# CERN COURIER

NO. 10 VOL. 13 OCTOBER 1973

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 1100 Fellows and Scientific Associates. Twelve European countries contribute, in proportion to their net national income, to the CERN Laboratory I budget, which totals 382.9 million Swiss francs in 1973.

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 1973 is 188 million Swiss francs and the staff will total about 370 people by the end of the year.

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

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

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*Cover photograph: During the high energy physics Conference at Aix, the general public was invited to discuss physics with the Conference participants. In the courtyard of a 17th Century palace, informal confrontations took place in the midst of prepared explanatory posters and exhibits. Each evening several hundred people would penetrate the courtyard and physicists were available to talk about scientific discoveries, the problems of science and society, their own research work — any science topic that the members of the public cared to raise. The evenings proved to be a considerable success and stimulating for scientists and public alike. In the photograph a radio team is joining in. (CERN 197.9.73 D)*

# Physics at Bonn and Aix

*This report of the recent high energy physics Conferences at Bonn and Aix-en-Provence was put together with help from H.F. Stier, J.V. Allaby and D.C. Cundy.*

Two important Conferences came close together at the end of the Summer. First Bonn was the scene of the '6th International Symposium on Electron and Photon Interactions at High Energies', held from 27 to 31 August, and then Aix was the scene of the '2nd Aix-en-Provence International Conference on Elementary Particles' held from 6 to 12 September.

## *Evidence of neutral currents*

At both Conferences the highlight and main talking point was the evidence of neutral currents. The discovery came in a CERN experiment with a neutrino beam into the heavy liquid bubble chamber Gargamelle and was confirmed at the National Accelerator Laboratory USA, with a neutrino beam into a huge counter-spark chamber array. The CERN experiment was carried out by physicists from Aachen, Brussels, CERN, Ecole Polytechnique Paris, Milan, Orsay and University College London; the NAL experiment by physicists from Harvard, Pennsylvania, NAL and Wisconsin.

It has been a basic assumption since the 1930s that the weak interactions take place with a coupling between charged currents — the particles involved swop charges. This was formulated mathematically, by Fermi many years ago and has stood the test of time during all the experiments from the study of beta decay to the wide variety of weak interactions observed at modern accelerators. What it says is that, when a weak interaction occurs, charged leptonic (electron, muon or neutrino) currents or charged hadronic currents are involved. For example beta decay can be expressed as a neutrino interacting with a neutron producing an electron and a proton. Charged currents are involved. The neutrino with no charge and the electron with negative charge shows the change of charge which has occurred.

All the observed weak interactions until the recent experiments could be described by such charged current processes. In principle there is nothing to prevent a weak interaction where no change of charge takes place (a weak interaction taking place with neutral current coupling), it is just that the Fermi theory fitted all observations and therefore was a solid basis for interpreting the interaction.

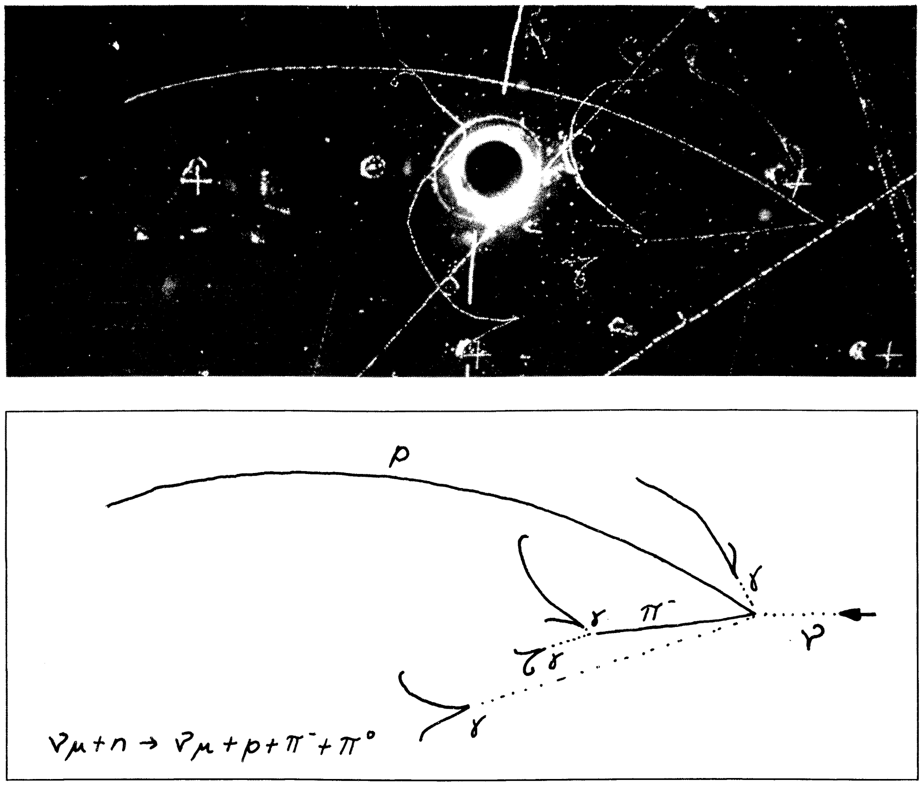
Nevertheless the Fermi theory is not entirely satisfactory. When pushed hard it falls over or, to put it more scientifically, the theory diverges. For example, the theory implies a linear rise of the electron-neutrino interaction cross-section with energy. Since we can associate a wavelength, and thus a maximum region of influence with the particles at each energy, we can see that this linear rise predicted by the theory leads to a cross-section which extends beyond the maximum region of influence permitted by the theory. This is not possible (violates 'unitarity'). However the energies at which it falls over and these violations come in are extremely high — several thousand GeV. But this breakdown of the Fermi theory is not purely academic because, in attempting to tidy it up, we can no longer understand why it works well in the regions of energy which can be investigated.

It is intellectually unsatisfying to have such deficiencies in a theory even though it covers the experimental evidence so competently. The introduction of the intermediate boson into weak interaction theory (as the carrier of the weak force in parallel to the behaviour of the photon in the well-understood electromagnetic interaction) eases the problem but does not remove it. For example, it bends over the previously linear rise of electron-neutrino cross-section with energy so that the violation of unitarity occurs at still higher energies.

