mechanisms of ρ, f, g and A_2 meson production and the states in which these resonances are produced according to the angular distributions of the pion pairs. This experiment will gather high statistics since 20 million triggers are planned to be recorded.

P 17 is a Clermont-Ferrand/Lyon/Strasbourg collaboration to study coherent scattering, in which the following reactions are examined:
$p + {}^4He \rightarrow p + {}^4He$
$p + {}^4He \rightarrow N^* + {}^4He$
$p + {}^4He \rightarrow X + {}^4He$
$p + {}^4He \rightarrow X + {}^3He$.

The detection of recoil helium particles from elastic and inelastic reactions is performed by means of a telescope with four semi-conductor detectors. The telescope explores the angular region between 70 and 88 degrees in 0.25 degree steps. This recoil technique using a gas target enables work to be carried out simultaneously at a focal point of the beam without disturbing the experiments downstream. By means of the elastic events, information can be obtained on the incident particle/nucleon interactions, on the structure of the scattering nucleus and on correlations between nucleons. Furthermore, the events provide a means of testing the Glauber model which is used to interpret hadron-nucleus interactions at high energies and small scattering angles.

100 000 elastic events have been recorded, as well as 100 000 inelastic events with N* production and 100 000 events with target nucleus dissociation.

P 21 is a Lyon/Warsaw collaboration for studying the excited states of ^{4}He and ^{4}H hypernuclei. It uses a beam of negative kaons absorbed by a lithium target leading to the production of a hypernucleus in which a lambda particle combines for a short time with protons and neutrons. It is then possible to study excited states of such nuclei by direct observation of the radiation they emit as they are de-excited. In a previous experiment, a Heidelberg/Warsaw team observed two de-excitation lines of hypernuclei at 1.09 MeV and 1.42 MeV but the parent nucleus was not identified (^{4}H or ^{4}He). The present experiment aims to identify the origin of the lines by observing the coincidence between the emission of a gamma and a pion from lambda disintegration. For the ^{4}H decay it is expected that in 50 % of the cases a 53 MeV negative pion will by emitted.

The gamma is detected in a sodium

Schematic layout of the beam-lines and experiments around the CERN proton synchrotron. The experimental areas are indicated as E — East Hall, SE-South East Area, S — South Hall and W — West Hall.

The concrete jungle of the East Hall. The camera is looking out over the m6 beam-line where electrostatic separators can be seen. They sift out comparatively low momentum particles for the 2 m bubble chamber. On the left is the hut which serves as local control room for the electronic experiment number S130 on neutral kaon-proton interactions.

iodide crystal and the direction and momentum of the pion is measured in a telescope of scintillation counters.

South-East Area

This experimental area is used for neutrino experiments and for the g-2 experiment. It receives a fast ejected beam from straight section 74 onto a target. For the g-2 experiment, pions are directed to the muon storage ring. For the neutrino experiments, pions and kaons are focused and aimed at the Gargamelle heavy liquid bubble chamber. They are allowed to travel a sufficient distance to ensure that the majority decay, leaving a beam of muons and neutrinos (or antineutrinos). This beam then passes into an iron shield which stops all particles except the neutrinos (or antineutrinos).

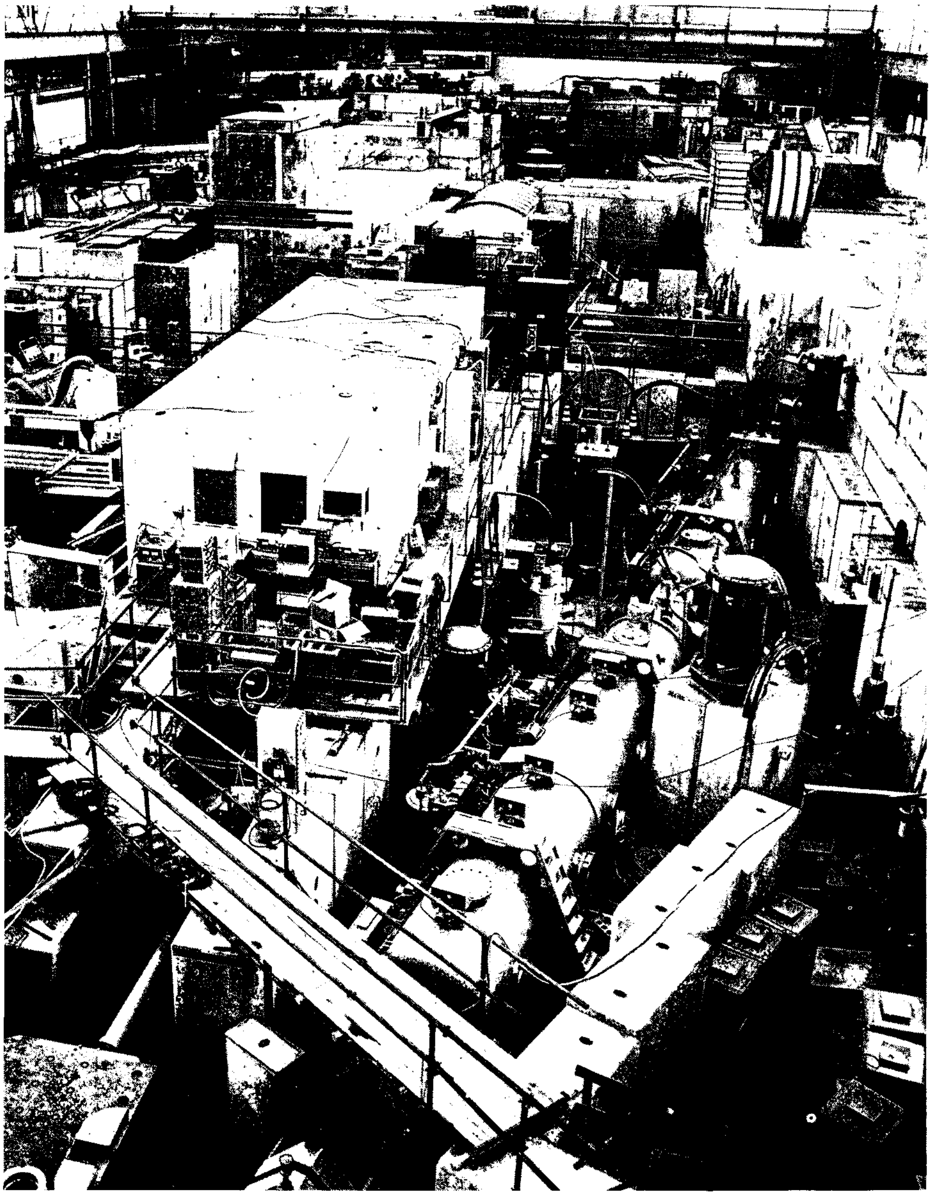
Gargamelle: Two neutrino experiments are under way. The first, by the Aachen / Brussels / CERN / Ecole Polytechnique / Milan / Orsay / University College of London team, uses the chamber filled with freon to study neutral current events involving elastic scattering of a neutrino by an electron. Two such events have been seen so far.

The second experiment, by an Aachen/Brussels/CERN/Ecole Polytechnique / Padua / Orsay for neutrinos and Bari/Bergen/Milan/Strasbourg/Turin/University College London team for antineutrinos, uses the chamber filled with propane to determine the relationships between the neutron and proton cross-sections for charged current events and to study certain neutral current events. The experiment is also designed to track down neutral current events involving elastic scattering of neutrinos on protons. About a million photographs remain to be taken with Gargamelle before it is transferred to the West Area to be fed with beams from the SPS.

S 97 is a CERN/Daresbury/Mainz collaboration measuring the anomalous magnetic moment of the muon with an accuracy 10 ppm. A 14 m diameter muon storage ring is filled with pions which decay into muons some of which are stored orbiting the ring of magnets. The muons are highly polarized and it is the precession of their spin axis in the magnetic field which is measured.

Twenty counters are positioned around the ring to measure the energy of the electrons emerging when the muons themselves decay. The energy is related to the spin axis direction and accurate knowledge of the energy and the magnetic field enables the muon magnetic moment to be calculated. Its value is a very important test of the theory of quantum electrodynamics.

T 230 is an Aachen/Padua colla-



CERN 42.9.74

boration investigating leptonic neutral currents via neutrino-electron elastic scattering. The experiment is installed in the neutrino beam behind Gargamelle. The detection system consists of a bank of 150 optical spark chambers 7 m long with thick aluminium plates. Sparks in the wake of charged particles are reflected towards a camera by two mirrors each having a surface area of about 15 m^2. Approximately 1 million photographs will be taken.

South Hall

Two internal targets (01 and 08) in the PS ring supply secondary beams alternately to the electronic experiments in this area.

S 131 is a study by a Geneva team of strange resonances (K*) which decay into a neutral kaon and a pion in reactions of the type $K^\pm p \rightarrow p K^{*\pm}$. Other reactions induced by pions, protons and antiprotons are also studied when they lead to decays of the same topology. The detection system consists of multiwire proportional chambers and scintillators in a wide aperture array giving a high number of recordable events. The experiment is carried out on-line with two IBM 1800 and PDP 11/45 computers which record the data at a rate of 230 events per PS pulse. The experiment will provide a means of confirming or modifying certain measurements made on the resonances and of exploring the mass region from 1.5 to 2.2 GeV where little information exists up to now.

S 134 is a CERN/ETH Zurich/Helsinki/Imperial College London/Southampton collaboration using a frozen spin polarized target for measuring all P, A and R spin parameters in the reaction $\pi^- p \rightarrow K^\circ \Lambda^\circ$ with an incident pion beam of 5 GeV/c. The purpose is to make complete measurements of the reaction amplitude and to study lambda decay into a proton and pion which emits the proton preferentially in the direction of the lambda spin.

The detection system consists of the target (described in the September issue, page 293) with two semiconductor counters in the cryostat enabling the beam to be defined onto the target. An anticoincidence system consisting of scintillation counters and tantalum plates eliminates all events including a charged particle or gamma. Spark chambers followed by scintillation counters are then required to detect at least one particle in order to trigger the photographing of the event.

S 135 is a Strasbourg/Turin collaboration studying form factors of the proton in the time-like region using the $\bar{p}p \rightarrow e^+ e^-$ reaction. The experiment uses a separated antiproton beam of 900 MeV/c. In order to obtain the proton form factor in the time-like region, the antiproton must be at rest when it is annihilated with a proton. Consequently, a moderator is placed in front of the 50 cm hydrogen target to ensure that antiprotons are stopped in the target.

The electron detector surrounding the target has about 4 π acceptance. It consists of scintillators, spark chambers and moderators to reveal the shower produced by an electron. The direction of the electrons is determined by wide gap spark chambers.

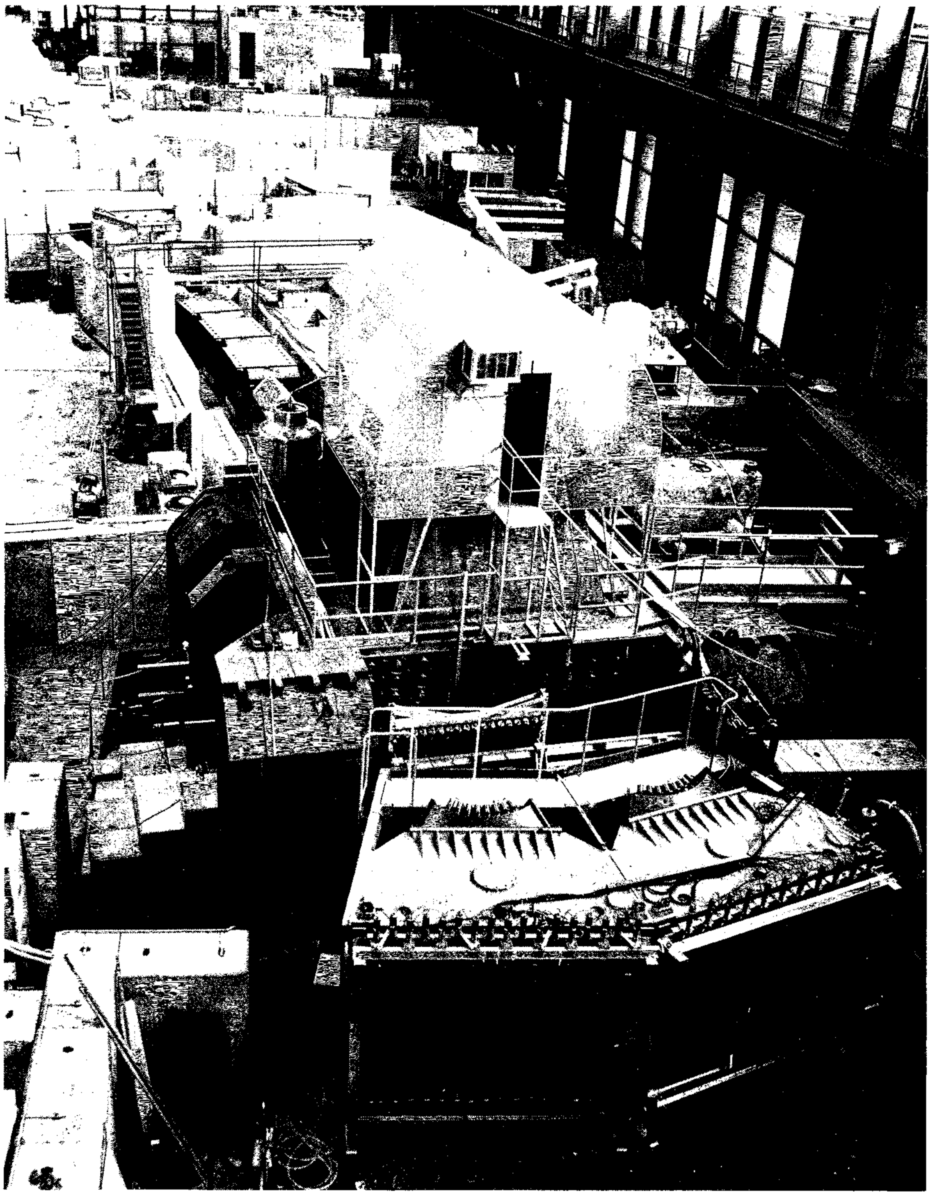
The experiment also provides a means of studying the production of ρ' mesons with masses below 1700 MeV. Their decay into electron-positron pairs will identify the mesons unambiguously.

P 11 is a high resolution spectroscopy experiment, carried out by a team from Heidelberg, studying hypernuclei in the $K^- + A \rightarrow A + \pi^-$ reaction. The spectrometer is in two parts — the first analyses the kaon momentum and the other the pion momentum. The target is located between and different nuclei are used (beryllium, carbon, oxygen, sulphur, aluminium, and bismuth).

Drift chambers and scintillators are placed at each end of the spectrometer and around the target so that the time-of-flight can be measured, as well as the angle and coordinates of kaons and pions. With the aid of these measurements it is then possible to calculate the energy states of the hypernuclei with an accuracy of up to 1 MeV. New energy states have already been observed in the case of beryllium, carbon and oxygen.

P 7 is a Karlsruhe/Stockholm experiment on exotic atoms with negative kaons, antiprotons or negative sigmas in orbit around nuclei. The equipment includes moderators to stop the particles in the target (hydrogen, helium, nitrogen, oxygen, sulphur, etc.) and a telescope of plastic scintillators plus two Cherenkov counters which make it possible to pin down coincidences between a stopped particle and emerging X rays detected by semiconductors.

When one of the incoming negative particles is in orbit around the nucleus it usually begins in a high energy orbit and falls through energy states emitting X rays. The X ray energies give important information on the particle involved and, as the particle orbits become entwined with the nucleus, on the nucleus itself. Information can be gathered on the distribution of particles at the nuclear surface, on the particle correlations in the nucleus, on the strong interaction between the particle and a nucleon, etc... An interesting feature of the experiment is to be able to extract information from zero energy systems which is not possible in the normal scattering experiments.



The Omega spectrometer in the West Hall. The 'igloo' on top of the superconducting magnet houses the Plumbicon cameras which receive the signals of charged particle track positions from the optical spark chambers placed in the large aperture. In the foreground is the large Cherenkov counter which covers the whole solid angle downstream of the magnet aperture.

CERN 175.8.74

West Hall

The West Hall receives beam along the transfer line towards the ISR which is deflected towards the Hall. It has two general purpose experimental set-ups: the Omega spectrometer and the 3.7 m European bubble chamber, BEBC. The chamber will resume its experimental programme at the beginning of next year.

The Omega spectrometer consists of a wide aperture superconducting magnet in which have been installed a hydrogen target and a series of optical spark chambers. The chambers are monitored by Plumbicon cameras and spark positions are recorded on magnetic tape. The detection systems can select particular types of reaction and consequently the system can collect data on relatively rare processes at a faster rate than is possible with a bubble chamber. At the same time the system can identify particles by means of a large Cherenkov counter which covers the entire horizontal aperture at the rear of the magnet. Several experiments can be set up simultaneously. While one team is collecting data via an on-line EMR 6130 computer, others can test triggering systems with their own mini-computers (PDP 11). Six teams are collecting data.

S 112 is a Birmingham/Rutherford/Tel Aviv/Westfield College experiment studying the production of neutral mesons in the reaction $\pi^- p \rightarrow X^\circ n$ at 12 GeV/c using slow neutron triggers. The time of flight and direction of the neutron define the mass of the X°. The range of masses explored extends from 0.8 to 2.3 GeV/c^2 and three million triggers have already been recorded. During a further run the team will work at 15 GeV/c thus increasing the range of explored masses to 2.6 GeV/c^2.

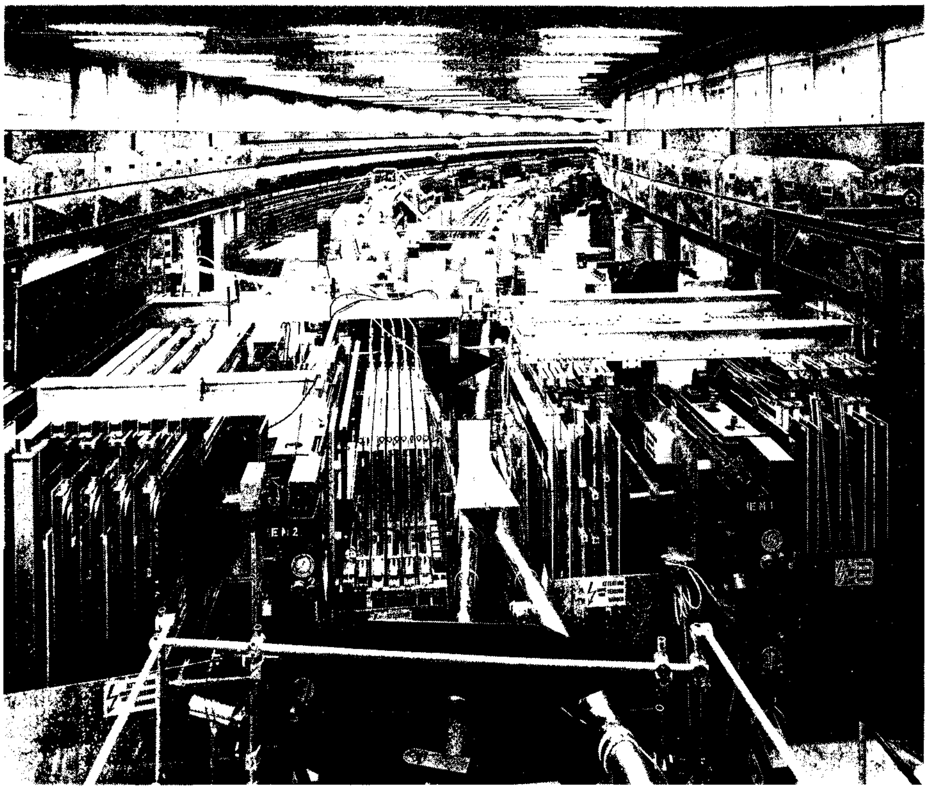
S 114 is a CERN/ETH/Freiburg im Breisgau/Karlsruhe/Saclay group studying baryonic exchange with production of a backward emitted lambda in the $\pi^\pm p \rightarrow \Lambda^\circ X$ reaction. Triggering is via the proton from lambda decay. The experiment can also measure lambda polarization. The group will collect further data on the $\pi^+ p \rightarrow \Lambda^\circ X^{++}$ at 12 GeV/c to look for exotic mesons produced by baryon exchange.