Among the most interesting exercises in theory during recent years have been the attempts to 'renormalise' weak interaction theory so as to remove the infinites which appear when the theory is pushed hard. These efforts were encouraged by the work of R.P. Feynmann, J. Schwinger and S. Tomanaga, who succeeded in removing the infinities in the electromagnetic theory via renormalisation. In 1971, G.'t Hooft showed how to renormalise a whole class of theoretical models. This rewakened interest in the weak interaction work of S. Weinberg and of A. Salam and J.G. Ward a few years previously. They had built a 'gauge invariant' theory for the weak interaction using a generalization of the approach in the theory of the electromagnetic interaction. In the theory the two types of interaction can be linked as different aspects of the same underlying force. This is potentially a very exciting advance in our understanding of Nature. The linking of such seemingly disparate phenomena as electricity and magnetism was one of the great scientific triumphs of the last century. It now seems feasible that such phenomena as radioactivity could be pulled under the same umbrella.

What particularly interests us here are the predictions of the theory which can be tested experimentally. The theory says that neutral currents or heavy leptons (or both) must exist and gives predictions as to what should be seen. But in all the data there was no evidence for either.

The CERN result has emerged from the copious data on neutrino interactions using the large heavy liquid bubble chamber, Gargamelle. The word 'large' is the key to the first evidence of neutral currents. They had obviously been looked for before, especially in neutrino experiments at CERN and elsewhere, but the scale of the detectors has been such that a neutral current interaction could not



*An example of a candidate for an interaction involving a neutral current photographed in the Gargamelle bubble chamber. The neutrino enters from the right and interacts with a neutron. No lepton (since the neutrino is not seen) is recorded emerging from the interaction so no charge change has occurred. Gargamelle provides sufficient volume to be able to identify all the other particles which were produced.*

confidently be pinned down. Gargamelle, with its 5 m of heavy liquid detector along the direction of the neutrino beam makes it possible to identify the emerging particles much more surely and this is crucial to deducing that neutral currents are at work.

The experimental conditions were of the usual type for neutrino studies: The beam, accelerated in the proton synchrotron, was fast ejected and directed on to a target. The resulting pions and kaons were focused (selecting positive particles if a neutrino beam was required and negative particles if an antineutrino beam was required) and directed at Gargamelle. They were given a distance over which they were likely to decay before they reached a large iron shield block. The neutrinos and antineutrinos which are produced in the decays are mainly of the muon type (and only about 1 % of the electron type), the decays being for example $\pi^+ \rightarrow \mu^+ + \nu_\mu$. The iron shield stops all other particles, including the penetrating muons, leaving a neutrino beam emerging into the bubble chamber. Gargamelle was filled with heavy freon ($CF_3Br$).

The first search was in 375 000 pictures taken with neutrinos fired into the chamber and 360 000 pictures with antineutrinos fired into the chamber. It looked for signs of neutrino-electron scattering which involves a neutral current. The lepton does not change charge in the interaction since an electron cannot go to a muon-type neutrino and vice-versa — the particles bounce off one another without charged currents being involved. In the conventional theory of weak interactions this cannot happen. But following Salam/Weinberg it can happen and 't Hooft has calculated the rate at which it might be expected.

From the Gargamelle pictures a single example of an antineutrino scattering on an electron was isolated. (The bubble chamber photograph, showing a high energy electron appearing by itself along the beam direction, was reproduced in the July-August issue page 212.) The observation was put rigorously through the mill to make sure that the event was not being confused for example with an interaction involving a neutron

$$\nu_e + n \rightarrow e + p$$

where the proton does not travel far enough in the liquid to be seen. After all the tests, the experimenters put at only a few percent the chances of misinterpreting the event.

However, one swallow does not make a summer and no-one was jumping up and down too much until the announcement of the latest results which have disclosed a full flight of swallows. This time the Gargamelle pictures were examined looking for neutral current interactions involving a nucleon rather than an electron. In other words, the events of interest were of the type

$$\nu_\mu + N \rightarrow \nu_\mu + \text{hadrons}$$

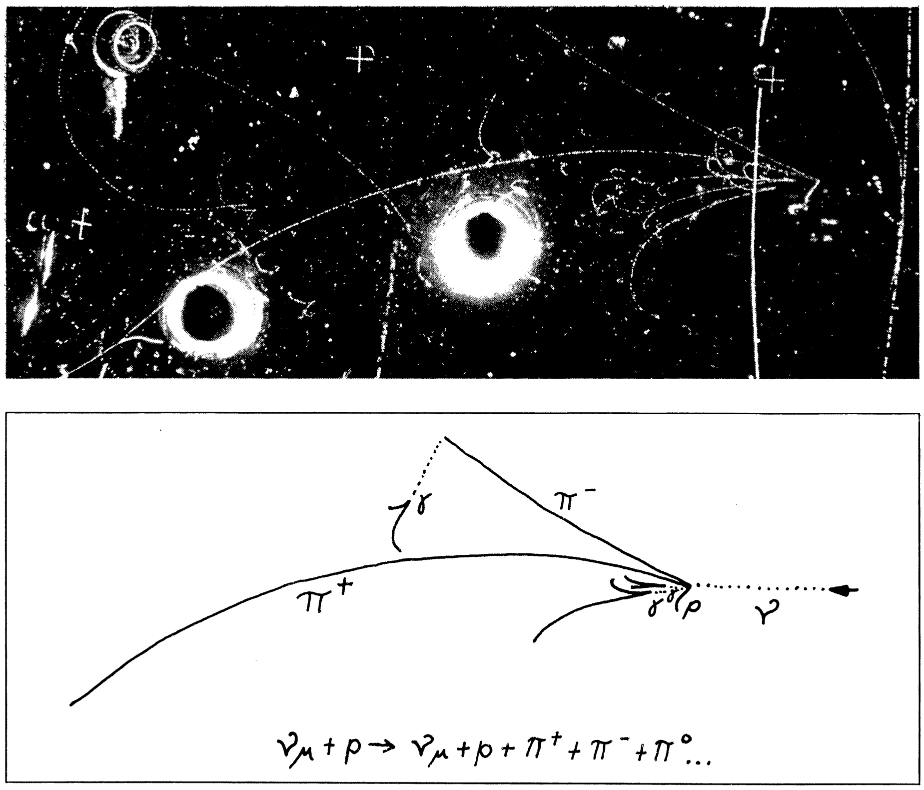
This again involves no charged current — the neutrino (or antineutrino) stays as a neutrino (antineutrino) and no change of charge is involved. The nucleon (proton or neutron) stays as it is or converts to a nucleon plus pions. The essential feature is that no muon is produced because events of the type

$$\nu_\mu + N \rightarrow \mu^- + \text{hadrons}$$
$$\bar{\nu}_\mu + N \rightarrow \mu^+ + \text{hadrons}$$

are of the charged current type where the lepton has changed charge, the neutrino becoming a muon. However, in order to distinguish between a high energy pion and a muon it is necessary for the particles to traverse many interaction lengths (several metres) and it is particularly this difficulty that prevented previous experiments from distinguishing neutral current interactions. With the large volume of Gargamelle it is possible.