S 117 is a CERN/Collège de France/Ecole Polytechnique/Orsay experiment studying baryon exchange processes in the $\pi^\pm p \rightarrow p X^\pm$ interaction. This experiment detects fast forward emitted kaons. A fast proton may originate from the decay of a hyperon or from an N*, with the result that the experiment can study a wide range of interactions.

S 133 is a CERN/Saclay experiment for the precise determination of the scattering lengths and phase shifts of $\pi^+ \pi^-$ and $\pi^+ \pi^+$. The $\pi^\pm p \rightarrow \pi^+ \pi^\pm n$ interactions are studied at 3.2 GeV/c with a triggering system designed to accept two pion events at a small aperture angle. The group will collect further data at about 5 GeV/c.

S 138 is a Birmingham/Glasgow collaboration using a 10 GeV/c positive kaon beam to study the interaction with hydrogen. An example of an interaction studied is $K^+ p \rightarrow K^+ \pi^+ \pi^- p$ in which the Cherenkov counter helps to remove the kinematic ambiguities which are large in bubble chambers. High statistics will be obtained for these interactions.

S 139 is a Bari/Bonn/CERN/Daresbury/Glasgow/Liverpool/Milan/Purdue/Vienna collaboration to study rare meson decay with an incident beam of negative pions. Triggering is initiated by kaons and antiprotons. The main interest of the experiment is meson decay into $\bar{K} K \pi$ and $p\bar{p} \pi$.



The installation in intersection I-1 for detecting the photons and electrons produced at wide angles relative to the direction of the incident proton beams. On each side of the intersection region may be seen wire chambers, an analysing magnet, lead-glass counters and scintillators.

CERN 124.8.74

Experiments at the ISR

The Intersecting Storage Rings have made it possible to observe almost head-on collisions between protons up to an energy equivalent to that of 2000 GeV protons striking a fixed target. A wide field of high energy physics research has been opened up and the experimental programme is now in full cry.

Among the range of experiments already carried out at the ISR, the measurements made of the total proton-proton cross-section struck the first notes of surprise (see vol. 11, page 185). Since then several experiments have been made on elastic scattering, contributing essential information for our understanding of the nature of the proton when looked at as a whole. The ISR provide an excellent opportunity for studying highly inelastic proton-proton scattering, and many experiments are supplying new data on the nature of these interactions and the modes of formation of new particles.

With the high energy available in the centre of mass in a proton-proton interaction, the ISR are the best available means for research into heavy particles. Hence the experiments directed towards the identification of the intermediate boson, magnetic monopoles, quarks, etc. — if of course any of these can exist as independent entities.

Let us now take a turn around the machine, stopping at each experimental area.

Intersection 1

R 105: A CERN/Columbia/Rockefeller/Saclay team has studied the production of neutral pions of high transverse momentum coming from inelastic proton-proton scattering. It has also looked for the intermediate boson, the hypothetical intermediary in the weak interaction. The equipment includes two analysing magnets arranged at 90° on either side of the intersection bicone, plus wire chambers, scintillators and lead-glass counters. This installation makes up a wide aperture photon and electron detector which captures the particles emitted at wide angles relative to the direction of the proton beams. The neutral pions are detected through the gamma rays which they emit on decaying while the intermediate boson, if the ISR are able to liberate it, could be detected by its mode of decay into electrons.

So far, the elusive intermediate boson has not been observed, but the preliminary results demonstrate the existence of a continuous distribution of electrons produced in the $p + p \rightarrow e^{\pm} +$ anything reaction with transverse momenta from 1.5 GeV/c to about 4 GeV/c. The rate of production of these electrons is about 10^{-4} times that of pions at the same angles and momenta. Similar results relating to the production of electrons have also been found at the Fermilab where also muons have been detected at a comparable rate. The origin of the electrons has not yet been explained, but the most popular hypothesis just now is that they come from the decay of vector mesons like Φ.

R 106: A Bologna/CERN/Saclay/Rome team has carried out research into magnetic monopoles looking for the north or south poles. The equipment used for this experiment is in complete contrast to the other assemblies as it consists simply of a dozen plastic film detectors stacked together as closely as possible on either side of the intersection region. Magnetic monopoles, it is thought, would on passing through these films, leave small holes behind, which would be visible after development through a microscope.

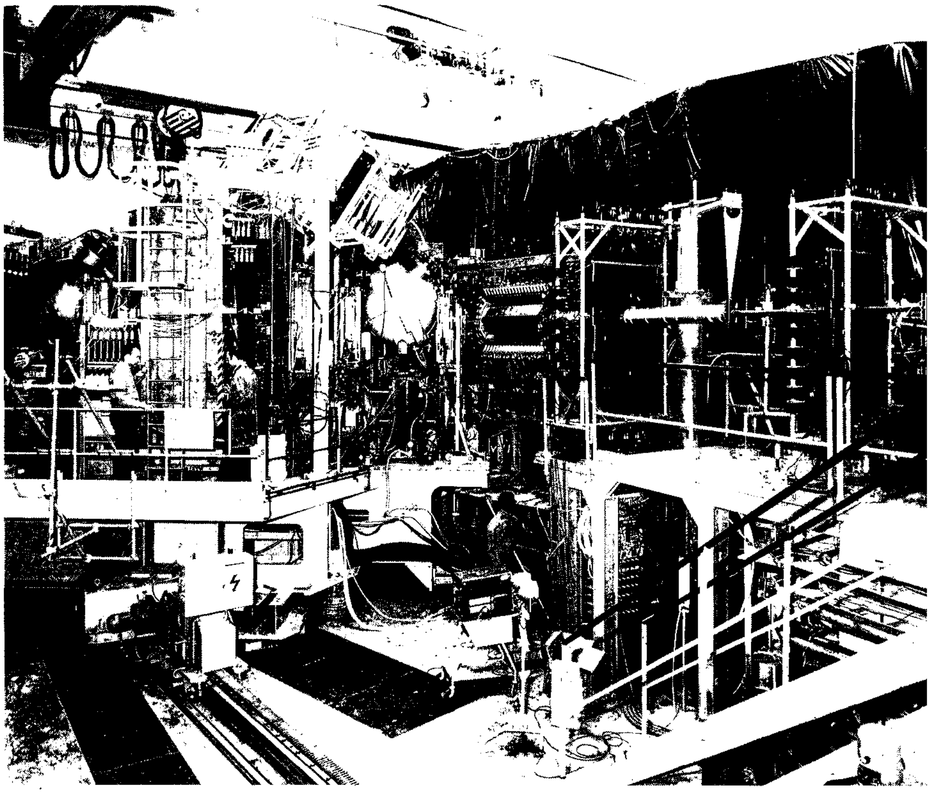
R 107: This experiment is being set up by a Brookhaven/Rome/Adelphi group, which will examine events where several gamma rays are produced. These 'multi-gamma' events may, for instance, be the result of the annihilation of a pair of monopoles.

The equipment comprises lead-glass counters, wire proportional chambers and scintillators. The lead-glass counters, which tend to yellow under the effect of prolonged irradiation, can be removed on rails by remote control from the intersection region during the periods when data are not being taken.

This experiment will start at the end of November.

Intersection 2

R 205: Here we have a Daresbury/Liverpool/Rutherford team studying the particles produced in the central



CERN 258.2.74

Intersection I-2: at the centre, is a barrel-shaped hodoscope surrounding the intersection region. On the left is the spectrometer which is capable of swinging between an angle of 30 and 90°, flanked by two spherical Cherenkov counters.

region. This team is using a 70 ton spectrometer capable of pivoting on its arms between 30° and 90° and consisting of an analysing magnet, spark chambers, scintillators and two spherical Cherenkov counters. A barrel-shaped hodoscope, made up of 120 scintillators and supplemented by twenty other end scintillators, surrounds the intersection region. This installation makes it possible to study the correlations associated with the production of a high transverse momentum particle. The experiment will be completed at the end of December.

R 206: This is a CERN/Netherlands/Lancaster/Manchester collaboration on the study of the production of particles at small angles between 30 and 200 mrad, using a 30 metre long spectrometer. The detector includes two special septum magnets through each of which passes a current of up to 20 kA. The magnets are used to separate from the ISR beam charged particles produced at small angles. Thereafter there are two threshold Cherenkov counters, two additional bending magnets and a 6 metre long Cherenkov counter. This team is also using the hodoscope mentioned in connection with the experiment at R 205 and is looking into the single diffractive dissociation process in which a proton in the ground state is scattered at a small angle, while the other proton is highly excited (up to 10 GeV/c) and generates a jet of particles along the general line of the excited proton.

The team is also engaged in checking the Feynman scale invariance law for transverse momenta below 2 GeV/c.

Intersection 4

The Split Field Magnet, a piece of general purpose equipment, has been installed in this intersection region. The magnetic fields of 1.14 T, which are in opposite directions in the two halves of the 900 ton magnet, cause the particles scattered or produced in the intersecting region to bend away from the circulating beams into the surrounding detectors. The useful volume for detection, about 30 m^3, is filled with multiwire proportional chambers arranged so as to form two forward detectors around the downstream arm of each beam and a central detector which records the secondary products emerging at a wide angle.

This multipurpose detector, which is arranged so as to record all the charged particles produced in an interaction and to reconstruct their trajectories, is therefore especially suitable for the study of particle correlations, multiplicities, diffractive dissociation as well as for the search for new particles. Various teams make use of the data collected, analysing the information stored in a computer in their own way.

R 401: Here, a CERN/Orsay/Hamburg/Vienna collaboration is investigating the proton fragmentation products in interactions in which a single proton is excited, the other being simply scattered in its ground state.

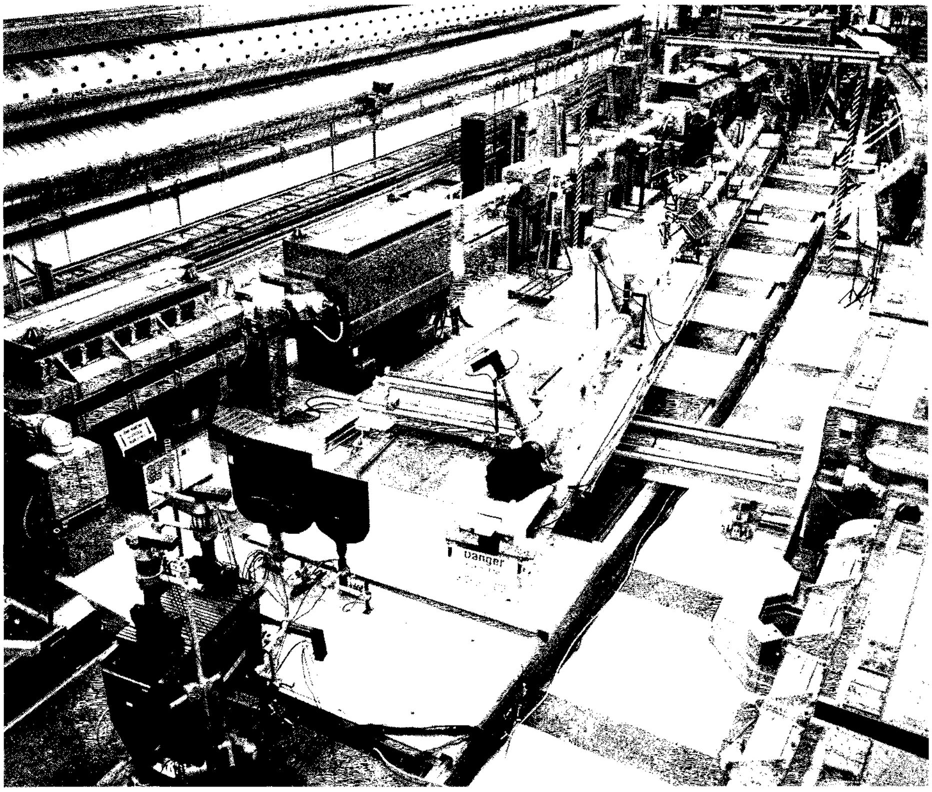
R 411: A Pavia/Princeton collaboration is studying the proton fragmentation products in interactions where the two protons are excited, bringing about the production of two opposite jets of particles in the general direction of the incident beams.

R 406: A CERN/Bologna collaboration is looking for new particles and, in particular, quarks, the detector being able to distinguish particles carrying fractional charge.

R 407/408: A CERN/Collège de France/Heidelberg/Karlsruhe collaboration is studying the two-particle correlations.

Intersection 6

R 603: A single-arm magnetic spectrometer with an azimuth acceptance of almost 2π is the central feature of an Aachen/CERN/UCLA collaboration. This piece of equipment, triggered by scintillation counters and fitted with a double septum analysing magnet (on either side of ring 1), multiwire proportional chambers and Cherenkov counters, is designed for research into inelastic processes. The team is collecting data on Δ^{++} production and on the production of unstable particles: N^*, Λ^0, K^0. The experiment will later give way to a new experiment on wide angle elastic scattering, due to start next spring.



Installation of experiment R802 in intersection I-8. At the centre are the four Cherenkov counters forming the final stage of the spectrometer fitted on a system of rails on which it can be moved. At the bottom left is the neutron counter arranged at 0° in relation to the downstream proton beam. In the background may be seen the experimental arrangement for experiment R801.

CERN 239.3.74

Intersection 7

R 701: This experiment is being conducted by a CERN/Aachen/Heidelberg/Munich collaboration and uses the large streamer chambers, described in our February issue on page 44. These chambers cover 95 % of the solid angle about the intersection region and make it possible to display almost all the particles produced during an interaction. Lead oxide plates are inserted close to the walls of the chamber so as to show up the gamma rays produced by neutral pion decays, by way of completing the assembly. The type of event sought can be selected by a set of triggering hodoscopes.

The equipment is eminently suitable for the study of multiplicities and correlations, helping to give us a clear picture of the various collision processes.

Another method of triggering is provided by an assembly of sixty-one total absorption Cherenkov counters of the lead-glass type, facilitating the study of particle correlations in an event where a high transverse momentum π^0 is produced.

The intersection is to be used for machine development with a view to building a 'low β' section. The purpose is to reduce the vertical dimensions of the two beams so as to obtain a twofold increase in luminosity.

Intersection 8

R 801: A Pisa/Stony Brook group is using a large hodoscope almost entirely surrounding the intersection region to make precise measurements of the total cross-section of high energy proton-proton interactions. To this end, the group is measuring the over-all number of interactions while, simultaneously, in R 802 measurements are being made of the small-angle elastic scattering rate. The total cross-section is deduced from these two measurements.

The Pisa/Stony Brook group is also studying correlations between charged secondary particles and correlations associated with the emission of high transverse momentum photons detected with the aid of lead-glass Cherenkov counters.

In collaboration with the R 802 and R 803 groups, studies are also being made of the correlations associated with negative particles and neutrons produced at 0° and charged particles produced at 90°.

R 802: Here, a CERN/Rome collaboration is working on the production of negative or neutral particles emerging at angles close to 0°. For this experiment, one of the ISR magnets has been replaced by a reversed-yoke type and modifications have been made to another magnet to allow a special vacuum tank to be fitted. The spectrometer used comprises three independent movable parts which can be controlled by an on-line computer, so that the desired position can be pinpointed to within less than 0.2 mm. It consists of wire chambers, scintillators, a septum magnet and large Cherenkov counters. The installation is supplemented by a neutron counter arranged on the 0° line.

This team has worked together with the R 801 experimental group on the total cross-section measurements, on correlation studies and on verifying the Feynman scale invariance laws, the dynamic mechanisms of hadron reactions. A search has also been made for quarks at 0°.

R 803: This is a United Kingdom/Scandinavia/MIT collaboration on the study of particles produced at 90° with low transverse momenta. The installation comprises a small single-arm spectrometer consisting of an analysing magnet, wire chambers and two scintillation telescopes.

The team is making a special study of the behaviour of the pp differential cross-section when particles like kaons, pions and protons are produced with transverse momenta which become very low.

Another type of study is the comparison between the production of charged and neutral pions. It is also possible, with this installation, to investigate the production of photons and particles which decay into two oppositely charged particles.

Together with the R 801 experiment group, this team is also studying the correlations associated with a particle produced at 90°.

Around the Laboratories

ARGONNE
Present machine and experimental programmes

The high energy physics programme at the Argonne National Laboratory has been under financial pressure for several years now. As at other USA Laboratories budgets have been falling for the past five years, in addition to the effects of inflation. Nevertheless Argonne is succeeding in turning on something special in order to sustain the vitality of its research programme.

The programme continues to be a very active one and if anyone chooses the criterion of the ratio of published papers per invested dollar, Argonne would even come out on top. There are about 300 users and about half of them are active in the Laboratory research programme at any one time. Nevertheless, the present budget is some 30 % below the figure which would make it possible to operate high energy physics research at the Laboratory somewhere near optimum.

In fiscal year 1975, which began on 1 July, the budget is $ 13.8 million and this implies that the 12.5 GeV Zero Gradient Synchrotron, ZGS, on which the research programme is based, can only be operated for six or seven months in the year. This time will probably be divided into one or two months of running for neutrino experiments in the 12 foot bubble chamber, two months for 12.5 GeV physics, one month for 10 GeV physics and two months for experiments with polarized proton beams.