83 000 photographs with neutrinos

*Another example. Here again the neutrino enters from the right and no charged lepton emerges from its interaction with a proton. All the observed tracks can be identified as strongly interacting particles by measuring their curvatures, observing their range in the heavy liquid and their subsequent interactions.*



into the chamber and 207 000 with antineutrinos were studied. In the search for neutral currents, the background to be feared most is that due to neutrons which enter the chamber from external sources. These give the reactions

$$n + N \rightarrow \text{hadrons}$$

and hence could be misinterpreted as neutral current events initiated by neutrinos. On the bubble chamber pictures they have the same characteristics — a neutral particle coming in and resulting only in hadrons. As the neutrons are known to be predominantly of low energy, such a possible background was removed by demanding that the total hadron energy in the neutral current candidates must be greater than 1 GeV. This was also done in a sample of charged current events which were measured in order to get a normalisation.

102 neutral current candidates of the type

$\nu_\mu + N \rightarrow \nu_\mu$ + hadrons ($\pi$ + anything)

and 64 neutral current candidates of the type

$\bar{\nu}_\mu + N \rightarrow \bar{\nu}_\mu$ + hadrons ($\pi$ + anything)

were observed. At the same time charged current events $\rightarrow \mu$ + hadrons ($\pi$ + anything) were recorded, 428 with neutrinos and 148 with antineutrinos.

The next important question is whether these neutral current type events could be due to high energy neutrons or whether they are definitely initiated by neutrinos. Any neutron entering Gargamelle with an energy sufficiently great to produce an event with an energy of over 1 GeV must be produced by a neutrino interaction occurring in the surrounding matter. Detailed calculations show that the number of interactions expected from neutrons produced outside the chamber is about equal to the number of known neutron interactions, seen as 'neutron stars' in the photographs, which are correlated to charged current neutrino interactions in the chamber. The figures are, in fact, 15 neutron stars in the neutrino pictures and 12 neutron stars in the antineutrino pictures, indicating that the neutron background in the neutral current candidates is small.

Finally, if these neutral current events are due to neutrinos one would expect the spatial distribution to be exactly the same as for the charged current events. This is found to be so. Calculations show that if they were due to neutrons the spatial distributions would be substantially different.

The count then comes out at 90 neutrino-induced neutral current events and 50 antineutrino-induced neutral current events. When this is compared to the charged current events — 400 neutrino and 100 antineutrino after corrections — neutral currents are obviously quite a large effect. Neutral currents are here to stay and the CERN experiment will continue so as to gather statistics giving more precise rates for the neutral current events to line up against the theories.

At NAL a neutrino experiment has been conducted at much higher energies. Data has been collected using proton beams of 300 and 400 GeV to produce the neutrinos. A measure of the different scale that this involves is that the decay region where the pions and kaons convert to neutrinos is 400 m long followed by a kilometer of earth shielding before a 'calorimeter' 9 m long and 4 m square cross-section composed of 16 tons of liquid scintillator interspersed with wide gap spark chambers. The word calorimeter is selected because it can measure the energy of the hadrons produced in its volume via the light they cause to be emitted. It is followed by a muon spectrometer of 5 m of magnetised steel with a counter behind. If the calorimeter fires (in conjuction with other conditions) and a charged current event has occurred the emerging muon has a calculable probability of traversing the muon spectrometer.

The basis of the NAL experiment is thus completely different from that of the CERN experiment. The number of muon-less events has to be compared with the number expected due to the detection efficiency of the apparatus.

They studied 1100 events recorded at 300 GeV proton energy and 400 events at 400 GeV proton energy. After pruning their data very hard, they were left with about 50 events which had no muon and could only be ascribed to a neutrino interaction. Their data gives a ratio of neutral current cross-section to charged current cross-section of about 30 % which is very similar to the results from the Gargamelle bubble chamber.

Naturally physicists have postulated other causes than neutral currents for these events — such as heavy leptons or a new type of penetrating particle. However, the NAL result is important not only in reinforcing the CERN figures but also because it backs the interpretation that neutral currents rather than heavy leptons are the new phenomena which are being observed. It is possible to explain the CERN data by postulating the existence of heavy leptons but if this were true then the much higher energies at NAL would have been expected to yield this type of event much more often, since the heavy leptons would be produced much more readily. Similarly, the interpretation that a new penetrating particle is involved cannot be completely ruled out but seems doubtful because the hadronic part of the charged and neutral events are so similar.

We have waxed long on the discovery of neutral currents but it seems worthwhile since it is certainly among the most important results ever to emerge from CERN. It feeds something completely new into our knowledge of weak interactions, it broadens the possibility of knitting the weak and electromagnetic interactions together and it has important repercussions in astrophysics where calculations on neutrino behaviour abound. We will now cover much more briefly some other topics from Bonn and Aix.

## *Other topics from Bonn*

Bonn drew together about 400 physicists, particularly from the electron Laboratories. They were treated to an unusual opening session. W. Paul repeated two fundamental experiments done by P.E.A. Lenard and H. Hertz at Bonn about eighty years ago. For this demonstration the original transmitter constructed by Hertz was used and the apparatus of Lenard's thesis was taken out of its cabinet. It worked, producing a nice light spot on a fluorescent screen outside a vacuum tube — an electron beam made visible to all participants by means of modern television techniques.

The Conference started with a session on recent results from electron storage ring experiments and their theoretical aspects. Tests of quantum electrodynamics were reported confirming the theoretical predictions to kinematical regions unknown up to now. Lower limits of 10 GeV/c$^2$ are established for the mass of a heavy photon which would lead to a modification of the photon propagator.

New results have been obtained in hadron production by electron-positron collisions. The surprisingly high cross-section is still increasing with energy up to 4 GeV. The cross-sections for pion pair and kaon pair production in these collisions seem to be nearly equal.

A lot of new data and new theoretical calculations on photo- and electroproduction in the resonance region were presented. The existing data on differential cross-sections, polarization and asymmetries in pion photoproduction have been extended and improve our knowledge of the resonance couplings involved.

In spite of a great effort to study the behaviour of exclusive reactions in the electroproduction in the region above the pion-nucleon resonances, a lot of problems remain unsolved. The influence of the 'variable mass' of virtual photons on the different cross-sections is not yet understood. It is still not clear whether there is parton-like behaviour. There is no definite evidence for photon shrinkage in rho production. A new measurement of the decay width of the two photon decay of the eta meson gives a value three times smaller than obtained in a previous measurement and is in better agreement with the SU3 prediction.