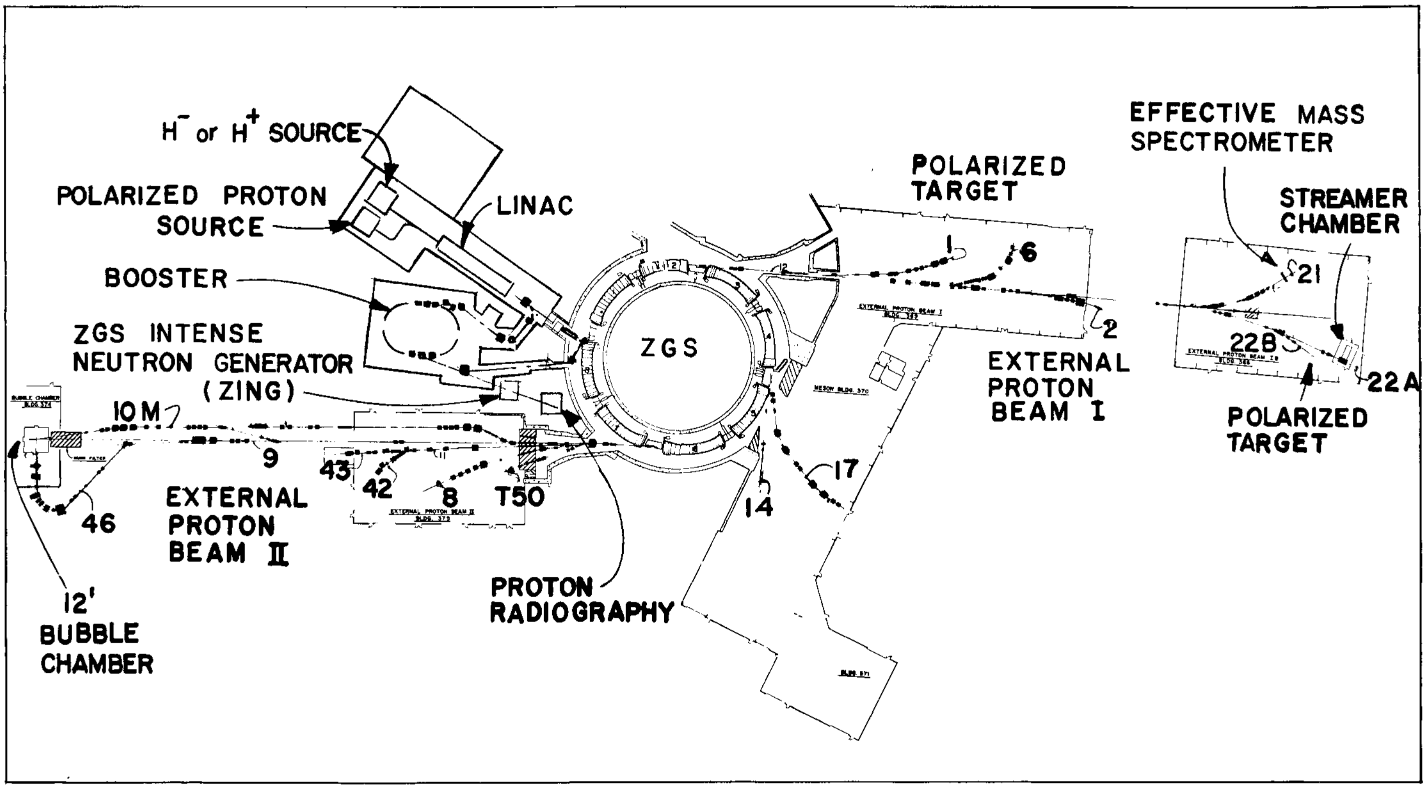
At present, it is the polarized proton beams at GeV energies, particularly, which are the 'something special' that Argonne is able to provide. It is possible to study particle interactions knowing the spin of the incoming proton and, when polarized targets are also used, the spin of the target particle. This gives unique handles to grasp some aspects of what is going on in the interactions.

In 1972, the ZGS had a major refurbishing with the installation of a titanium vacuum chamber to replace the original epoxy chamber. The new chamber makes it possible to incorporate pole face windings to give additional control of the accelerated beam and added abilities in terms of the beam ejection systems. Though the full design potential of the refurbished machine has not yet been reached, the performance has been progressively improved since 1973. The peak intensity, at 3.8 × 10^{12} protons per pulse, is over 25 % up on the previous value and the machine has operated for more than a year at 2.5 × 10^{12} average. Reliability has been as good as ever (91 % in 1973). Ejected beam efficiencies have not been as high as anticipated. Using a two thirds resonance, it was possible to eject simultaneously down two different channels and efficiencies up to 50 % were achieved on slow ejection (more difficult from a zero gradient machine than from an alternating gradient machine). However, beam control was poor and there was, at times, a lot of structure on the ejected beam. Work on the ejection system is continuing.

Recent developments have included building a separate preinjector for polarized protons. At present the source can provide an average of 8 μA with 73 % polarization (this is already much better than the initial plans for 4 μA with 65 % polarization). A peak of 12 μA has been reached and it is believed that as high as 50 μA could be feasible. Up to 10^9 polarized protons are fed onto the targets in the experimental areas (better control of the ejection systems should take this higher). So far, peak energy has been held at 6 GeV, mainly for financial reasons, but the experimentors have found quite enough to keep them busy at these energies. It should not be difficult when the requirement arises, to take polarized protons to the full machine energy of 12.5 GeV since no machine resonances as troublesome as those already conquered are expected above 6 GeV. Full energy polarized protons are planed for FY 1976.

Another foreseen improvement is to bring beam into another straight section of the ZGS ring for injection. This will enable negative hydrogen ions to be fed in which should increase the injected intensity since stripping the negative ions in the ring itself to give protons, slides around the restriction on how much beam of a given emittance can be taken into an accelerator of a fixed acceptance. With normal proton beams at present, 35 mA are fed to the ring during 100 μs with the field rising at 1.8 T/s resulting in an average capture efficiency of 30 %. It is intended to feed in the negative ions during 400 μs with the field rising at 0.5 T/s with an efficiency of about 85 %. Only 2 mA of negative ions will be needed from the linac to equal the present injection performance with protons. Already 2 mA have been taken through the linac and, since then, the output performance of the negative hydrogen ion source has been doubled.

A negative hydrogen ion source is now regularly on tap and this will aid another machine improvement which has been going slowly over the past few years because of lack of manpower and of regular opportunities for testing. This is the booster programme designed to increase ZGS intensity by increasing the injection energy into the ring above the 50 MeV available from the present linac. Tests began using a prototype 200 MeV booster, previously the 2 GeV electron synchrotron at Cornell, fed with



negative ions. Unfortunately it was never possible up to now to carry out tests when the ZGS was running with protons and this has delayed booster development considerably. A few times 10^{11} protons have been accelerated in this booster but several times higher than this are needed for the ZGS ring.

It has, however, provided excellent experience of the potential of negative ion injection and, based on this experience, a 500 MeV machine, called booster II, has now been designed and funded. The magnet steel and copper is on order and it is hoped that it will be in action for the ZGS in 1976.

Very interesting byproducts of the booster programme include the proton radiography reported in the September issue (page 303).

Another is the use of proton beams of several hundred MeV to generate pulsed high fluxes of thermal and epithermal neutrons. Tests were carried out ploughing the 200 MeV beam into heavy element targets surrounded by a moderator. Pulsed neutron fluxes four times those of the input proton intensities were recorded, to the delight of solid state physicists. It is intended therefore to build ZING (ZGS Intense Neutron Generator) in association with the new booster to give even more copious neutron pulses at the rate of 30 Hz for solid state research.

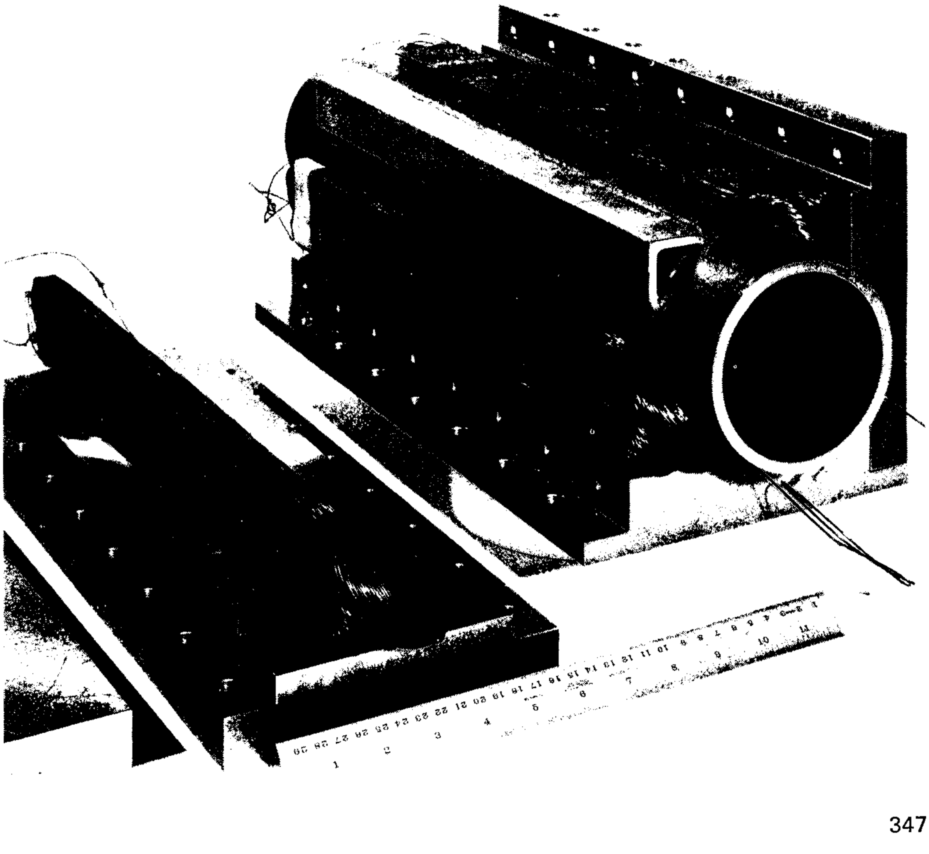
To conclude the story on the accelerator, a long term project is the development of superconducting magnets intended for use in a 'stretcher ring'. The idea is to pass the full energy ZGS beams into a ring of superconducting magnets where they would be stored and could then be drawn off to the experiments at leisure (see June issue, page 204). The Superconducting Stretcher Ring, SSR, requires 3 T bending magnets (dipoles) and 2.25 T/cm quadrupoles. These are comparatively modest fields for superconducting magnets and in addition the magnets need not be pulsed. The requirements are, therefore, less stringent than those being pursued by most superconducting synchrotron aspirants. So far, ten dipoles and five quadrupoles have been wound; this is enough for five SSR modules of which 48 are needed for a full ring. Two dipoles and a quadrupole have been built into a module cryostat for tests; simple magnet construction techniques have been developed at the Laboratory so that the coils for a full module can now be wound within four weeks.

Dipole performance usually reaches about 3.4 T with some training. Wire of 1 mm diameter, with 400 niobium titanium superconducting filaments 24 μm diameter in a copper matrix, is wound in a coil with distributed ends capable of giving field uniformities (including the ends) at the 1 in 10^3 level over 75 % of the aperture. It is intended to complete and test five modules by the middle of next year. Funding for the SSR has, however, not yet been accepted into the budgets; it is estimated that about $ 5 million would be needed including $ 2 million for the ring itself.

Three elements of the present programme of experiments merit particular mention — the polarized proton experiments, the 12 foot bubble chamber and the Effective Mass Spectrometer. The physics interest in using polarized beams continues to grow. Some experiments are building up more statistics to check, or make more precise, the very interesting data which has emerged from the work so far. There are experiments on cross-sections with polarized beams, on polarization effects in inelastic scattering, on measuring the polarization of the recoil proton and on parity checks with longitudinally and transversely polarized protons on a variety of nuclei.

Polarized proton beams have also been sent to the Effective Mass Spectrometer and to the 12 foot bubble chamber. The very fruitful physics programme of the 12 foot bubble chamber continues in full vigour. Until the advent of the 15 foot chamber at the FermiLab and BEBC at CERN, the 12 foot held pride of place as the world's largest volume chamber for many years and was the pioneer of the new generation of big bubble chambers. It has operated with remarkable

The layout of the Argonne Zero Gradient Synchrotron and its experimental halls. The article describes the present operation and development of the accelerator and covers some items in the experimental programme.



A superconducting quadrupole such as is being built for model tests with a view to a superconducting stretcher ring at Argonne. Note the simplicity of the construction techniques which have been developed. This is an important aspect of the project since costs have to be kept very low.

reliability and its large superconducting magnet, providing 1.8 T in the chamber volume, again a pioneer of its type, has been completely trouble-free. Recent activity with the chamber has been as follows:

A polarized proton run was concluded in May. There was then a very successful test run with a hydrogen-neon mixture (34 % neon) in further preparation for experiments with a track sensitive target installed. The aim of the TST scheme (as described many times before, see for example vol. 13 page 377) is to combine the simplicity of hydrogen as a target liquid with the particle identification abilities of a heavier liquid such as the mixture. It is intended to begin experiments with a hydrogen target volume installed within the chamber filled with hydrogen-neon mixture early next year. A high pressure dewar for the neon is now being installed at Argonne.

The TST experiments are a collaboration between physicists from Argonne, CERN (where the idea originated), Japan (from where the neon is being supplied) and Rutherford (where most experience with these targets exists). Four experiments have been approved — runs with 12 GeV protons, 8 GeV negative pions, stopping antiprotons, 6 GeV positive pions. 3 and 5.7 GeV antiproton and 12 GeV polarized proton runs have also been proposed.

After the hydrogen-neon mixture tests, the chamber was refilled with deuterium and had a two week run with neutrinos in July. This was intended to be the last of a series of runs taking 1.5 million pictures for neutrino physics. The beam has been equipped with a two horn focusing system to point the pions and kaons towards the chamber before they decay into neutrinos. Unfortunately, a leak developed on the omega shaped expansion bellows in the chamber and only a portion of the pictures were taken. The seal has been rewelded in place and the chamber is due back in November for a second instalment of a 1 million picture experiment with 6.5 GeV negative kaons from an r.f. separated beam for a high statistics study of meson and hyperon resonance production and decay. A 300 000 picture experiment will use stopped antiprotons from a new electrostatic separated beam. The neutrino experiment will resume in December.

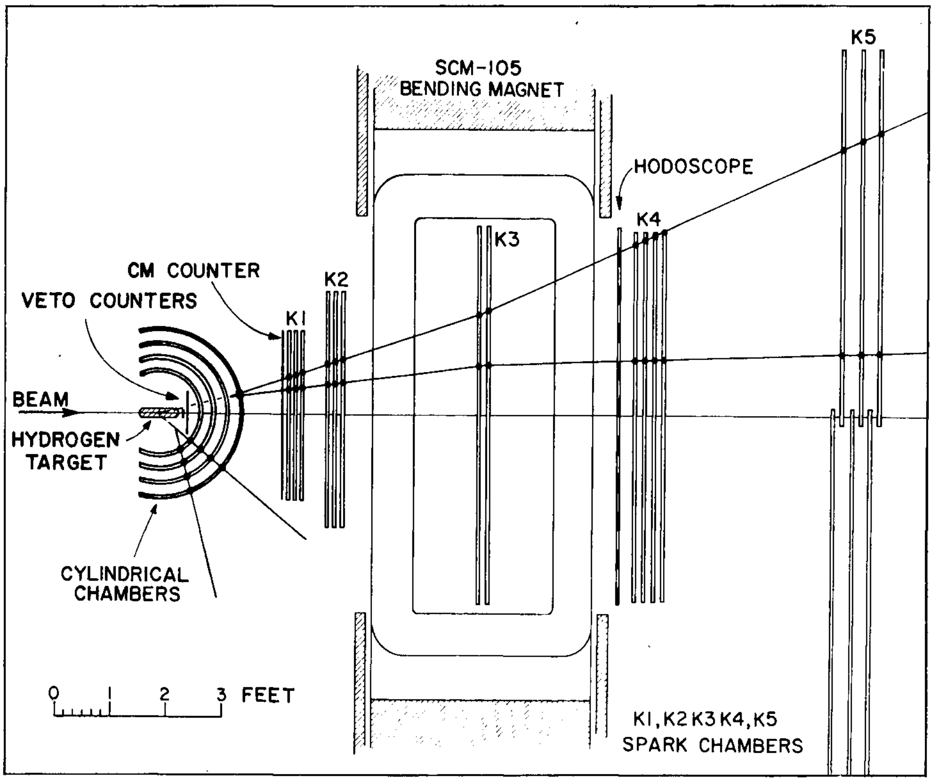
The Effective Mass Spectrometer is a multipurpose detection system capable of easy adaption to accommodate different target geometries and triggering signals. It is built around a large aperture magnet with arrays of magnetostrictive spark chambers detecting the forward going particles. Four threshold Cherenkov counters identify the incoming beam particles (which can have a momentum up to 6 GeV/c). Various detector arrays can surround the target, giving different triggers, and there are wire planes before, inside and beyond the magnet aperture with scintillation counters for triggering and, finally, a large Cherenkov counter. The system is on-line to a EMR 6050 computer.

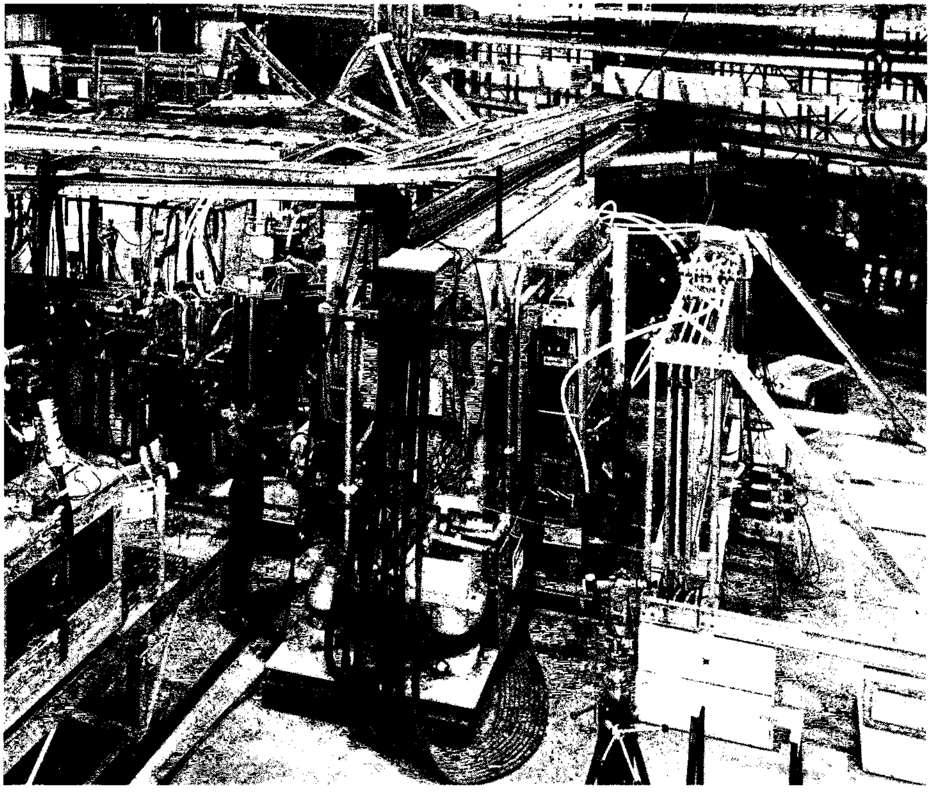
Since it came into action for physics towards the end of 1971, the EMS has catered for thirteen experiments. For example, over 400 000 events of negative pion-proton interactions giving two pions and a neutron are being analysed for a rich crop of information including omega-rho interference, pion-pion scattering, etc... Data was also taken with positive pions interacting with neutrons in a deuterium target and compared with the negative pion-proton. This gives a beautiful demonstration of 'interference' between the omega and rho particles. We are used to light waves and even diffracted electron beams interfering so

Schematic view of a layout for an experiment with the Effective Mass Spectrometer. The detection system can be completed by a large Cherenkov counter following the K5 chambers.

The spectrometer itself. Beam approaches from the left. The large aperture bending magnet is in the centre of the photograph and the downstream chambers are easily distinguished on the right. The Cherenkov was not in use in the experiment under way and has been rolled back out of the picture.

(Photos Argonne)





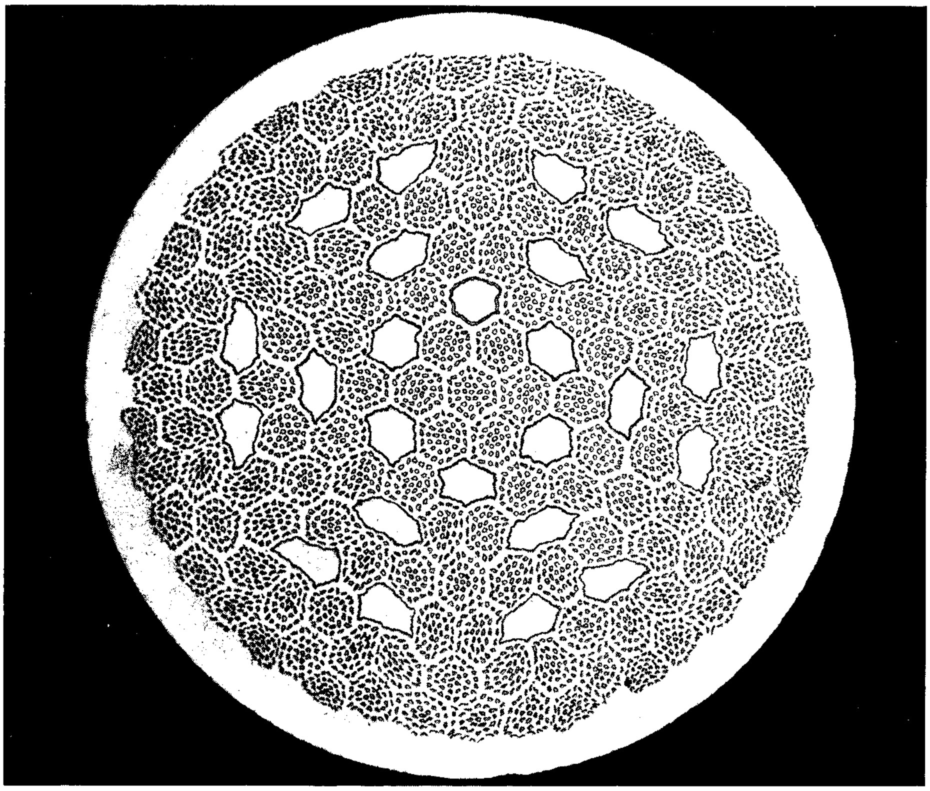
that their amplitudes reinforce or diminish one another. Exactly this effect in the two pion decays of the omega and rho are seen by the EMS. In the negative pion-proton case the amplitudes add to give a sharpened peak on top of the bump showing the two pion mass distribution. In the positive pion-neutron case the amplitudes subtract and give a depression at the top of the bump.

Recently the polarized proton beam was used with the EMS to gather data on the interaction giving a proton, a neutron and a positive pion with knowledge of the spin of the incident proton. An indication of the power of the system is that two hundred thousand good events were collected in the first few days of spectrometer operation.

Other experiments at the ZGS include a study of the beta decay of hyperons. The lambda decay has already been examined and the sigma minus is now being tackled using a spectrometer with multiwire proportional chamber and spark chambers in a large aperture magnet. Other experiments have examined the possibility that polarized protons may also enter this picture as a source of polarized hyperons. Another detection system is a large streamer chamber where, in addition to conventional streamer chamber experiments, interactions giving a coherent recoil helium nucleus will be studied.

It will be obvious from this report that the Laboratory is sustaining an interesting research programme. It is supplying experimental possibilities not available elsewhere and has long term plans to improve further the research potential. It also has both eyes open to the applications of particle beams in other fields. The question is the availability of money for adequate funding of the various competing high energy physics programmes in the USA.

Another cross-sectional view of the niobium-tin conductor which has given such hopeful results at Rutherford. This time the magnification is 80 times and shows a complete conductor cross-section with 5143 filaments, about 5 μm in diameter, of niobium-tin (in circular groups) within a bronze matrix. There are also 24 hexagonally shaped regions of pure copper to help curb instabilities and to take the brunt of quench effects.



RUTHERFORD
Let's hear it for niobium-tin

Very promising results with niobium-tin superconductor were obtained by the Rutherford/Harwell team in September. With a 30 mm bore solenoid of filamentary niobium-tin they reached a magnetic field of 12.25 T in very good agreement with the 'short sample' test.

Learning how to handle niobium-tin is one of the big challenges of the technology of superconductors. The rewards would be great. First of all, it can take very high current densities (around 2000 A/mm^2 compared with around 800 A/mm^2 for the more common niobium-titanium) giving higher magnetic fields (say 10 T compared with 4.5 T) without losing its superconducting property. Secondly, it can provide higher fields while operating at higher temperatures. It can thus be used in magnets with a greater margin of temperature stability rather than operating on the hairy edge of temperature stability as is often the case for niobium-titanium.

The problem is that niobium-tin is a very brittle material and there is no obvious way of building coils incorporating fine filaments such as are needed for pulsed superconducting magnets. Strains of much less than 1 % are sufficient to break niobium-tin filaments. The trick that a few groups are trying (including, for example, the Brookhaven team of W.B. Sampson with the help of metallurgist M. Suenaga) is to arrive at niobium-tin by a solid state route after having formed the magnet.

In the method used by the Harwell/Rutherford people (J.P. Charlesworth, V.W. Edwards, D.C. Larbalestier, J.A. Lee, P.E. Madsen, C.A. Scott, M.N. Wilson) the conductor begins life as a composite of niobium rods in a copper-tin bronze. By normal mechanical drawing techniques this is reduced to wire size. It is insulated with glass fibre braid and wound on a stainless steel former in the required magnet coil configuration. The coil is then popped in a vacuum furnace and cooked at around 700°C. A reaction process takes place and tin diffuses from the bronze into the niobium forming a layer of niobium-tin alloy at the interface. In this way niobium-tin in filamentary form is produced in required coil configurations.

With the high current densities offered by niobium-tin, care has to be taken to protect the magnet when a quench occurs (the superconductor going normal). This has been done by incorporating regions of high purity copper (protected by an inert barrier to limit contamination when the conductor is cooked) into the conductor. The copper helps take away heat and is a low resistance shunt when the coil quenches.

Using these ideas, a series of coils have been produced. The latest one is a solenoid which has about 1 kg of niobium-tin superconductor with the parameters indicated in the photograph caption. It gave a field of close to 10 T, when powered by itself, which climbed to 12.25 T in a background field of 6.5 T from a niobium-titanium coil.

There is still a lot of research to be done to optimise the technique and to become convinced that the method gives magnets which will survive the rigours of accelerator environments. Nevertheless, it does look as if the 'wind and react' trick works. The next moves are to build larger magnets both of solenoid and of 'saddle' (such as are used in bending magnets) configurations. The results will be of great interest.

LOS ALAMOS
LAMPF preparing for second assault

In a similar way to the FermiLab having the first crack at a new energy range for high energy physics experiments, the Clinton P. Anderson Los Alamos Meson Physics Facility has the first crack at a new range of nuclear physics experiments. The advantage of their 800 MeV proton linear accelerator, LAMPF, is predominantly in the intensity of the particle beams it can furnish for the study of nuclear phenomena. It has recently been joined as a 'meson factory' by the cyclotron of the Swiss Institute for Nuclear Research (see September issue, page 301) and the Canadian TRIUMF cyclotron (June issue, page 215) is not far behind. LAMPF is, however, already having a first look and is preparing for a 'great shutdown' in which the accelerator will be tidied up ready for the second assault with still higher intensities. The great shutdown is scheduled to begin at the end of this year with the experimental programme opening up again around June 1975.

The machine has been described in detail in our pages before (vol. 8, page 132). Its major features are — twin preinjectors so that protons and negative hydrogen ions can be accelerated at the same time; a 100 MeV Alvarez type linac; subsequent acceleration to 800 MeV in a Los Alamos-invented side coupled cavity linac; switchyard dividing accelerated particles into a variety of experimental areas. The first full energy beam was achieved in June 1972 and we begin this report of the present status of LAMPF with a review of the machine performance, problems and plans.

The average accelerated current is about 10 μA with a duty factor of 5 %. It is fed to about six experiments simultaneously and as many as nine beam-lines could be fed at the same time. (Eventually as many as twelve beam-lines could be in action at the same time — thanks to savings on the accelerator itself, the experimental areas have some four times their initial design potential.) Reliability has been erratic during the past year with an overall average of about 65 %. Despite these limitations in performance, the experimental targets can already be fed with beam at an intensity a factor of a hundred higher than has been available before from the cyclotrons normally used for nuclear physics. The ultimate aim is for beams of 1 mA (900 μA of protons, 100 μA of negative hydrogen ions) to be accelerated with a duty factor of 6-12 % and this is ten thousand times beyond pre-meson factory intensities.

The major problems which are holding back the climb to higher currents are imprecise machine alignment, difficulties in achieving optimum settings for the r.f. amplitude and phase and the inability, as yet, to handle much higher intensities in the experimental areas. They are all to receive attention during the great shutdown.

The 100 MeV linac section will be completely realigned. It appears that the initial positioning went adrift in using laser alignment techniques over distances which were sufficiently long for refractive index effects to produce faulty readings. Both optical and magnetic techniques will be used in the realignment and, prior to the side coupled linac section, further magnets will be set so that the emerging 100 MeV beam is correctly aimed along the axis of 800 MeV section which is slightly offset vertically with respect to the first section. This is no hindrance to transmitting the full beam once the matching has been achieved. The realignment is, however, vital to enable positive and negative beams to be accelerated at the same time.

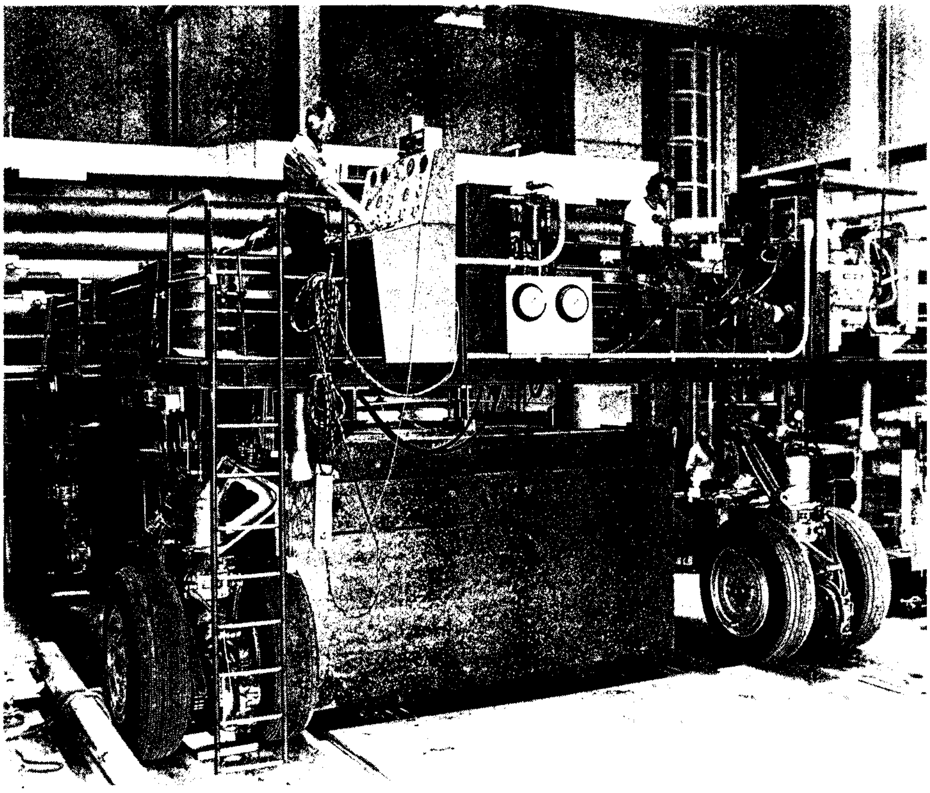
The second difficulty has been to achieve and maintain near optimum settings of the phase and amplitude of the r.f. accelerating voltage experienced by the particles as they travel down the linac. This is obviously no easy task since, in a sense, there is an injection problem at each module along the machine where the accelerating kick has to be given at just the right time and with just the right strength to reach the next station when that is correctly lined up for its kick. Achieving the correct r.f. settings has proved to be a hard task requiring patient adjustments working progressively along the machine.

Even this is a successive approximation approach since oscillations induced in the beam by an incorrect setting may only become obvious several modules later leading to much gnashing of teeth. In addition, it has not proved possible, for reasons unknown, to achieve good settings and then to re-establish them by pressing a memory button on the next run. One source of error, which has thrown the settings some way from the theoretical predictions, is that the length of the modules is as much as 2.5 mm (in 18 m) away from specification. Precise module length was not expected to be so important.

During the great shutdown more beam monitoring instrumentation will be installed to help the machine setting problem. Computer control has been an invaluable help (or, to quote the machine specialists, 'We would be dead without it'). Considering that LAMPF pioneered complete computer control of an accelerator, this is a fine achievement. The computer makes it possible to set about three hundred of the crucial operating parameters (and some six hundred others of less importance) in a few minutes. It can also do a lot of 'number crunching' on-line and greatly eases the training of machine operators. There is still room for improvement in the computer programs and, as more effort can be turned on to this, the contribution of the computer to machine operation will increase.

A consequence of the alignment and setting difficulties is that about 1 % of the particles are spilled out of the beam as it travels through the linac. Most of these particles continue through the machine and emerge in an uncontrolled fashion into the beam switchyard region. Up to now the resulting induced radioactivity has not been very troublesome but, until the spill is reduced to a lower percentage, it is not useful to push for much higher intensities. As an example of what can happen, mis-steering a 10 μA beam for a short time brought the surface of a flange to a radiation level of 200 rad.

Most experiments have been content with the 10 μA beam during this first period of machine operation but the heat is now on to take the



Servicing heavily irradiated components is a major problem at the meson factories. LAMPF's answer is Merrimac. It rolls across the top of concrete shielding to the 'hot' zone which needs attention, carrying a 200 ton shielded box on its gantry. The box is lowered hydraulically through the opened up shielding and work can be carried out using a manipulator and a 5 ton hoist. The whole assembly can be controlled remotely using a duplicate control box (seen hanging from the ladder). Aircraft buffs may recognize the B52 undercarriage.

intensity higher rather than to build up more hours with the existing intensity. Hence the great shutdown during which LAMPF is expected to be brought into shape to accelerate 100 μA beams with, possibly, a shot at still higher intensities if all goes well. At the same time, it will be necessary to rebuild much of the experimental areas to cope with the extra particles and steel and concrete shielding will abound.

We can now move on to the experimental programme at LAMPF where the variety of the research is much greater than at high energy physics Laboratories. On the one hand, this is a natural consequence of the energy range under investigation — it is an energy range which was the 'high energy' physics of the previous generation of accelerators. This uncovered the gross features of nuclear behaviour and it is for the most part the detailed behaviour which the meson factories will now reveal while high energy physics moves on to explore the individual particles of the nucleus. Knowing features of nuclear behaviour, and having experience of this energy range, enables us to exploit the nucleus in a variety of ways such as is not yet possible with particles around the highest energy synchrotrons.

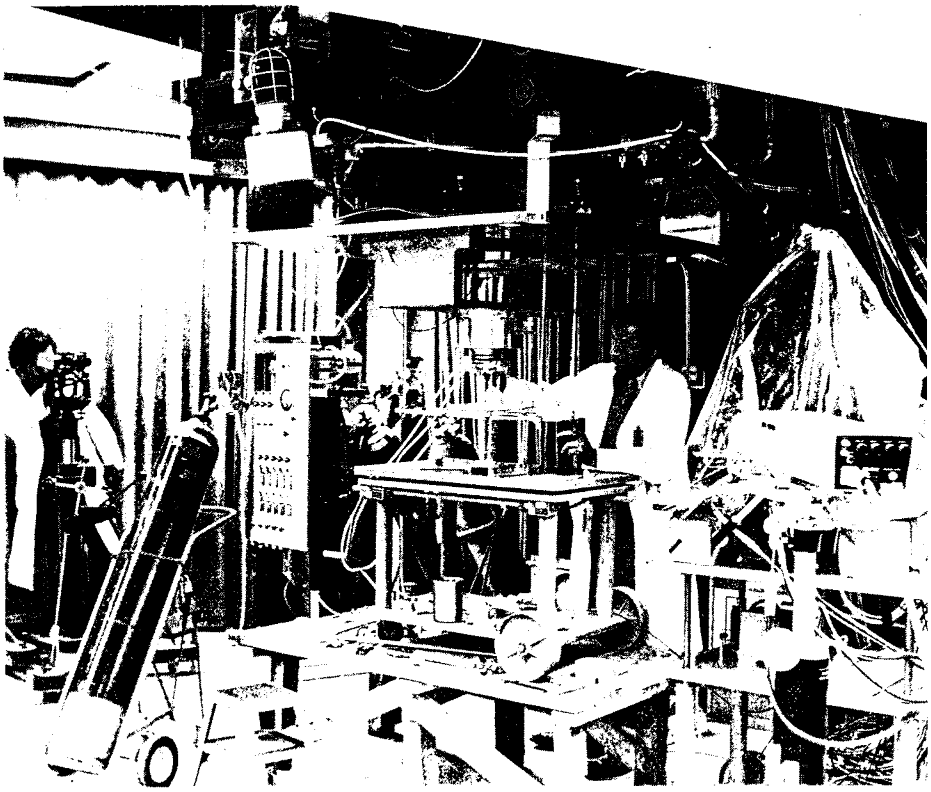
On the other hand, the variety of the research programme is a reflection of the concern of the LAMPF Director, L. Rosen, who has consistently sought for ways of using what is principally a 'pure research' instrument to attack some of the present and near future problems of society at large. Thus the programme includes nuclear physics, particle physics, solid state physics, atomic physics, nuclear chemistry, isotope production and radiotherapy.

At the moment the available beams are a low to medium energy pion beam of high quality which can send particles to two experimental set ups, a medium energy pion beam also feeding two stations, a muon beam of high quality also feeding two stations (a low quality pion arm is being added), a highly monochromatic neutron beam derived from sending the proton beam onto a deuterium target, a nuclear chemistry beam where fragments from nuclear reactions in thin targets can be measured by time of flight, a proton beam, an irradiation beam for isotope production, a low energy pion beam for biomedical studies and a neutrino beam (feeding three experiments) derived from the stop at the end of the beam.

Nuclear and particle physics experiments include studies of pion total cross-sections (Los Alamos/Montana/Washington), pion induced deuteron disintegration (Los Alamos/North Carolina/Virginia), forward elastic scattering of pions on various nuclei (Rice-Houston), beta decay of the pion (Los Alamos/Temple), studies of neutron spectra from protons on deuterons which yielded the excellent neutron beam (Los Alamos/New Mexico/Texas), muonium formation in noble gases (Heidelberg/Wyoming/Yale) which is continuing by a study of the hyperfine structure of muonium (Yale), mu mesic X rays (Cal Tech/Los Alamos/Yale), studies of highly excited nuclear states (Carnegie-Mellon), test of parity conservation in proton-proton scattering (Illinois/Los Alamos) studies of neutrino scattering (UCI) of lepton conservation in neutrino interactions (Yale) of neutrino detection using tetrachloroethylene to check the ability to detect neutrinos as used in the underground solar neutrino experiment (Brookhaven), etc...

In the not too distant future, it is anticipated that the bulk of the nuclear physics research programme will be taken over by two monster spectrometers — HRS (High Resolution Spectrometer) and EPICS (Energetic Pion Channel and Spectrometers). HRS will be capable of accepting, on to its target, protons of energy from 300 to 800 MeV. It will be fed by the negative hydrogen ion beam stripped to protons (enabling the beam emittance to be tailored) which are steered to the target, the beam being twisted through 90° before reaching the vertically mounted spectrometer. The beam-line is complete to this point where it enters the large domed building which houses HRS.