Inclusive reactions induced by electromagnetic currents have been compared to strong interactions and many similar properties, as for example the energy dependence of the charged multiplicity, have been found.

In addition to the neutral current work, very interesting results were reported from neutrino experiments (neutrino results having entered this series of Conferences for the first time). The total neutrino cross-section per nucleon continues to rise linearly with the neutrino energy. The lower energy measurements (up to about 5 GeV) are now very precise but it is fascinating to see the NAL measurements up to neutrino energies of about 200 GeV lying on the same lines. Their preliminary result corresponds to a lower limit on the mass of the intermediate boson of about 20 GeV/c$^2$.

The main impression from the Conference was that, despite the many open problems, progress has been made in understanding weak and electromagnetic reactions and the

*One of the intersection regions at the CERN ISR, I-8, where data on proton-proton interactions in the highest range of energies now available (as high as an equivalent conventional accelerator energy of 2000 GeV) are being collected. At this intersection region Pisa-Stony Brook and CERN-Rome teams have surrounded the position where the beams cross with detectors. Results from the ISR were among the most important reported at Aix.*

*CERN 87.6.73*

progress as always is accompanied by unexpected and surprising results.

The plans of the Laboratories for improving their facilities to study electromagnetic interactions were presented at the Conference. At Batavia the first priority is going to improving the quality of the muon beam; for the moment the pressure is off the electron/photon beam. At Cornell a superconducting r.f. cavity has performed well in bench tests (Q of $10^9$) and is scheduled to be installed in the electron synchrotron towards the end of the year. The additional r.f. power should enable the peak energy to climb from 12.5 GeV to 15 GeV. Beyond that stage a magnet reshuffle would be required to allow more room for r.f. units if the energy is to be taken any higher.

At DESY, the storage ring complex called DORIS (see vol. 12, page 40) is nearing the commissioning phase. Electron and positron beams of up to 2 GeV are hoped for about the end of this year and in later months this will be taken to 3.5 GeV and 4.5 GeV in successive steps. It is also intended to store protons (after injection from a 3 MeV Van de Graaff and acceleration to GeV energies in the synchrotron) for electron-proton colliding beam physics.

At Frascati there are thoughts of a Super-ADONE storage ring with electron and positron beams of energies up to 5 GeV and luminosities up to $10^{32}$. The existing storage ring ADONE would be used as injector at 1.5 GeV and some additional manoeuvres would need to be done to keep the positron beam intensities high. At Stanford the recirculating linac, to use the accelerating abilities of the 22.5 GeV electron linear accelerator twice over, is still under study but the exceptionally fine performance of the storage ring SPEAR (now operating with beams up to 2.6 GeV) has tended to shift the emphasis to further development of their colliding beam facilities. By the end of 1974, more r.f. power will be installed to take stored electron and positron beams to 4.5 GeV. A Super-SPEAR is under discussion with beams up to 15 GeV and a luminosity of $10^{32}$ in a ring of 200 m radius.

In addition Stanford and Berkeley are working on a very ambitious storage ring complex known as PEP (see vol. 11, page 279), where very high energy electrons, positrons and protons could be used for colliding beam physics in various combinations. A scheme with some similar features, known as EPIC, is under serious study in the UK and we hope to report on it soon.

## *Other topics from Aix*

Aix drew together about 600 physicists and the Conference leaned on strong interaction physics since it was preceded by Bonn. Again the flood of completely new information from the experiments at the CERN Intersecting Storage Rings was prominent and it was joined by data from the experiments in the new high energy ranges opened up by the 400 GeV proton synchrotron at the National Accelerator Laboratory, Batavia.

Some of the results from the ISR we have covered in standard issues of CERN COURIER as they have emerged. The now famous proton-proton total cross-section results, which were announced six months previously (see March issue page 67), were not presented at the Conference but they were underlying much other work particularly in theoretical papers where attempts to explain, in detail, the rising cross-section and to predict what will happen at still higher energies are keeping many people busy.

The other 'old' result — the observation of high momentum particles in

** Confusion between IHEP (Institute for High Energy Physics at Serpukhov) and ITEP (Institute of Theoretical and Experimental Physics at Moscow) led us to assign the kaon spectrometer using streamer chambers to Serpukhow on page 264 of the last issue. In fact it is an ITEP project operating at their 7 GeV proton synchrotron. Apologies to all concerned.*

much higher profusion than expected scattered at large angles, (probably due to structure within the proton) was also the subject of a lot of discussion. There are new results from NAL on this topic in general lining up with the ISR data but looking different in the ratios of protons to pions. There also seem to be some figures to be tidied up between the different ISR experiments concerning the energy dependence of this phenomenon and the neutral pion figures.

There was much more data on proton-proton scattering from the ISR. Optical models seem to be working very well with the inelastic scattering measurements. The multiplicity measurements have also been extended and more detail has been fed into the missing mass spectra. This gives us the opportunity to correct some loose wording in the July/August issue where we wrote of the observation of resonances of as high as twelve proton masses. What is seen is that in about 20 % of inelastic proton-proton collisions one of the protons is transformed into a cluster of particles with a total energy which can be as high as twelve proton masses (depending on the ISR energy). There is no evidence that the clusters are resonances.

A string of very impressive results were reported from Serpukhov — for example, charge exchange data (for pions between 20 and 50 GeV/c and kaons and antiprotons between 25 and 35 GeV/c) and elastic scattering data (more detailed work on pion-proton and neutron-proton forward slopes).*

The experimental programme at NAL was described by J.D. Jackson and, since we have not described much of it before in our pages, we will add some information to what is covered above. Up to now 21 experiments have been completed and 59 others are in progress.

Experiments are carried out in an internal target area and in three experimental areas fed by the ejected proton beam. Typically the machine operates at 300 GeV with an intensity of $3 \times 10^{12}$ protons per pulse and one pulse per 6 s (up to 1 s flat top). The ejection efficiency is between 90 and 95 % and, when the machine is running well, up to eight experiments can be given beam on the same pulse using two splitter magnets to divide the beam between the three areas. Splitter S1 bends beam off to the 'Proton Laboratory' where a further splitter, S4, divides protons along beam-lines into west, central and east regions.

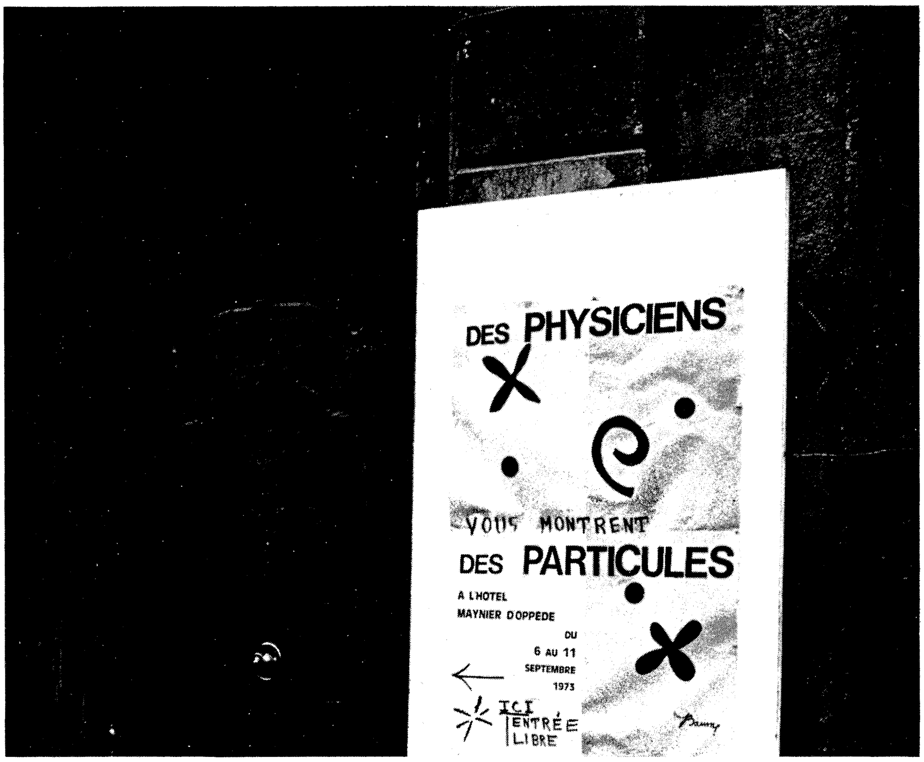
A second splitter, S2, bends beam off to the 'Meson Laboratory' where lower energy work (up to 200 GeV incident protons) is under way using five beam-lines (one more test beam is to be added). In the forward direction, protons proceed towards the 'Neutrino Laboratory'. Two more splitters, S3 and S5, send beam to the 30 inch bubble chamber and to the 15 foot bubble chamber. A muon beam is also available at the same time as neutrino or hadron beams to the bubble chambers.

The 30 inch chamber has over 300 000 high energy pictures in hydrogen under its belt and is now operating in conjunction with electronic detectors (wide gap spark chambers and multiwire proportional chambers) in hybrid set-ups. Some experiments with deuterium and possibly neon are planned. The 15 foot chamber came into operation after the Conference, taking its first pictures on 29 September (more about this next month). It will begin with neutrino physics in hydrogen and possibly hydrogen/neon mixtures hoping for one event per ten pictures with $10^{13}$ protons onto the target in the neutrino beam-line.

At the internal target area as many as four experiments have been squeezed in simultaneously. Two separate targets are now in use and their great attraction is that they allow experiments to be carried out at any energy in the range from 8 GeV (injection energy into the main ring) to 400 GeV. The best known of the experiments is that involving the use of the hydrogen jet target taken to NAL by Soviet physicists. Results have been reported on proton-proton and proton-deuteron elastic and inelastic scattering, on inclusive interactions and on photon measurements. Elastic scattering shows the continued shrinkage of the forward diffraction cone right up to 400 GeV, in good agreement with the Serpukhov and ISR data. Inelastic scattering shows the approach to scaling and ties up nicely with other NAL data from the 30 inch chamber.

In the 30 inch chamber, photographs have been taken with proton and positive and negative pion beams with energies spread between 400 and 100 GeV. They have been used in survey experiments of high energy interactions measuring total cross-sections, multiplicities and particle ratios and their energy dependencies. Of particular interest are measurements on small momentum transfers where something interesting seems to be going on in data from the ISR. The NAL measurements as yet show no dip as the transverse momentum approaches zero which causes some theoretical consternation. Scaling has been studied up to 400 GeV and holds well in the fragmentation region while showing a rise in the central region (as at the ISR).

News from the neutrino experiments is reported above. They have used a broad band neutrino beam achieving about 15 events per hour. A focusing horn is being installed and will improve this figure. A narrow band neutrino beam will provide 50 GeV neutrinos



*Not the sort of poster you see every day. Aix was plastered with posters of this type during the Conference luring the public to find out what high energy physicists are doing and why.*

*CERN 188.9.73 F*

from pion decay and 130 GeV neutrinos from kaon decay.

The associated muon beam has so far been of low intensity (below $10^5$ppp) but is now becoming useful for physics. As mentioned above, emphasis will be placed on improving the muon beam. It will start with a deep inelastic scattering experiment (à la Stanford with electrons) and an inelastic scattering experiment using a large spectrometer (incorporating the magnet from the Chicago cyclotron) which will analyse also the final hadronic states.

In the Meson Laboratory experiments are under way on three beamlines. Total cross-section measurements are about to start with positive and negative pion, kaon and proton beams on hydrogen and deuterium targets. Another total cross-section experiment is looking at neutron-proton with neutrons of up to 300 GeV energy and a charge exchange experiment is also looking at neutron-proton.

Two quark searches have been carried out without success at energies which might have spotted fractionally charged particles of mass up to around 10 GeV. The continued absence of fractionally charged quarks up to such high masses is influencing new looks at the quark theory which are producing more complicated versions where integral charge is possible. Quark addicts may also meet in the recent literature, in association with quarks, the words 'charm', (which is a sort of added property like a higher-order strangeness limiting their interactions) and 'coloured' (which tints three kinds of three quarks to explain their behaviour extending to weak and electromagnetic as well as strong interactions).

In addition to the experiments we have mentioned, a long list is in the pipe line, including such things as a lepton search with single and double arm spectrometers, total photon cross-section measurements and a magnetic monopole search — all destined for the Proton Laboratory. We have referred above to the large momentum transfer work which has preliminary data from the Proton Laboratory.

## *Meet the people*

During the week of the Aix Conference much more attention than usual was given to the need for communication with non-physicists. A plenary session was held on 'Popularizing High Energy Physics' and on several evenings 'La Physique dans la Rue' events were organized in the town centre.