The spectrometer will have three large magnets — quadrupole, dipole, dipole — with a mean radius of curvature of 3.5 m. They will make it possible to analyse protons up to 800 MeV with 1.4 T in the magnets, deuterons of 800 MeV with 1.8 T and tritons of 635 MeV with 1.9 T. The hoped for energy resolution is a few times 10^{-5} (pin-pointing energy to better than 30 keV in 800 MeV). This is better than has been achieved before — the nearest rival being on the Saturne



Inside the biomedical facility at LAMPF. It receives pion beams for radiological research and for the treatment of cancer. The first clinical radiation is tentatively scheduled for October.

(Photos Los Alamos)

accelerator at Saclay (see vol. 12 page 134). Very precise measurements will then be possible on the incoming proton and one outgoing particle after the target. The possibility of also catching a second outgoing particle has been left open and there is room for an additional spectrometer at some later stage.

At the present time, HRS is in the painstaking phase of magnet shimming. This is, of course, crucial since it dictates the resolution which will ultimately be possible from the spectrometer. Enough money to concentrate on bringing HRS into action has been made available for the first time this fiscal year and it is intended to have construction complete by the middle of 1975. A long series of experiments have been proposed.

EPICS is an all singing, all dancing facility for experiments with pions such as has never been built before. A comparable system is designed for the SIN cyclotron in Villigen. The aim is for good energy resolution (better than 50 keV) and good angular resolution (better than 10 mrad). The incoming pion beam will be of high intensity, so that it will be possible to investigate interactions with low interaction probabilities, and can be of a wide range of energies (from 50 to 300 MeV). The beam-line incorporates a separator to prevent protons contaminating the pion beam onto the target.

Construction is proceeding in phases. Item 1 is the pion beam-line which is expected to be complete by the middle of 1975. Item 2 is a low momentum spectrometer capable of handling up to 670 MeV/c. A physics programme, with EPICS in this phase, will then be possible. Item 3 is an additional high momentum spectrometer capable of handling up to 1000 MeV/c which will extend the initial physics programme and make it possible to measure two particles emerging from the target. As with HRS, a long series of experiments is already envisaged.

For the nuclear chemistry programme a large number of target irradiations have been carried out, averaging about fifty (and many of those multitarget irradiations) in a three months' period. For the isotope production programme, the first shipment of a radioactive isotope was made at the beginning of August. 120 microcuries of strontium 82, produced by bombarding a molybdenum target with 800 MeV protons, was delivered to a Denver hospital for clinical studies. The strontium isotope has a half-life of 25 days and decays to rubidium 82 with a half-life of 75 s; it is the rubidium isotope which willl be used in the hospital since its short life limits the radiation exposure of patients. LAMPF will become an isotope factory as well as a meson factory providing large quantities of radioisotopes for diagnostics and treatment.

For the biomedical programme the beam-line tuning started in May. With present machine operating characteristics, pions at the dose rate of about 5 rad per minute are available.

The properties of the pion beam have been carefully studied and dosimetry measurements taken ready for the first patient irradiation which has been tentatively scheduled for October.

The purposes of the biomedical facility are to support a clinical programme for cancer treatment and to carry out basic radiological research. The field of radiology has opened wide beyond the traditional X ray irradiations with the new possibilities of producing, from accelerators, controlled beams of heavy ions, protons, neutrons and pions. Each particle type has particular irradiation characteristics in its favour (from amongst relative biological efficiency, oxygen enhancement ratio, depth dose, etc...) and clinical experience is needed to select the type or types which are likely to become standard hospital facilities. LAMPF will be one of the first in the field.

The LAMPF Users Group, who have interests in this broad experimental programme, has over a thousand members. Of these about a hundred on average will be at Los Alamos participating in experiments at any one time. The Users Group has taken a very active part in the evolution of the project and continues to have input to the LAMPF Director via a Technical Advisory Panel and via members of the Programme Advisory Committee. LAMPF is a national research facility and two thirds of the experimentors are from outside Los Alamos itself. There is also strong international participation (about 12 %) which may well grow stronger as exchanges get under way when SIN and TRIUMF also become fully operating meson factories.

Before leaving Los Alamos, mention should be made of some of the Laboratory's work in superconductivity. We reported in the September issue that the FermiLab intends to build and operate superconducting energy transfer and energy storage systems. Los Alamos has research and development programmes in both fields.

The latest advance in the work on the transmission of electrical power is to deposit a layer of niobium germanide (Nb_3Ge) on a metallic substrate, the superconducting layer being sufficiently thick to carry high currents. The significance of this achievement is that it confirms that niobium germanide retains its superconducting property in bulk (previous thin film tests were made at Westinghouse and Bell Laboratories). Niobium germanide goes superconducting at about 22 K and thus the much cheaper and more abundant liquid hydrogen (at 20 K) rather than liquid helium (at 4 K) could be used for cooling the cable. During tests at 17 K a sample at Los Alamos carried currents equivalent to 60 kA/cm^2 without loss.

The interest in large superconducting coils as energy stores began at Los Alamos about eighteen months ago with the same 'load levelling' aims for the power industry, that were described last month, in view. Progressively larger coils are being built — now in the 100 kJ to 1 MJ energy storage range using niobium-titanium superconductor on a copper/copper nickel substrate. The possibility of using superfluid helium for forced flow cooling, as in the CERN Omega spectrometer magnet, is being investigated so as to push the operating temperature down to 1.8 K. Ultimately, power networks will need stores in the 10^{14} J range but stores of about 10 MWh could already be very useful to cope with small scale power fluctuations that a generator cannot easily follow because of its response time. This application is being kept in mind in planning the next steps at Los Alamos.

BERKELEY/STANFORD PEP Summer Study

A PEP Summer Study (sponsored by the Lawrence Berkeley Laboratory, the Stanford Linear Accelerator Centre and the Associated Users of Western High Energy Accelerators) was held from 5 to 30 August at Berkeley. The first week was a multi-participant jamboree to mull over the new range of physics that would become available with the construction of the 15 GeV electron-positron colliding beam facility called PEP. The Study was then attended by 192 high energy physicists in an atmosphere of keen interest stimulated not only by the attraction of the proposed research but also by the enthusiasm of the many young physicists who took part in the discussions.

For the following three weeks, sixty physicists (including ten from Europe) stayed to get to grips in more detail with some of new ideas. The goals were to define the types of physics experiments which could be done with this machine, to specify parameters of the experimental systems, and to determine what logistic support would be necessary to conduct such experiments.

The physics that could be attacked at PEP was examined by twelve subgroups. In the (intentional) absence of directive, they discussed creative approaches to the general categories of total and inclusive hadronic cross-sections, two photon processes, tests of the validity of quantum electrodynamics down to distances of 10^{-16} cm, searches for heavy lepton and W boson pair production, use of polarized beams and searches for asymmetries in particle production due to interference effects between weak and electromagnetic interactions.

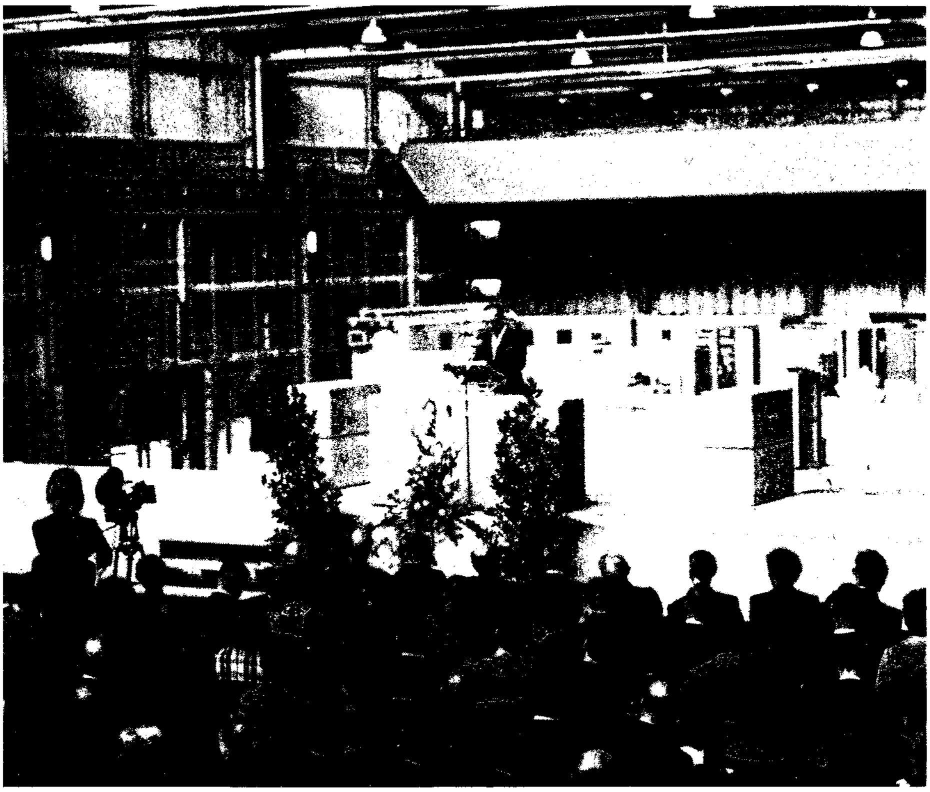
Particular attention was given to specifying a variety of detectors, including toroidal magnets, superconducting magnets, gamma ray detectors, streamer chambers, calorimeters and other ingenious devices. They varied in weight from 10 to 13 000 tons, incorporating from 20 to 1200 counters! All recommended systems fit into a 20 m intersection region and many into a 10 m intersection region.

Reports on many of these topics will emerge in some 35 papers to be included in the PEP Summer Study proceedings, which will probably be available about mid-November. This intensive effort is firming up the project which it is hoped will be given the green light in the President's budget for Fiscal Year 1976.

DUBNA Synthesis of element 106

Work on producing the heavy element 106 has been going on for several years at Berkeley, Dubna and Oakridge. The Dubna experiments were led by G.N. Flerov and since the spring of this year a radically different method, proposed by Yu.Ts. Oganesyan has been used, and is giving very interesting results.

The traditional method of producing new heavy elements consists of exposing targets of the heaviest available elements (such as plutonium or californium) to accelerated multiply charged ions. The relatively high excitation energies of the com-



The Swiss Institute for Nuclear Research (SIN) was inaugurated in a ceremony on 4 October. The Laboratory and its research facilities were officially opened by Bundesrat H. Hürlimann, seen in the photograph addressing an invited audience and SIN staff in the main experimental hall. Other speakers were C. Seippel, President of the SIN construction commission, J.P. Blaser, Director of SIN and W.K. Jentschke, Director of CERN Laboratory I.

(Photo SIN)

pound nuclei produced in such collisions give only very small cross-sections for the required reactions. A disadvantage of the method is that there is a high background from the fission of the target material and from the spontaneously fissile uranium to californium isomers which are also produced. Thus the decay chain of a new element is often difficult to unravel from many other decay chains in action.

The new technique aims to avoid the high background by using stable 'magic' nuclei, lead or bismuth, as targets and bombarding them with accelerated ions of mass greater than 40 atomic units. The use of lead or bismuth instead of highly fissile elements considerably simplifies the experiments, eliminates background and makes it possible to use a high sensitivity, rapid method of detecting new nuclei by spontaneous fission. These advantages were clearly evident in the experiments carried out at the beginning of this year on the synthesis of two new isotopes of element 104 using lead bombarded by titanium.

A vital contribution to this work has been the ability to accelerate heavy ions. Titanium ions (and also chromium and vanadium ions) were accelerated for the first time ever with intensities of 2×10^{11} ion/s. A powerful ion source, of original construction, makes it possible to use the working material in the solid phase and thus to obtain multiply charged ions of practically all the elements in the periodic table.

The results considerably change ideas concerning the stability of heavy nuclei with regard to spontaneous fission. A marked increase in stability takes place (by a factor between 10^6 and 10^{12}) when nuclei have a number of neutrons, N, in the neighbourhood of 152. This is true even for californium, fermium and nobelium isotopes. This is practically non-existent however for element 104 isotopes and their half-lives increase smoothly when going from N = 152 to N = 156. This may be due to regularities in the variation of the fine structure of the fission potential barrier when the number of protons or neutrons varies by a few units.

The new method of synthesis seems to be highly efficient. The reactions Pb (^{40}Ar, 2n) 102 and Pb (^{50}Ti, 2n) 104 were shown to have approximately equal cross-sections. Chromium ions were then accelerated and the reaction Pb (^{54}Cr, xn) 106 was studied. In the $^{208,\ 207}$Pb + ^{54}Cr reactions a spontaneously fissile isotope with a half-life of 7.5 μs was detected; in the reaction with ^{206}Pb the yield of this isotope sharply decreased (by a factor of more than five). The contributions of reactions with emission of protons or alphas were studied theoretically and experimentally. It was shown that the yield of spontaneously fissile isotopes of elements 104 and 105 was negligible at the ion energies used. On the basis of the results and the new ideas concerning the classification of periods of spontaneous fission, it is concluded that the effect observed is due to the decay of element 106 in its uneven ^{259}106 isotope form which is produced in the reactions with the emission of two or three neutrons.

Experiments are now being carried out on the synthesis of other isotopes of element 106. It is hoped that the new method will also be successfully in the synthesis of heavier elements (108, 110) for which it will be necessary to use accelerated ions of the iron 58 and nickel 64 type.

BERKELEY
More on element 106

It is appropriate to report at the same time as the news of element 106 work at Dubna that the element producing factory at the Lawrence Berkeley Laboratory also continues to turn them out. Using the traditional method at the SuperHilac (see June issue, page 213) they accelerated oxygen 18 ions to manufacture an isotope of element 106 by bombarding a californium 249 target. A. Ghiorso and G. Seaborg announced the news on 9 September.

The isotope was seen, with a lifetime of 0.9 s, via its alpha decay (9.06 MeV) to element 104 which further decayed by alpha emission (8.8 MeV) to nobelium.

The experiment depended greatly on the purity of the special californium target prepared by K. Hulet and R. Lougheed. Atoms of 106 bounce out of the target and are swept by a flow of gas onto the rim of a wheel which revolves them in front of detectors where the alpha decays are measured.

PRECISION MONOLITHICS INC.

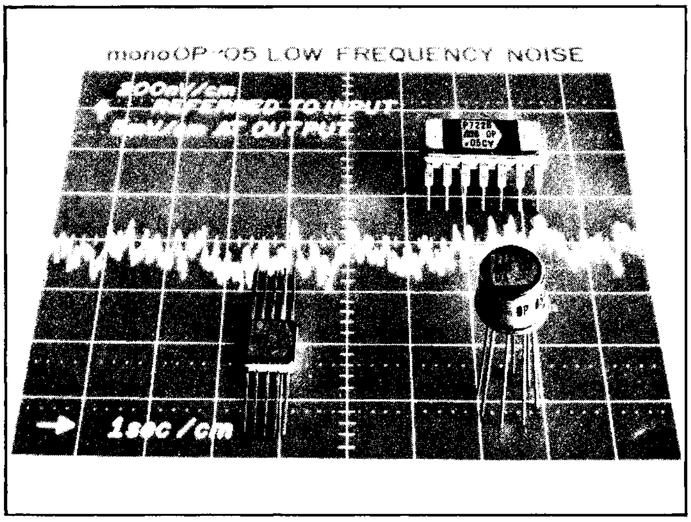
A BOURNS Affiliate

OP-05

INSTRUMENTATION OPERATIONAL AMPLIFIER SERIES

FEATURES:

Low Noise	0.6μV p-p Max. −0.1 to 10Hz
Low Drift vs. Temp	0.5μV/°C Max
Low Drift vs. Time	2.5μV/Month Typ
Low Bias Current	2.0nA Max
Low V_{OS}	0.15mV Max
High CMRR	114dB Min
High PSRR	100dB Min
High Gain	300,000 Min
High R_{in} Diff	30MΩ Min
High R_{in} CM	200GΩ Typ
High Slew Rate	0.25V/μsec Typ
Internally Compensated	Stable to 500pF Load
Easy to Use	Fully Protected
Easy Offset Nulling	Single 20kΩ Pot
Fits 725, 108A and 741 Sockets	
Completely Free of "Popcorn" Noise	

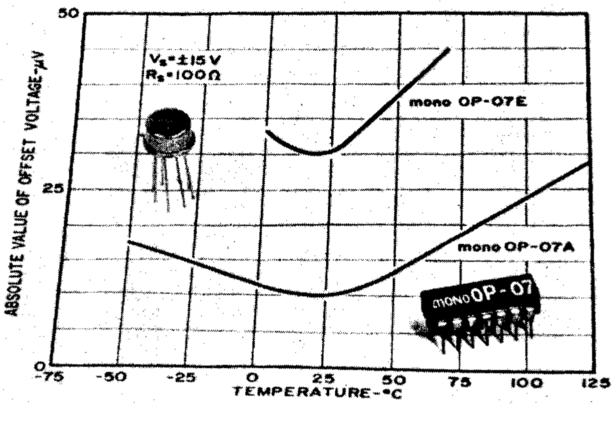


OP-07

ULTRA-LOW OFFSET VOLTAGE OP AMP SERIES

FEATURES:

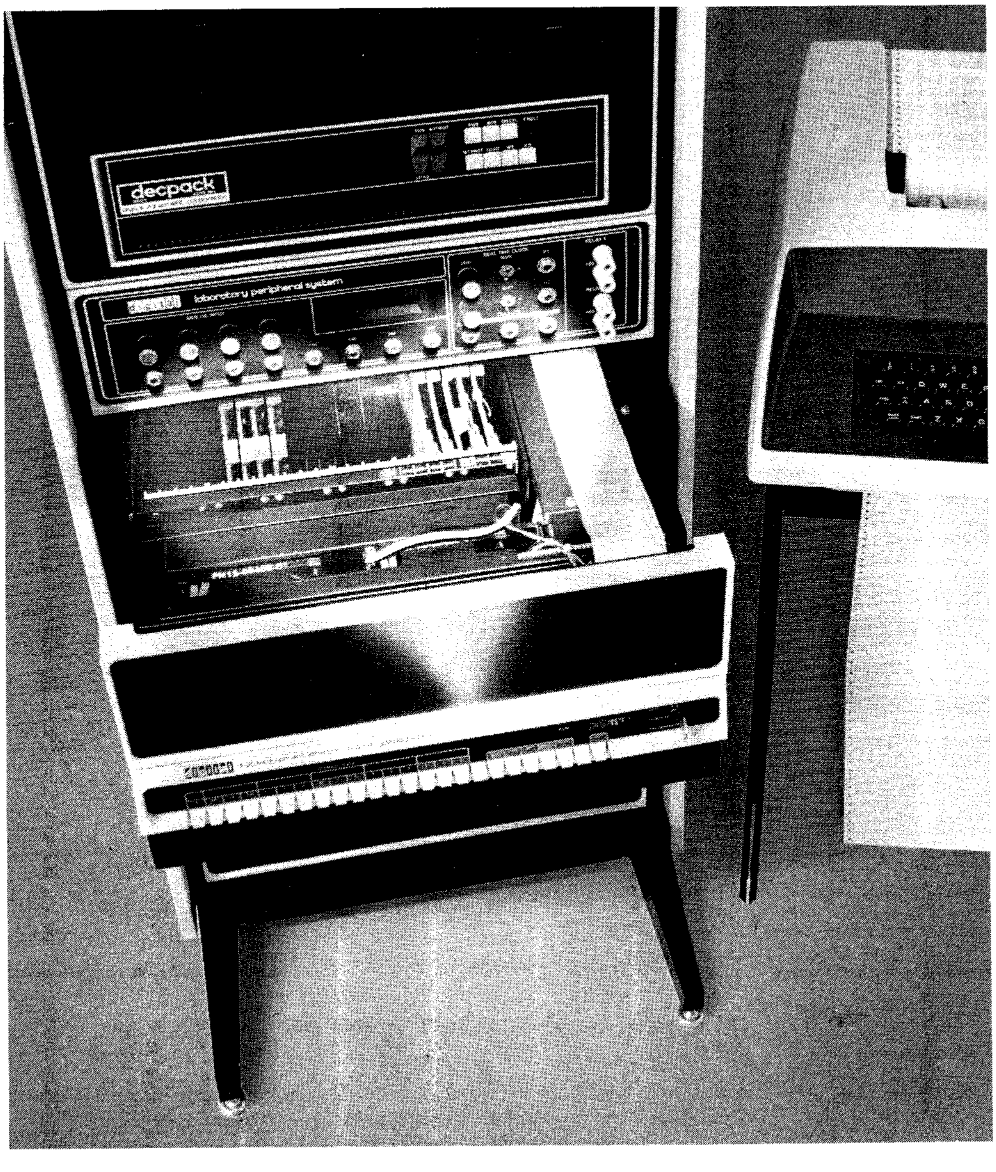
Ultra-Low Vos	10μV
Ultra-Low Vos Drift	0.2μV/°C
Ultra-Stable vs. Time	0.2μV/Month
Ultra-Low Noise	0.35μVp-p
No External Components Required	
Replaces Chopper amps at Lower Cost	
True Differential Input	CMRR-126dB
High Common Mode Input Range	±14.0V
Wide Supply Voltage Range	±3V to ±18V
Fits 725, 108A/308A, 741 Sockets	



PMI... LEADERS IN LINEARS!

BOURNS (Schweiz) AG **Baarerstrasse 8** **6301 Zug**
Tel. 042 23 22 42 **Telex 78 722**

Five new low-cost lab computer systems with a big heart.



Powerful low-cost systems. That's Digital's DECLAB-11/10 system family. Five generous hardware/software packages designated A through E. Priced from only S.Fr. 48.000 (S.Fr. 44.000*) to S.Fr. 119.000 (S.Fr. 107.000*). Capable of handling the research jobs you're likely to encounter without having to develop additional programs. And fully compatible so they'll expand as your needs grow.

Powerful low-cost heart. That's Digital's performance-proved 16-bit PDP-11/10 CPU. The heart of the systems. Now at a new low price. With 8K words of memory, line frequency clock, power fail and auto restart, serial line unit and paper tape software, just S.Fr. 24.800 (S.Fr. 21.000*). With 16K words, just S.Fr. 31.000 (S.Fr. 27.000*).

Wide hardware range. The DECLAB-11/10 family gives you a wide range of hardware options. So you can choose the right system to meet your price/performance needs. All systems include the PDP-11/10 processor with 16K words of memory. With a choice of paper tape, magnetic cassette or cartridge magnetic disk drive storage. And a hardcopy teleprinter or DECwriter.

Plus Digital's new AR-11 one-module real-time analog subsystem. The AR-11 features a 16-channel multiplexer, 10-bit analog-to-digital converter, programmable real-time clock and display controller. Or, if you want a more comprehensive analog subsystem, you can choose our LPS laboratory peripheral system.

Lab-oriented software. User programs for the DECLAB-11/10 systems are developed using Digital's unique Applications-11 library. A package of laboratory applications modules subdivided into five categories: data processing, data display, data analysis, data acquisition and interactive dialogue. The library can be used in conjunction with Digital's RT-11 and CAPS-11 cassette programming systems. In addition, BASIC and FORTRAN compilers are available.

Digital. Gets to the heart of your needs.

Please send me complete information about Digital's five new DECLAB-11/10 laboratory systems.

Name ______________________

Position ______________________

Company ______________________

Address ______________________

____

Telephone ______________________

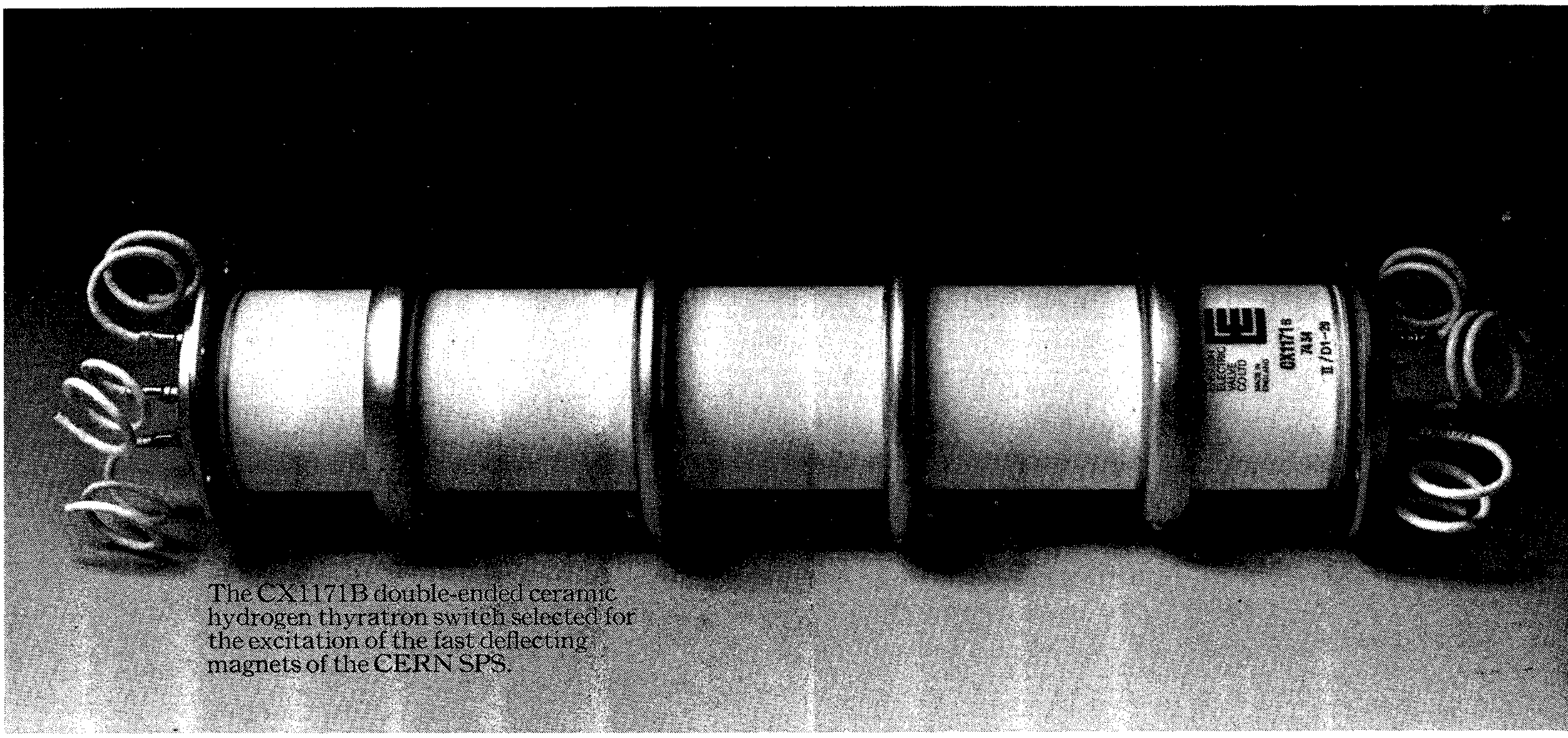
Digital Equipment Corporation
International (Europe),
81, route de l'Aire,
CH-1211 Geneva 26,
Tel. (022) 42 79 50.

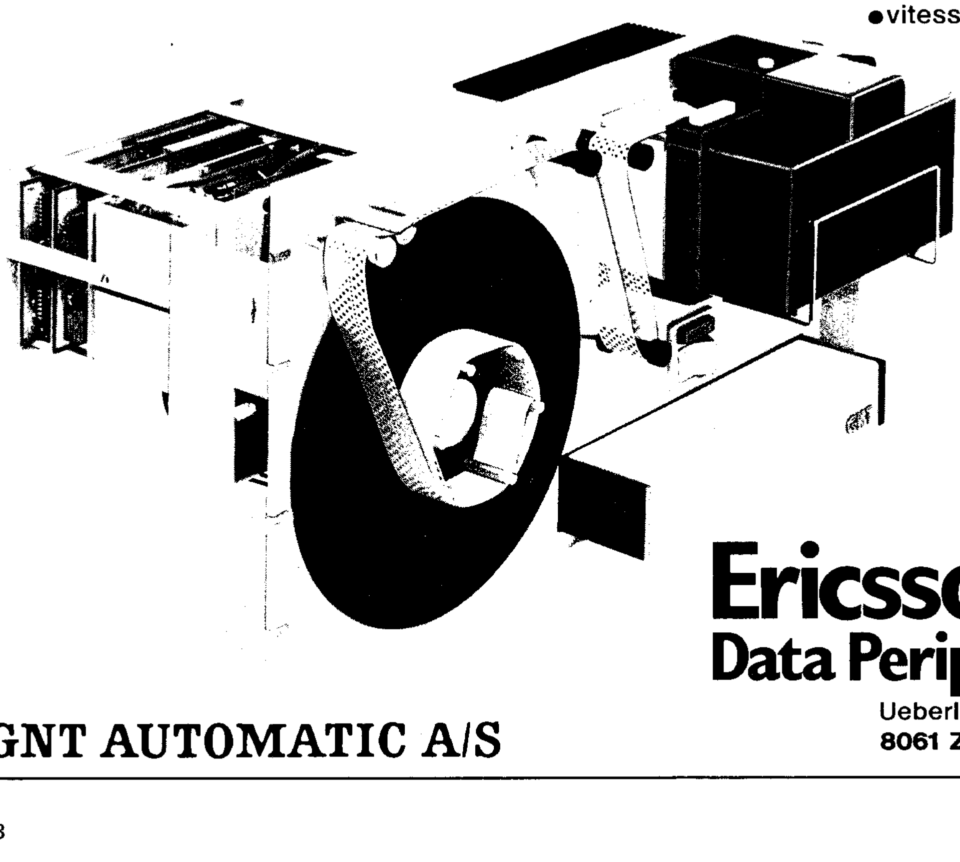
Cern

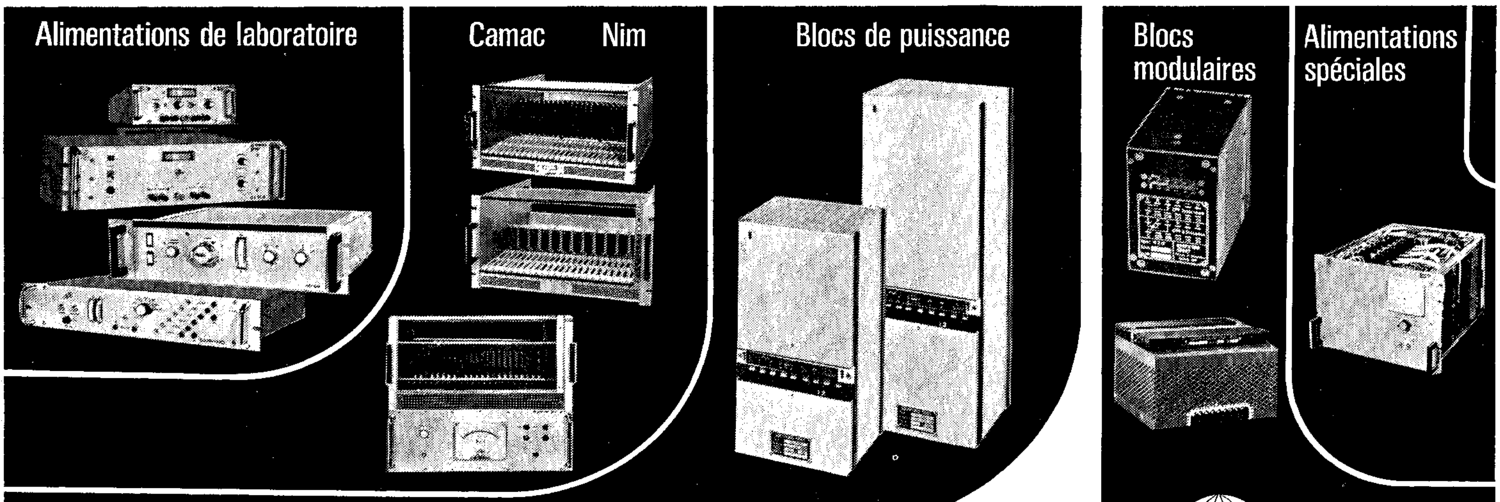
Offices in Reading, London, Birmingham, Bristol, Manchester, Edinburgh, Munich, Berlin, Cologne, Frankfurt, Hambourg, Hannover, Stuttgart, Vienna, Stockholm, Oslo, Copenhagen, Helsinki, Paris, Grenoble, Utrecht, Brussels, Geneva, Zurich, Milan, Turin.

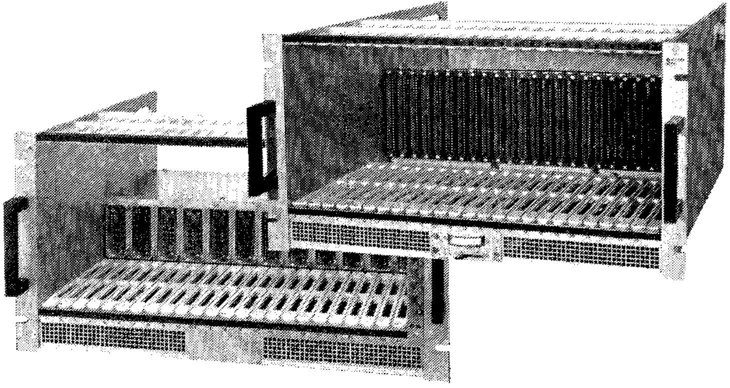
digital

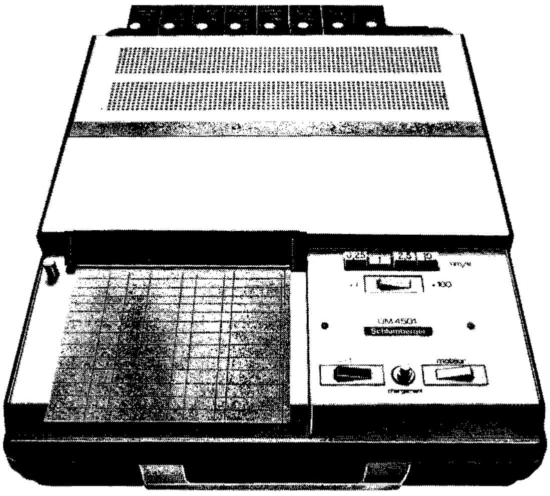
*Special price for nonprofit-oriented educational, medical and research institutions.

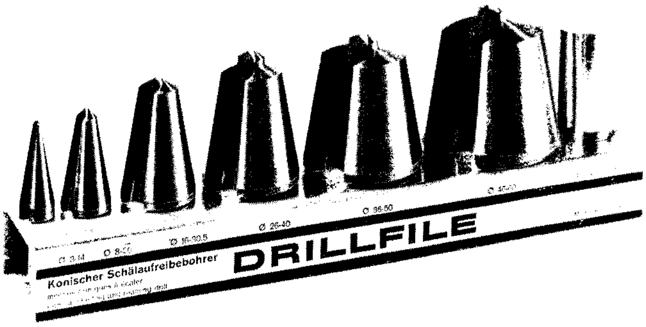




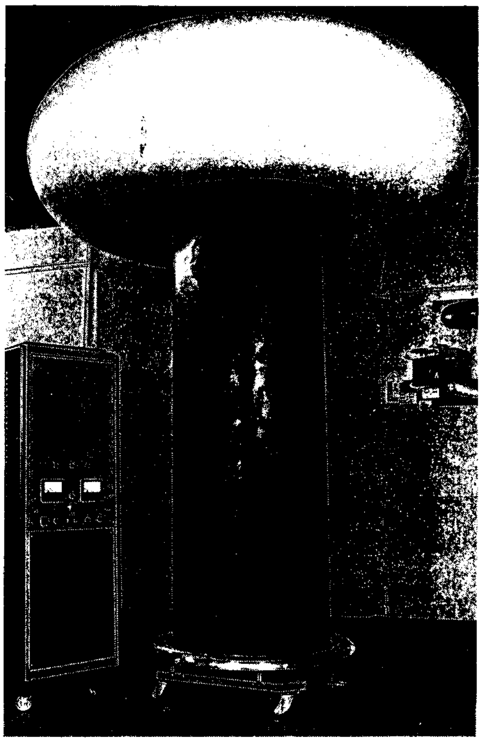

Alimentations de laboratoire
Camac
Nim
Blocs de puissance
Blocs modulaires
Alimentations spéciales

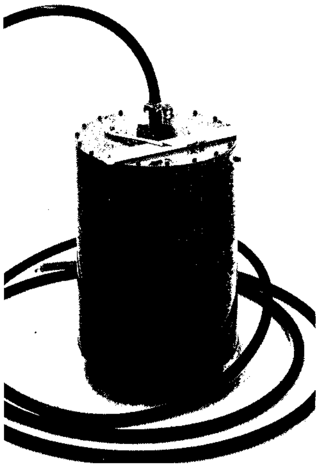




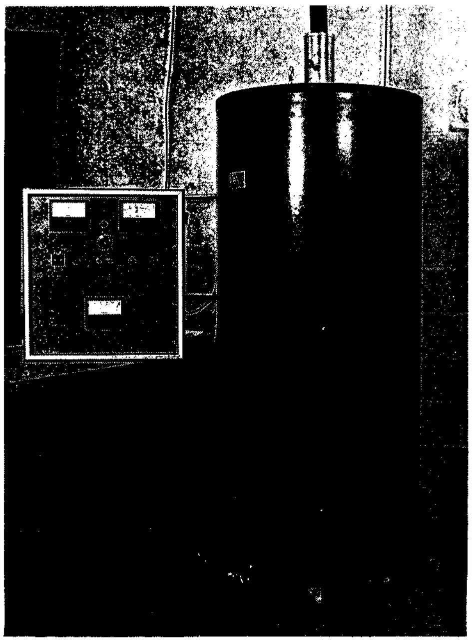

DRILLFILE
Konischer Schälaufreibebohrer

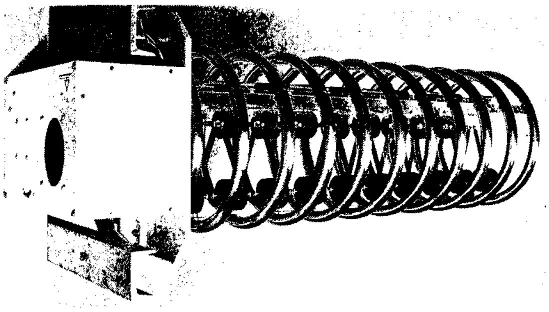
DELTATRON / HV POWER SUPPLIES 50 kV - 1.5 MV

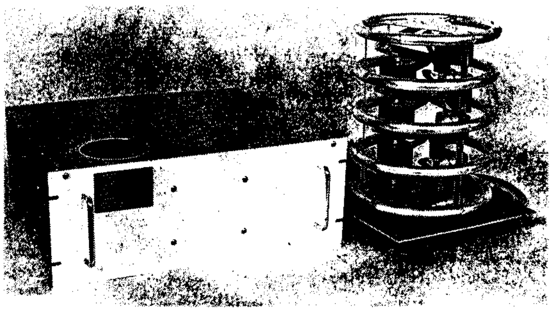

Model M1000-2A : 1000 kV, 2 mA


Model L150-2C : 150 kV, 2 mA

WRITE OR CALL
FOR OUR
TWENTY PAGE
CATALOG


Model L500-1.3C : 500 kV, 1.3 mA


Model S350-1A : 350 kV, 1 mA


Model S130-1A

APPLICATIONS

Electron and positive ion accelerator, ion implanters, x-ray generators, high voltage studies, electron microscopes and microprobes, lasers, isotope separators, insulation testing.