Among the most illuminating features of the plenary session devoted to popularizing physics were the omissions but some interesting talks were given on other subjects. Stealing the limelight were the Chinese delegates who explained that, of necessity, pure research had received little attention in China in recent years but that this was a short term policy. However, in answer to a question explicitly asking if high energy physics would be studied only if it showed material benefit to the people rather than just a cultural one, Wang Yung gave the straight answer, 'Of course'.

R.F. Stannard in his resumé of the courses given by the British Open University gave an object lesson in the presentation of information, showing the results of his professional training in communication which is necessary to make the maximum use of precious television time. But it was V.F. Weisskopf, that long-standing warrior in the fight for popularizing, who brought the attention of the meeting to the main subject. He made the telling comment that not a single science writer had been invited to the Conference and could have added that not a single person professionally concerned with popularizing had been invited to contribute to the discussion at the plenary session.

He urged that more attention should be paid to recapitulating what was known rather than talking only on what had just been discovered. He also warned against the dangers of over simplification as this might make physics seem easy — a remark which could have been misinterpreted as suggesting that the object was to impress rather than inform. But he was adamant that the physicist had a duty to explain what he was doing to the people who paid him. It was a bonus if this also encouraged the flow of funds.

Apart from a little skirmishing concerned with the difficulties of communicating high energy physics — without any serious attempt to identify the barriers on the physics side of the communication gap — there was little instructive in the way of 'what', 'to whom' and 'how'.

Nevertheless 250 people showed sufficient interest to participate in the

*Another typical courtyard scene at Aix where small groups gathered to discuss anything from Madame Soleil to high energy physics.*
*And anybody could ask questions and expect an answer!*

*Crowd scene, of a more traditional type this time, during the talk by Leprince Ringuet. It is obvious that the popularization exercise attracted a surprisingly large number of the people of Aix.*

*(Photos H. Nicollas)*

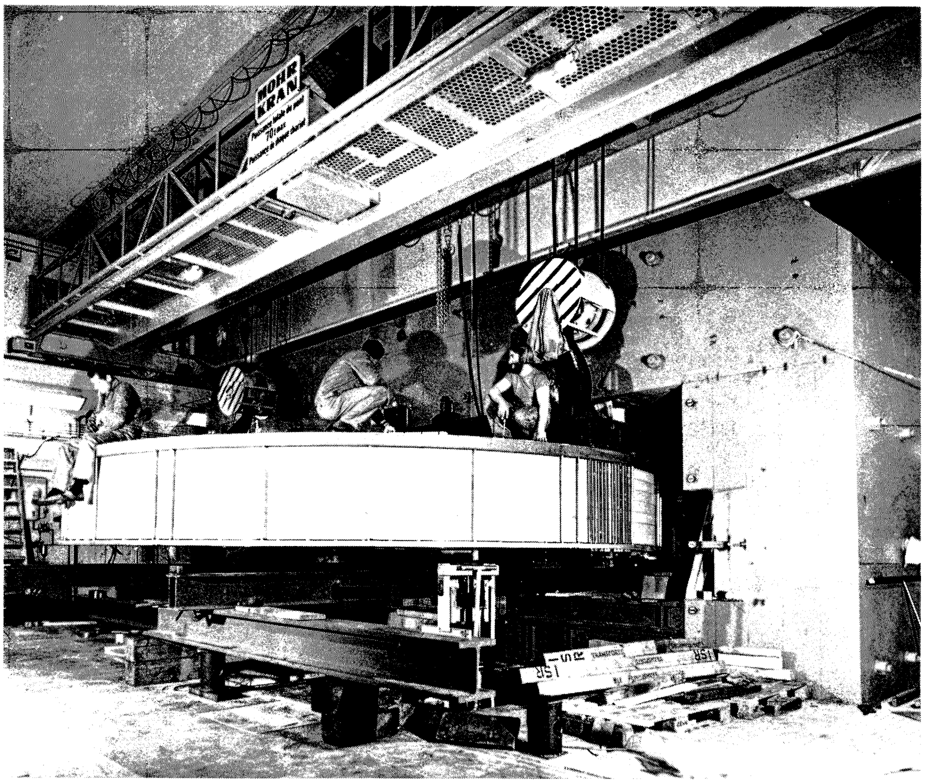
session and even more took part in the practical operation of meeting the public which took place on the other side of the town. Here, the combination of the indomitable determination of a group of physicists led by P. Sonderegger coupled to the professional expertise of public relations people (in particular C. Nugue who is responsible for promoting the town of Aix), a most agreeable series of soirées took place, involving several hundred people per evening.

The public was attracted to a courtyard where they could talk to physicists against a background of posters, panels and working models. In an atmosphere of complete informality and friendly exchange, there were many lively discussions. Subjects ranged from astrology to homoeopathy, from nuclear reactors to scientific conscience and occasionally touched on high energy physics — particularly in the neighbourhood of the superb operating cylindrical spark chambers brought from Saclay.

One evening saw a more classical presentation of information with talks by L. Leprince-Ringuet (on the beauties of pure research), B.P. Gregory (on the role of fundamental science and its pioneering role in international collaboration) and V.L. Telegdi (on the intricate subject of neutral currents). Over 600 people heard these talks, no doubt attracted particularly by the well-known television personality of Leprince-Ringuet.