In two years, we have sold more than a hundred dc power supplies with voltages from 100 kV to 1.5 MV, which are setting new standards of precision. Consider the performance of the ultra stable 150 kV unit:

Deltatron Model L150-2C

Voltage:	0 - 150 kV
Current:	2 mA
Regulation:	0.001% line and load
Ripple:	0.001% peak-to-peak
Temperature Coefficient:	25 ppm/°C
Response Time:	<200 microseconds
Stored Energy:	5 J
Dimensions:	19" high x 12.75" diameter

Other features include built-in surge limiting resistors, overcurrent relay, zero start and customer interlocks, voltage control by ten-turn potentiometer or 0 - 10 V dc external signal, connection for digital voltmeter, polarity reversal, and plenty more.

Not all applications need such high stability, and others require more current; for these uses we have series S and series M units. Whatever your needs for dc high voltage may be, please contact us.

DELTARAY CORPORATION • South Bedford Street, Burlington, Mass. 01803 • 617-273-1513
A SUBSIDIARY OF HIGH VOLTAGE ENGINEERING CORPORATION

SWITZERLAND

Fritz Weber
In der Rehweid 8
8122 Pfaffhausen-Zurich

Tel. 01-85 44 44

GERMANY, THE NETHERLANDS, BELGIUM, DENMARK, NORWAY, SWEDEN

High Voltage Engineering (Europa)
Amsterdamseweg 61
Amersfoort, The Netherlands

Tel. (03490) 19741
TWX #84447275

FRANCE

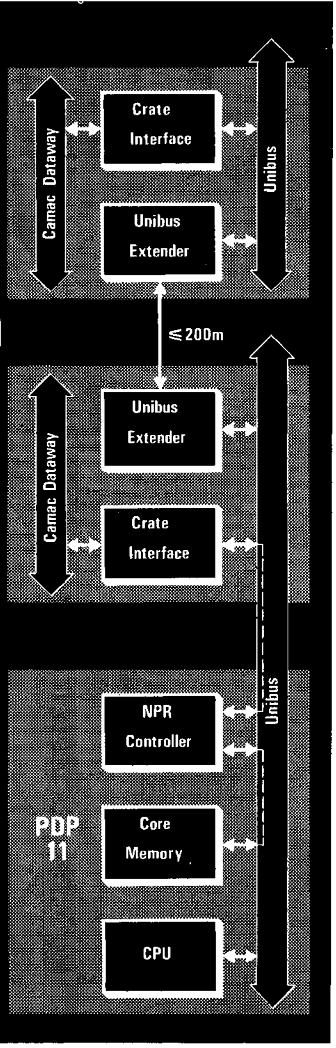
Radian
BP 410
94152 Paris Rungis

Tel. 686.34.28
Cable: MESTRA, Paris

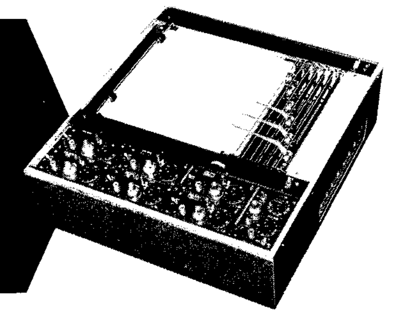
U.K.

Hartley Measurements Ltd.
HML House, London Rd.
Hartley Wintney
Hampshire RG 27 8RT

Tel. (025-126) 3126



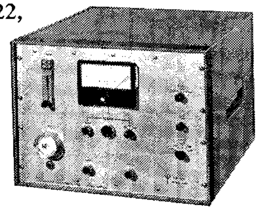
Camac Dataway
Crate Interface
Unibus Extender
Unibus
≤200m
Camac Dataway
Unibus Extender
Crate Interface
Unibus
PDP 11
NPR Controller
Core Memory
CPU

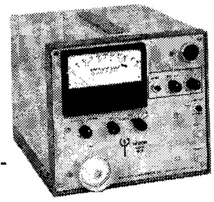


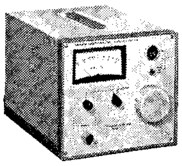
Reliability

...built into every instrument we make.

Beta Gas Monitors







TRITON systems monitor tritium, argon-41, carbon-14, chlorine-36, fluorine-18, krypton-85, radon-222, sulfur-35, xenon-133, xenon-135, and gamma radiation. Features: 0.5 micron absolute filters, electrostatic precipitators, positive displacement pumps, gamma compensation to 5mR/hour.

TRITON 955B — Highest sensitivity system: 10μCi/M^3 full scale for tritium. Highest sensitivity as a gamma area monitor: 0.05 mR/HR full scale. Particularly useful for industrial and reactor monitoring, as an analytical tool, and for H^3 and C^{14} tracer work generally.

TRITON 1055B for portability — A lightweight (less than 20 lbs.) battery-operated monitor whose size belies its sensitivity (50μCi/M^3, full scale). Features rechargeable nickel-cadmium batteries. The 1055 can be operated (and its batteries recharged) on standard line current. Has recorder output.

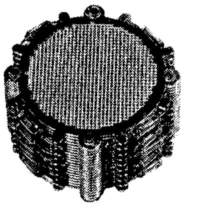
TRITON 1125 — Mil-spec quality. Portable, rugged, rainproof. 100μCi/M^3 full scale for H^3.

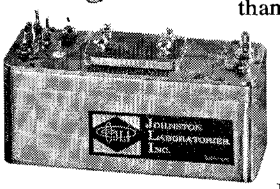
TRITON Calibrator (CL-1) and Remote Alarm (RA-1) — A calibrator (with enough tritium gas for 1000 or more calibrations) and a remote alarm (with both visual and audible systems) are also available.

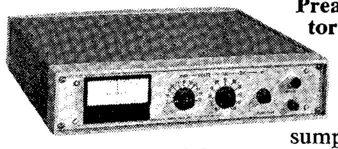
RADON SYSTEM for low-level analysis of radon samples from human respiration, mine, or water supply effluents, air. Includes Radon Concentrator (RCTS-2) which purifies, concentrates, and transfers samples to Radon Counter (LAC-2). Its scintillations produced by Radon gas are counted by photomultiplier in Radon Analyzer (LLRC-2)

NEW! ^{133}Xe MONITOR (MODEL 133). Protects lab personnel from accidental exposure to ^{133}Xe radiation. Reads 0.1 to 10 MPC of ^{133}Xe. Features large panel meter, audible and visual alarms, and a recorder output. This low-cost monitor provides reliable, unattended operation.

Particle & Photon Detection







Focused Mesh Multiplier Model MM-1 For use in mass spectrometers, electron and ion velocity analyzers, X-ray and vacuum U.V. spectrometers, and neutral particle experiments. Detects electrons, ions, protons, UV, X-ray photons, energetic neutral atoms and molecules. Guaranteed delivered gain. Typical electron gain: 10^6 at 2.5 kv., 10^7 at 3 kv./10^8 at 3.5 kv. Gain is stable with count rates in excess of 10^6 per second. No ion feedback or spurious pulses. Non-magnetic. Low noise: less than 1 count/minute at 10^7 gain. Ultra high vacuum operation: bakeable to 350°C. Rugged. Flight proven in many rocket launches. Size: 1.25" high, 2" diameter.

Model MM-2 Similar characteristics as MM-1 but only half the diameter (1").

Preamplifier-Amplifier-Discriminator (Model PAD) Rugged. Miniature. Charge sensitive input. Risetime: 3 nsec. Adjustable discriminator: 20:1 range. PAD-1: lowest power consumption. Pulse count rates to 10^5/second. PAD-2: for pulse count rates to 10^7/second.

Regulated High Voltage Power Supply (Model HV-4R). All solid state. Output: 500v to 6.1 kv. Low noise: less than 300 microvolts RMS. Low drift: less than 0.01%/hour, 0.02%/day. Lightweight. Rack mounted.

BACTEC*®

Bacterial Detection Systems

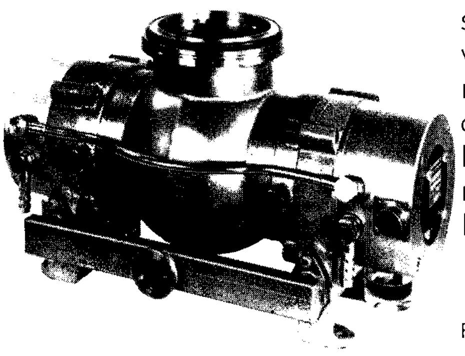
BACTEC Model 225, fully automatic; BACTEC Model 301, semi-automatic. For bacterial detection in clinical samples of blood, urine, spinal, synovial, and pleural fluids. And for sterility testing of pharmaceuticals, foods, drugs, radioisotopes and other products.

BACTEC Model R301. For research use as a radiometric Warburg apparatus for chemical, biochemical, or biological reactions and procedures in which a radioactive gas is released.

*Patented: U.S. No. 3,676,679
Other U.S. and foreign patents pending.

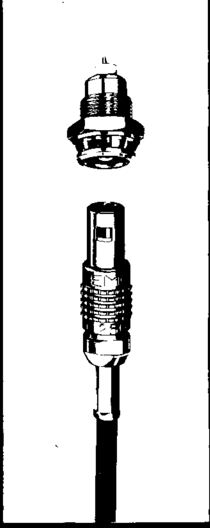
Johnston
Laboratories, Inc. JLI

3 Industry Lane, Cockeysville, Maryland 21030, USA
Phone: (301) 666-9500 Cable: "JOHNLAB"



LEMO SELF-LOCKING CONNECTORS FORM A SOLID BOND.

IMPOSSIBLE FOR THEM TO DISCONNECT ON THEIR OWN.



Our production programme

Connectors, unipole (1÷150 A). Connectors, coaxial (50-60-75-100Ω). Connectors, biaxial and triaxal. Connectors, high voltage (2-5-8-10-15-30 KV.DC). Connectors, multi-coaxial, multiple contacts, multiple high voltage. Connectors, combined, high and low voltage. Connectors, combined, coaxial and signal. Connectors, combined special. Connectors, for thermo-couples. Adaptors to connectors type: BNC-UHF-C-N-CONHEX-PET-Suhner-G. Radio, etc.

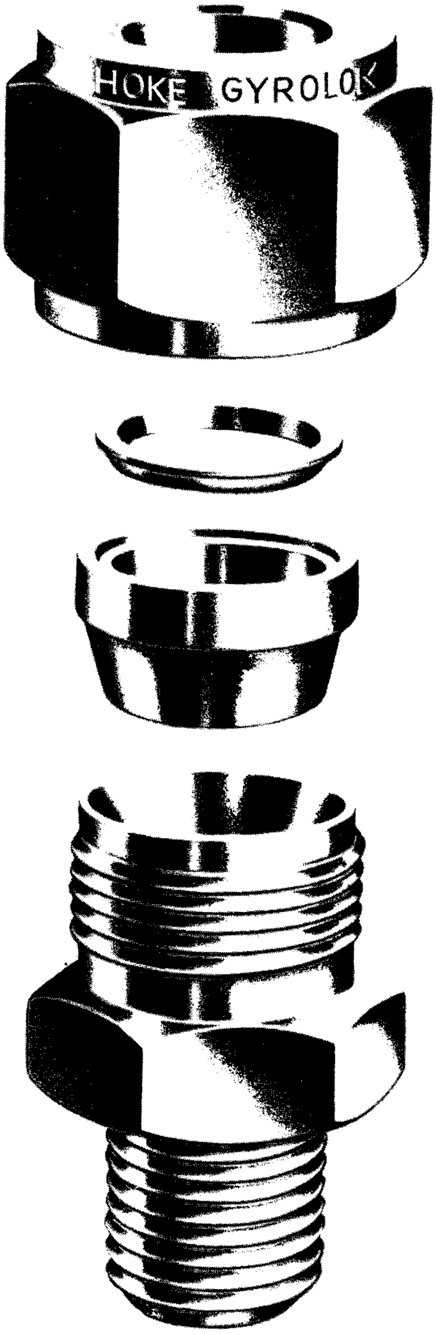
International connections:

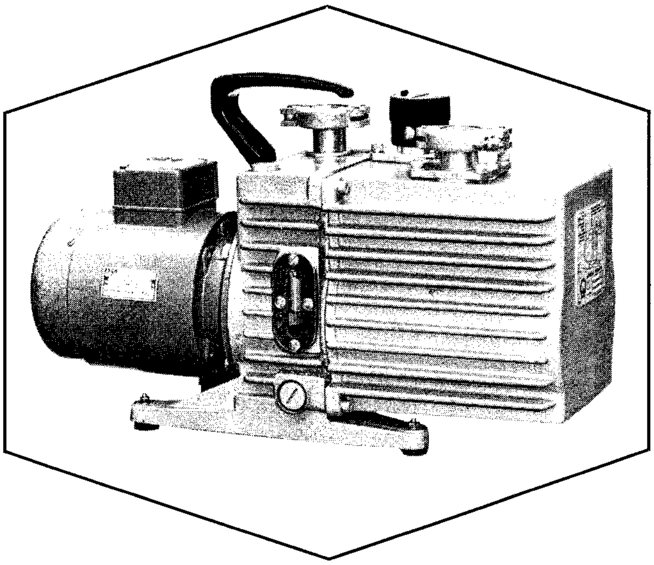
Germany: LEMOSA GmbH. Wernher von Braun Strasse 16. D-8011 Putzbrunn. **England:** LEMO U.K. Ltd. 6, South Street. Worthing, Sussex. **Austria:** LEMOSA GmbH. Postfach 703. A-1011 Wien. **Belgium:** Ets. Clofis Sprl. 539, Steenweg Brussel. B-1900 Overijse. **Denmark:** K. Kamuk A/S. Bredebovej 31. DK-2800 Lyngby. **United States:** LEMO USA, INC. 2015 Second Street. Berkeley, California 94710. **Finland:** Oy Chester AB. Uudenmaankatu 23 A. SF-00120 Helsinki 12. **France:** Jupiter S.A. Constructions électriques. 104, rue Garibaldi. F-94 Saint-Maur. **Holland:** Geveke. Elektronica en Automatie NV. P.O. Box 652. Amsterdam. **Italy:** LEMO Italia S.R.L. 10, via Calzecchi. I-20133 Milano. **Norway:** Henaco A/S. P.O. Box Okern. Oslo 5. **Sweden:** AB D.J. Stork. Humblegatan 32. Box 37. S-172 21 Sundbyberg 1.

LEMO S.A.

Electrotechnique

Tel. (021) 71 13 41 Telex 24 683 1110 Morges (Switzerland)

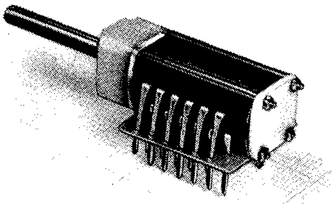

HOKE GYROLOK



SI VOUS AVEZ BESOIN D'UN COMMUTATEUR ROTATIF POUR IMPLANTATION DIRECTE SUR CARTE DE C.I. - CAPABLE DE FAIRE CE QUE FONT TOUS LES AUTRES COMMUTATEURS ROTATIFS - AVEC, CEPENDANT, LA PETITE DIFFERENCE QU'IL LE FAIT MIEUX, (ELECTRIQUEMENT ET MECANIQUEMENT) CAR SES CARACTERISTIQUES DE FIABILITE ET DE DUREE DE VIE SONT NETTEMENT SUPERIEURES....

.... VOUS DEVRIEZ EXAMINER DE PLUS PRES LE KR 10 DE R.E.S.

INUTILE DE CHERCHER PLUS LOIN - VOUS NE TROUVEREZ PAS MIEUX.



KR 10

C 86-1

Société anonyme

PRECIMATION

Rue de l'Hôpital 12 — 2501 Bienne
Tél. 032 223 223 Télex 34 222 preci ch

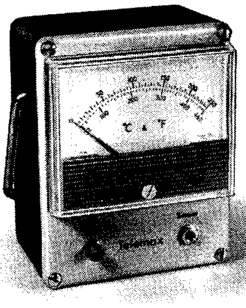
Commutateur rotatif conforme CCTU 08-03 B pour circuit imprimé • stator simple ou double • 3 galettes max. avec 12 positions chacune (total 36 circuits) • tension d'essai 1000 V CC/800 V 50 Hz • pouvoir de coupure 0,15A/150 V • isolement 10^6 Mégohms • résistance de contact 2 à 5 Milliohms • fréqu. de résonance 150 MHz • angle de perte 1 MHz tg $150 \cdot 10^{-4}$

S'IL VOUS ARRIVE FREQUEMMENT DE MESURER DES TEMPERATURES AUX ENDROITS LES PLUS DIVERS (ET PEUT-ETRE INACCESSIBLES) SANS QUE VOUS PUISSIEZ VOUS PERMETTRE DE PERDRE DU TEMPS INUTILEMENT....

.... VOUS AVEZ BESOIN D'UN INSTRUMENT AUTONOME, PORTATIF, ROBUSTE ET SURTOUT: A REACTION RAPIDE - TEL QUE LE TELEMAX DE TELEMECHANICS.

MALGRE SA BONNE QUALITE, NOUS L'OFFRONS A UN PRIX TRES MODERE. NOUS ESPERONS QUE CELA NE VOUS DERANGE PAS.

117 × 92 × 68 cm



TELEMAX

M 21-1

Société anonyme

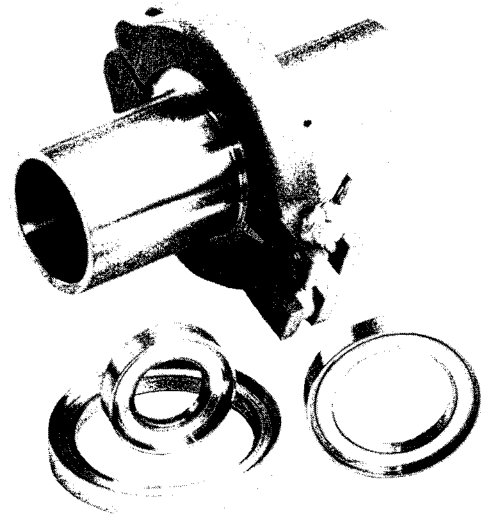
PRECIMATION

Rue de l'Hôpital 12 — 2501 Bienne
Tél. 032 223 223 Télex 34 222 preci ch

53 gammes de mesure entre −100 et +900° C • sondes à thermistor entre −100 et +160° C • sondes à résistance Pt entre −50 et +900° C • gammes spéciales entre 0 et 1100° C avec sondes thermocouples • précision 1% de la capacité • les sondes du même groupe sont interchangeables sans étalonnage supplémentaire

news!

All metal indium seals for small flange connections



They are interchangeable with the centring rings comprising an elastomer used so far.

They ensure perfect leak-tightness between small stainless steel flanges, as well as between those in light alloy.

As they are centred on the outside of the flanges, they can therefore fit flanges to the old NW 10 - 20 - 32 standards and to the Pneurop 16 - 25 - 40 range.

They are leak-tight as many times as required, even when using a standard clamp.