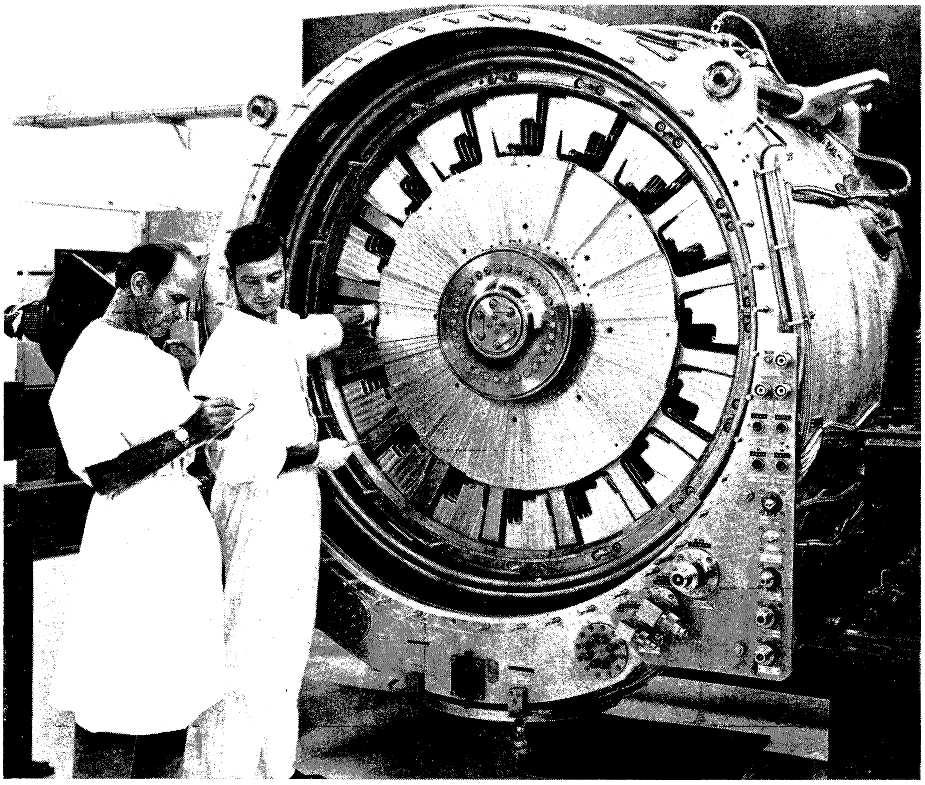
The exercise definitely made an impression on the public and by the end of the week physicists sporting a Conference badge risked being interrogated anywhere in the town. The press were intrigued — radio and TV likewise — and for a few brief days Aix-en-Provence had the feeling that it knew what a physicist looked like. Perhaps just as important, quite a few physicists had the opportunity of finding out what the public looked like too.

# CERN News



*Reassembly of the SC magnet. After partial dismantling, which was necessary in order to drill an axial hole through the magnet yoke and pole pieces, the magnet of the 600 MeV synchrocyclotron is being reassembled. The picture shows one of the two new 60 ton main field coils being brought into position. The coils were manufactured by Alsthom.*

*CERN 304.9.73*



*The first of the two rotary condensers for the new radio-frequency system of the SC was transported to CERN in June and has been reassembled by a CERN-AEG team. A second (spare) condenser is being completed in Berlin. In the picture the clearances between the radial rotor blades and the specially shaped stator blades mounted on the circumference of the housing are being checked.*

*CERN 84.9.73*

## SPS: Take one !

The various stages in the construction and installation of the SPS will be filmed under the direction of Georges Pessis who specialises in documentary films (his work includes 'Matter in Question' filmed at CERN in 1959). The first shots were taken during October.

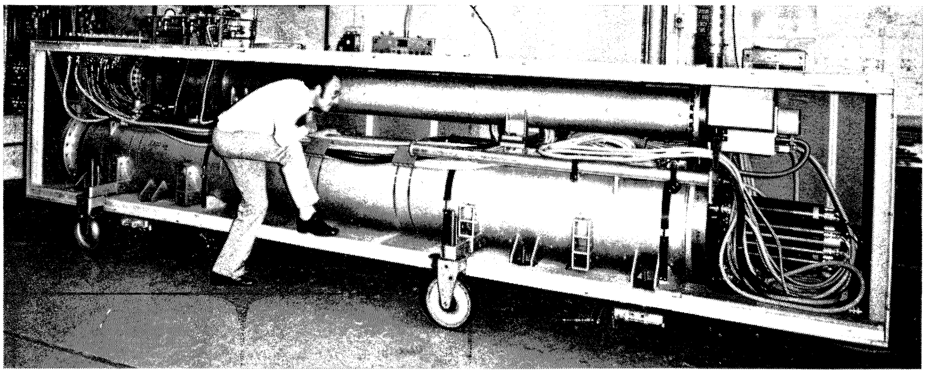
The outcome is envisaged as three films — a forty minute documentary for public showing in cinemas and on television, a twenty minute film suitable for showing to visitors to CERN and a series of technical sequences, lasting forty minutes in all, for specialists. Each of the three will be shot in colour on 16 or 35 mm film as dictated by shooting conditions. The sound track will be recorded in two or more languages. Sequences will be made at intervals during the construction work until the machine has been completed. Nevertheless it should be possible to project part of the first film (forty minutes) in 1976, just before 300 GeV beams are sent for the first time towards the West Hall. Thereafter, it will be regularly up-dated, until completion of construction at the beginning of 1979.

The film intended for visitors to CERN should be available as early as 1974 and it is proposed to up-date this film also during the subsequent years. The third film will be divided into sequences intended for separate showing, each sequence to last only a few minutes. These sequences will be essentially technical and will give an expert audience descriptions of the main components of the SPS (magnets, r.f. system, civil engineering, beam transfer lines, control system, etc.).

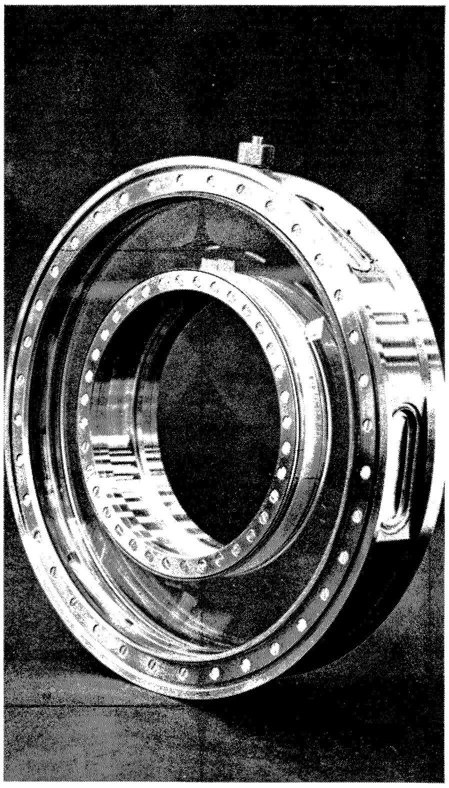
The idea is to emphasis the various distinctive features of the gigantic accelerator. In the films for general viewing, emphasis will be placed on the fact that this is a machine which

*1. The DISC Cherenkov counter after its removal from the test beam. The large vessel of the counter is mounted on wheels and the photomultipliers are located to the right in the photograph. On the top is a smaller tube housing a precision refractometer. The whole counter is thermally isolated in a foam-lined box.*

*2. The special chromatic corrector of the DISC counter is a triplet lens consisting of elements of fused silica and sodium chloride mounted in a barrel of invar.*



*1.* *CERN 58.90.73*



2. *CERN 62.10.73*

literally passes underneath the Franco-Swiss frontier, the important technological aspects will be highlighted, mention will be made of construction within strict budget limits to a fixed time schedule and of the measures to ensure environmental protection, etc.