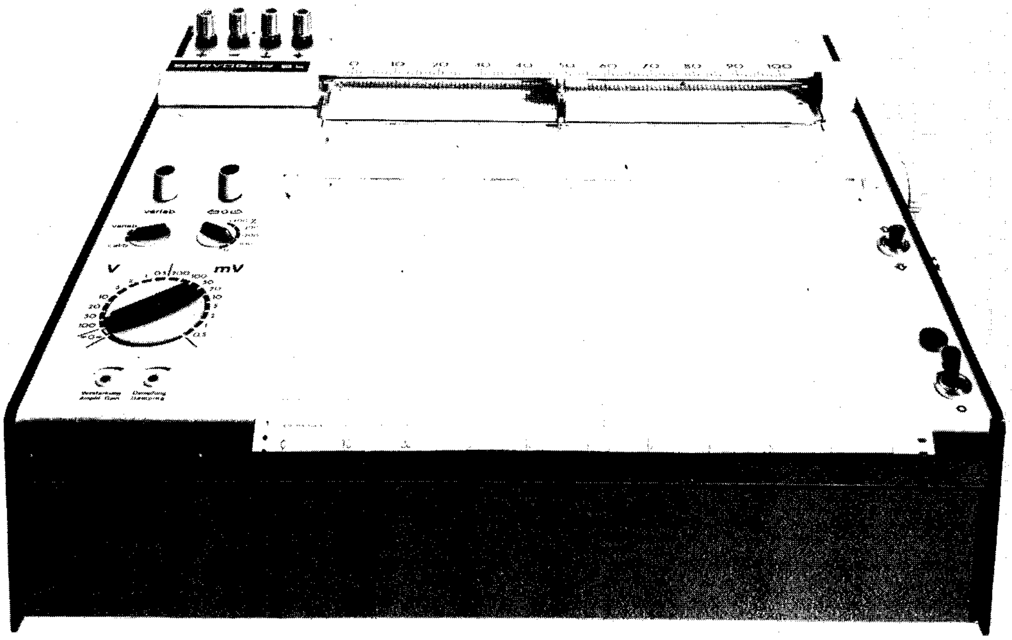
The sealing material being an indium/silver alloy, there are no leaks nor measurable degassing.

Unlimited resistance to radiations.

VAT AKTIENGESELLSCHAFT
für Vakuum-Apparate-Technik
CH-9499 Haag/SG, Switzerland
Phone: 085/7 15 85

Ein **breites** Programm zur Lösung Ihres Registrier-Problemes

Kompensationsschreiber
SERVOGOR® S

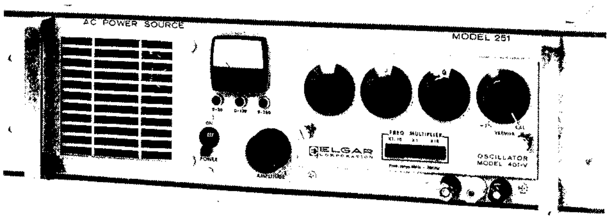


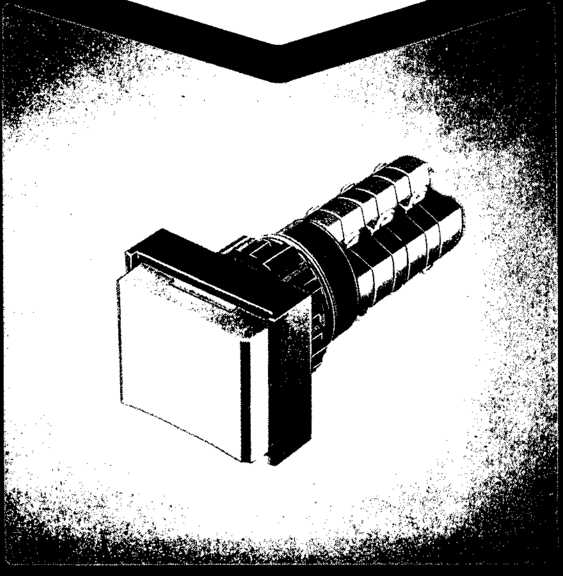
250 mm Schreibbreite
0,3 sek. Einstellzeit
0,25% Genauigkeit
Bitte verlangen Sie Liste B-8·13

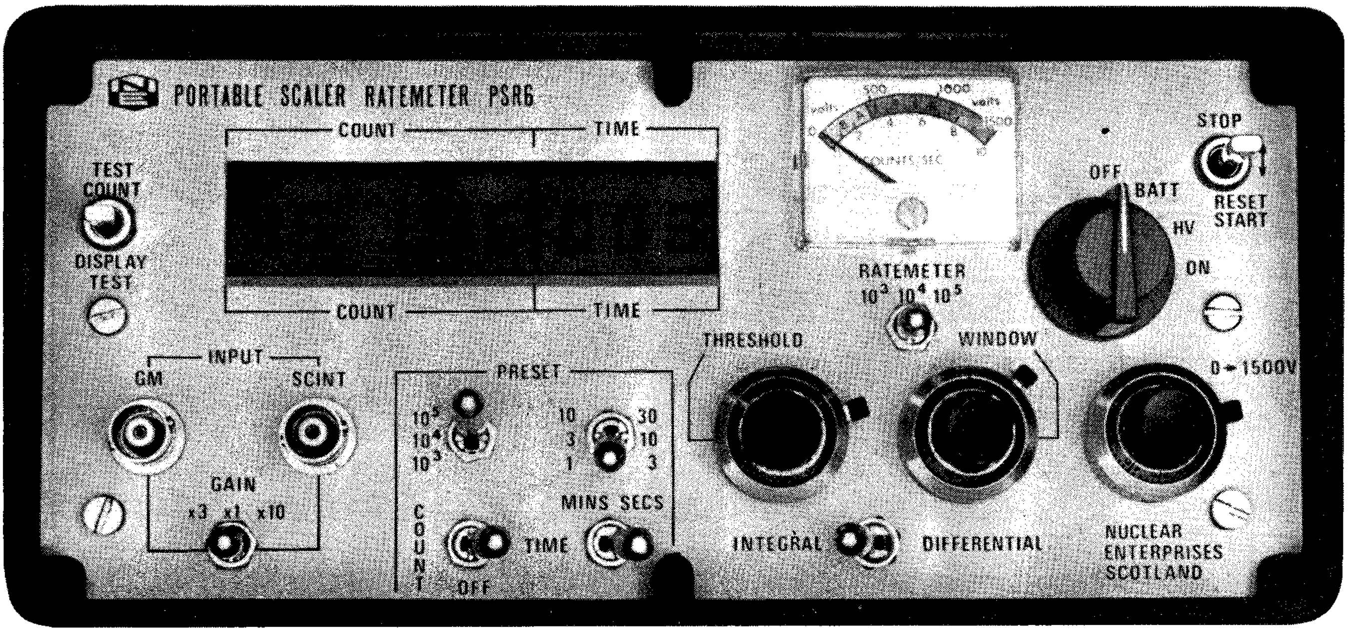
Das Servogor S-Programm
bietet 40 verschiedene
Typen mit umfangreichen
Zusätzen und Zubehör.

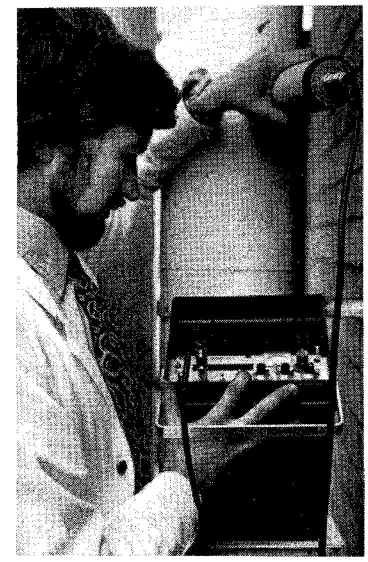
BBC GOERZ

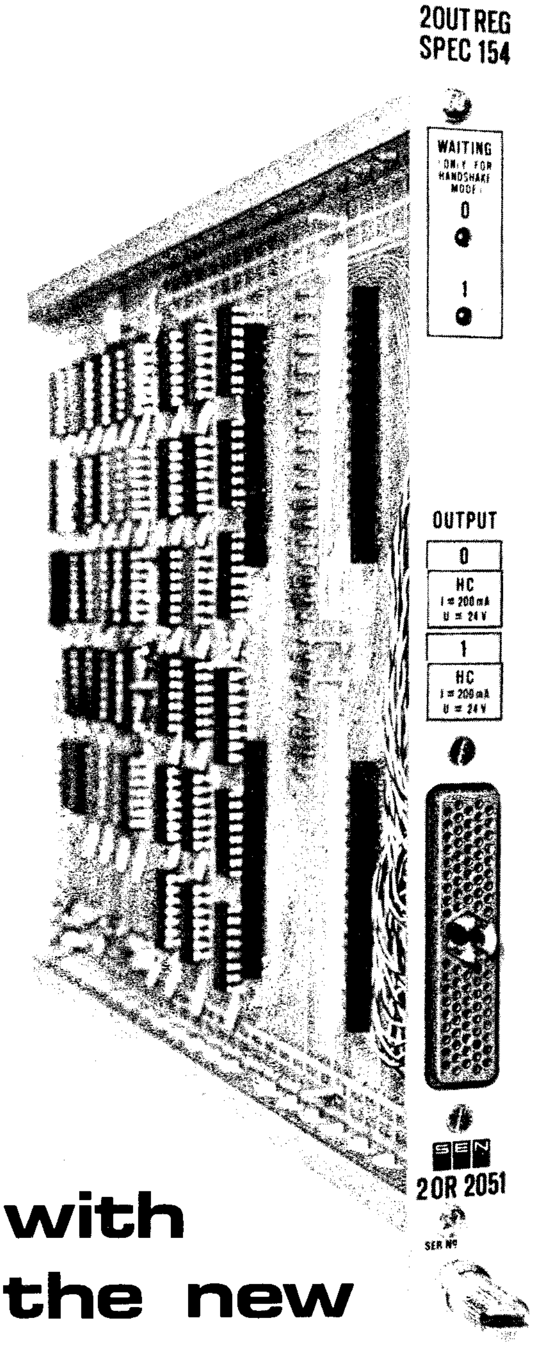
GOERZ ELECTRO Ges.m.b.H. · A-1101 Wien · Postfach 204 · Telex 01-3161
Telefon (0 22 2) 64 36 66


AC POWER SOURCE
MODEL 251
ELGAR
OSCILLATOR



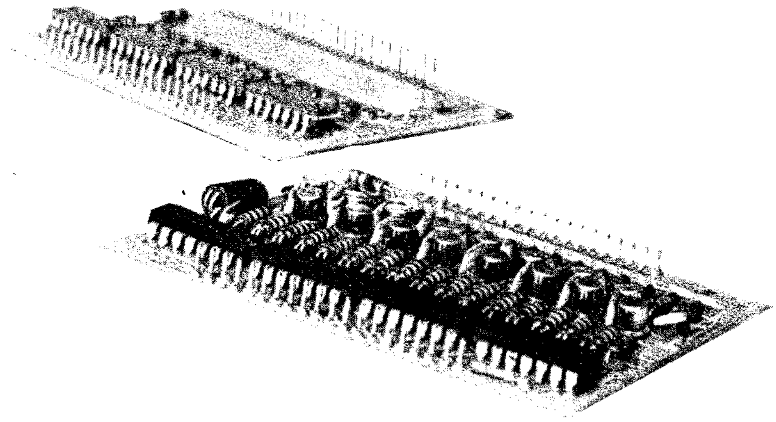

PORTABLE SCALER RATEMETER PSR6
COUNT
TIME
TEST COUNT
DISPLAY TEST
COUNT
TIME
INPUT
GM
SCINT
GAIN
x3 x1 x10
PRESET
10^5 10^4 10^3
10 3 1
30 10 3
MINS SECS
COUNT
TIME
OFF
RATEMETER
10^3 10^4 10^5
THRESHOLD
WINDOW
INTEGRAL
DIFFERENTIAL
OFF
BATT
HV
ON
STOP
RESET START
0→1500V
NUCLEAR ENTERPRISES SCOTLAND





SEN

put their cards on the table



with the new

Dual 16 bit Output Register

2OR 2051

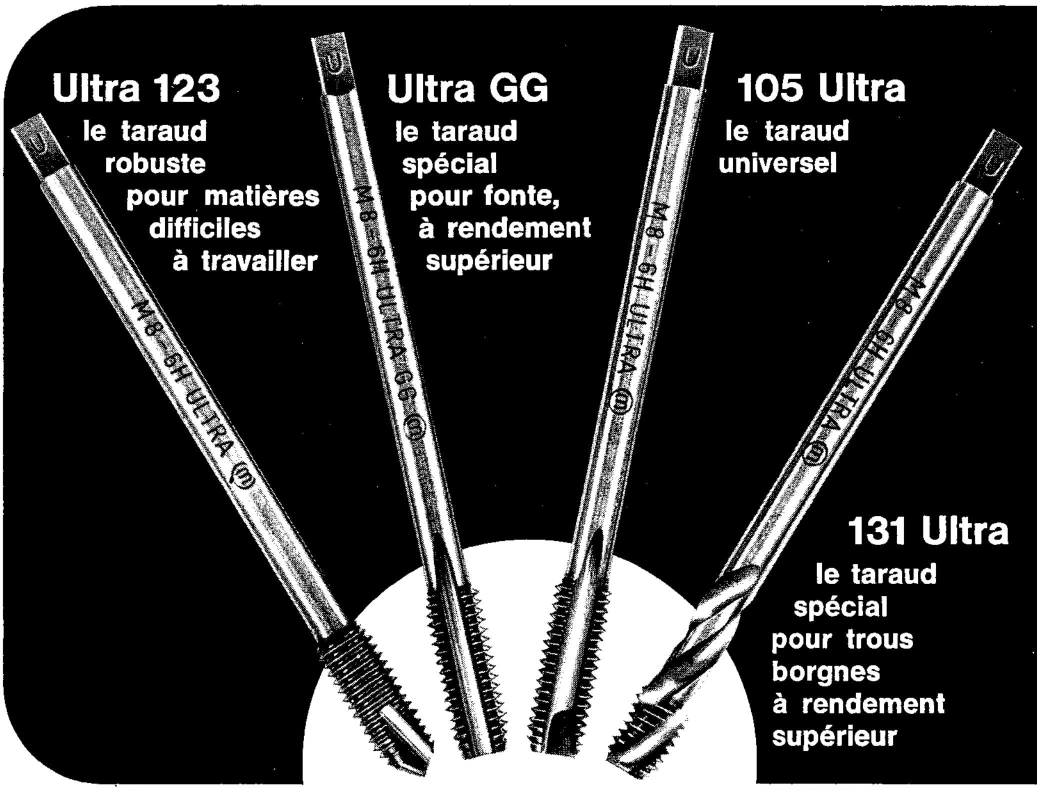
This high-efficiency instrument contains two individually controlled 16 bit registers which will execute HANDSHAKE dialogues with external units. When connected with a SEN 2 IR 2002 Dual Input Register, 16 bit words can be transferred between two CAMAC systems.

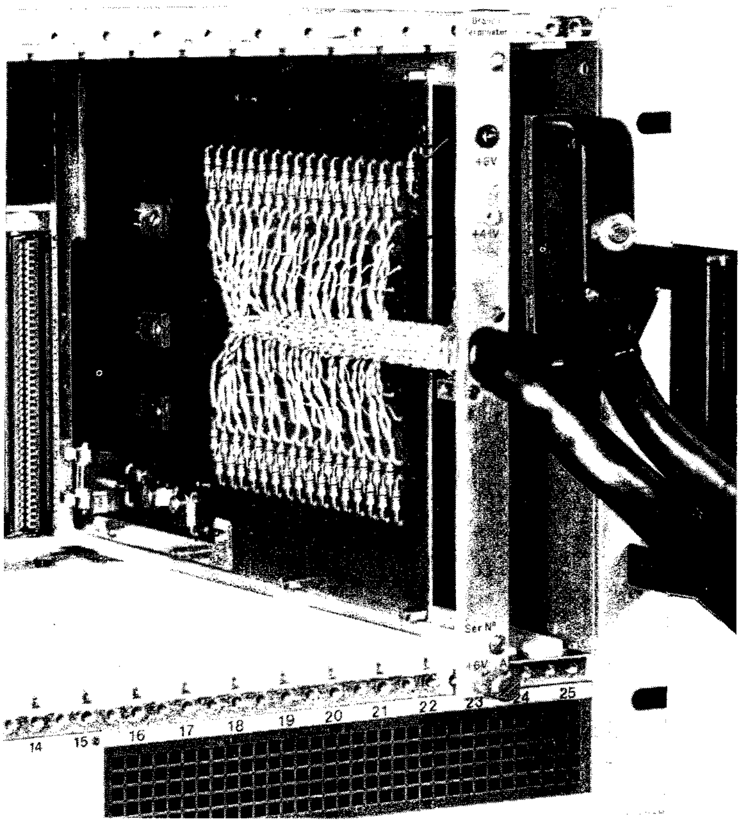
The unusual versatility of the 2051 lies in the two pluggable output stages, which provide systems operators with the possibility of changing module assignment in a few seconds. A full range of standard stages is available, covering the most frequently required working levels.

Price: S. Frs. 1,650.00
cif Switzerland

SEN
ELECTRONIQUE

31, Av. Ernest Pictet 1211 GENEVE 13 SUISSE Case postale 39 Tel. (022) 44 29 40 Telex 23359 CH
SEN ELEKTRONIK AG ZURICH Tel. (01) 86 51 03 Telex 58257 CH
SEN ELEKTRONIK GmbH HAMBURG, Germany Tel. 04103 6282 Telex 2189 548 D


M8 6H ULTRA
M8 6H ULTRA GG
M8 6H ULTRA
M8 6H ULTRA


+6V
Ser Nº
14
15
16
17
18
19
20
21
22
23
24
25

Nos photomultiplicateurs s'adaptent à votre problème particulier.

Un champion de grande envergure

Les photomultiplicateurs XP 2230 de R.T.C. permettent la détection en photoélectron unique, en lumière Cerenkov, en carbotrimétrie.
Les XP 2230 de R.T.C. disposent du meilleur rapport rapidité/bruit et peuvent être utilisés avec des scintillateurs rapides.

Ainsi la détection en physique nucléaire progresse avec R.T.C.

XP 2230
bruit < 600 c.s^{-1}
écart type de la
distribution
du temps de transit :
0,35 ns

R.T.C. c'est aussi l'optronique.

RTC

R.T.C. LA RADIOTECHNIQUE - COMPELEC - 130, av. Ledru-Rollin
75540 - PARIS CEDEX 11, tél. 355.44.99

LCAC 430

The first modular instrumentation calculator.

TEKTRONIX 31/53

It's our 31/53 Calculator Instrumentation System

A powerful, yet inexpensive calculator combined with our TM 500 power supply and system software. You add the instrumentation modules you need. It's all there and it's portable. Now that's versatility! With our 31 Calculator, you can read input from our DMM's and counters. You can log data selectively, calculate results and output data or trigger signals.

Programming?

Little more than natural math. Go ahead, write your own. Also, our standard software gives you data logging (on the optional printer) and data capture on the 31 at operator selected intervals.

Energy monitoring.

Quality control testing. Laboratory and production instrumentation. The applications go on, and so does our system's potential. Just add the mainframes and modules you need. We have a graphic calculator system, too. Let our sales engineer fill you in. Pick up your phone and call our nearest center: 042 21 91 92.

Our programmable calculators. Natural. Powerful. Significantly less expensive.

TEKTRONIX®

Tektronix Int. AG, 6301 Zug, Tel.: 042 21 91 92