## DISC ready for Atlantic crossing

A high resolution differential Cherenkov counter, built by a combined team from Data Handling and Nuclear Physics Divisions has passed its beam tests at the CERN PS and is now being shipped to the National Accelerator Laboratory, Batavia.

The counter is of the 'DISC' type (described in vol. 12, page 234). It is 5.5 m long, uses a Cherenkov angle of 24.5 mrad and has a theoretical velocity resolution of $4\times10^{-7}$ when filled with helium gas; this is sufficient to separate pions and kaons up to about 250 GeV/c and pions and protons up to about 500 GeV/c. When a high energy charged particle passes through the gas in the counter, a ring image of the Cherenkov light is focused onto a circular diaphragm. Light which passes through the annular opening in the diaphragm is detected by a coincidence arrangement of eight high quality photomultipliers.

A set of special optics inside the counter corrects for chromatic and geometric aberrations in the light image. The chromatic corrector, consisting of a triplet lens of fused silica and sodium chloride elements, is adjustable in position along the axis of the counter so as to provide the best resolution over a wide range of beam momenta (for example, to detect antiprotons from 30 to 500 GeV/c) and a wide range of particle mass (for abundant particles and rarer particles such as hyperons, antideuterons, etc.).

During the tests at CERN the detector was mounted in a 10 GeV/c pion beam (d 31) in the South Hall of the PS and was operating satisfactorily after only twenty hours. Precision alignment of the counter is not necessary since remote adjustment is possible. The detector is also insensitive to the temperature of its surroundings because temperature compensation is built into the design of the optics. However a stable temperature is required and this is achieved by thermally isolating the whole counter. The counter was filled with air for the tests and by setting the pressure with an interferometer it was possible to cross-calibrate the mean momentum of the beam to an accuracy of about 0.1%. The counter could then be set for the detection of particles of any given mass.

The figure shows some results taken during the test. The counting rate was recorded as the gas pressure was slowly increased. Peaks in the yield of particles correspond to electrons, muons and pions in the beam. The width of the peaks is determined by multiple scattering of the 10 GeV/c beam in the gas filling of the counter, but is not affected by the large divergence of the beam (about 5 mrad). The small bump on one side of the pion peak is not claimed as the discovery of a new kind of particle but is more likely to be some impurity (such as muons of 8 GeV/c) leaking into the beam.

These results indicate that the counter should perform to specification but to determine the ultimate velocity resolution will require a beam of much higher energy. For this, upon arrival at Batavia, it will be installed in the beam-line of the focusing spectrometer facility (NAL experiment 96). The experience gained will be useful for the design of future high resolution Cherenkov detectors for use both at NAL and at the CERN SPS.

## Hunting for muons

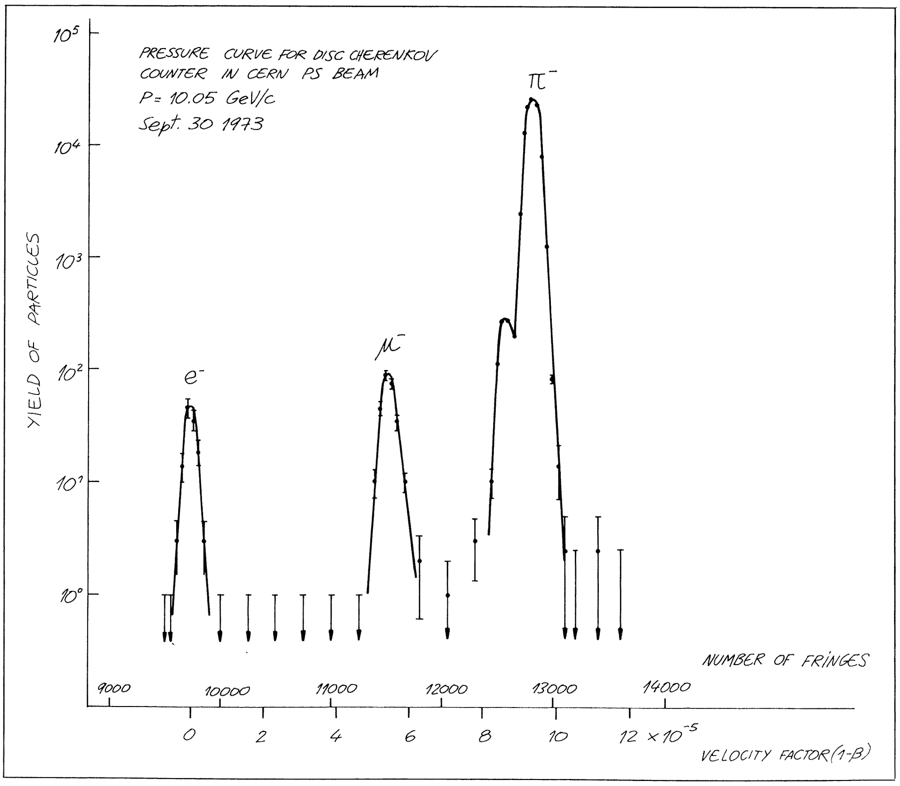
For about a year now a Health Physics team at CERN has been busy with an unusual piece of equipment which has been touring around in the South Hall, in the car park behind BEBC and in the West Hall. The equipment is easily recognizable as consisting of scintillation counters but they have been set up outside the shielding walls, instead of inside in the usual experimental set-ups.

The equipment is a telescope for recording muons, which has been added to the large number of monitors that the Health Physics Group has around the CERN site for checking the radiation levels continuously. The standard monitors give an overall record of all radiation reaching them and the idea of developing the telescope arose when it was found that the radiation level on the car park behind the BEBC bubble chamber was higher (although not dangerously so) than was expected from neutrons alone. This higher dose could only be caused by muons, which can penetrate shielding much more easily than other particles (except for neutrinos). Neutrons make the biggest contribution to the dose rates measured on the CERN site but the contribution from muons predominate at certain points if the pions and kaons, generated by the interaction of the primary proton beam with a target, can travel the distance required for their decay into muons before meeting a shielding wall.

The telescope consists of a bar supporting three scintillation counters in triple coincidence. The bar can be set in either the horizontal or the vertical plane by means of two perpendicular pivots, which is how it earned the name of 'telescope'.

The pulses from the telescope are recorded and counted according to their amplitude by a 512-channel analyser. The various measurements are made with reference to two counters in coincidence arranged in a fixed position in the radiation field in order to take into account the intensity variations of the accelerator.

The general idea of the equipment was approved in March 1971 and it was tested during 1972. During this time, the conditions in which the equipment is truly selective to muons



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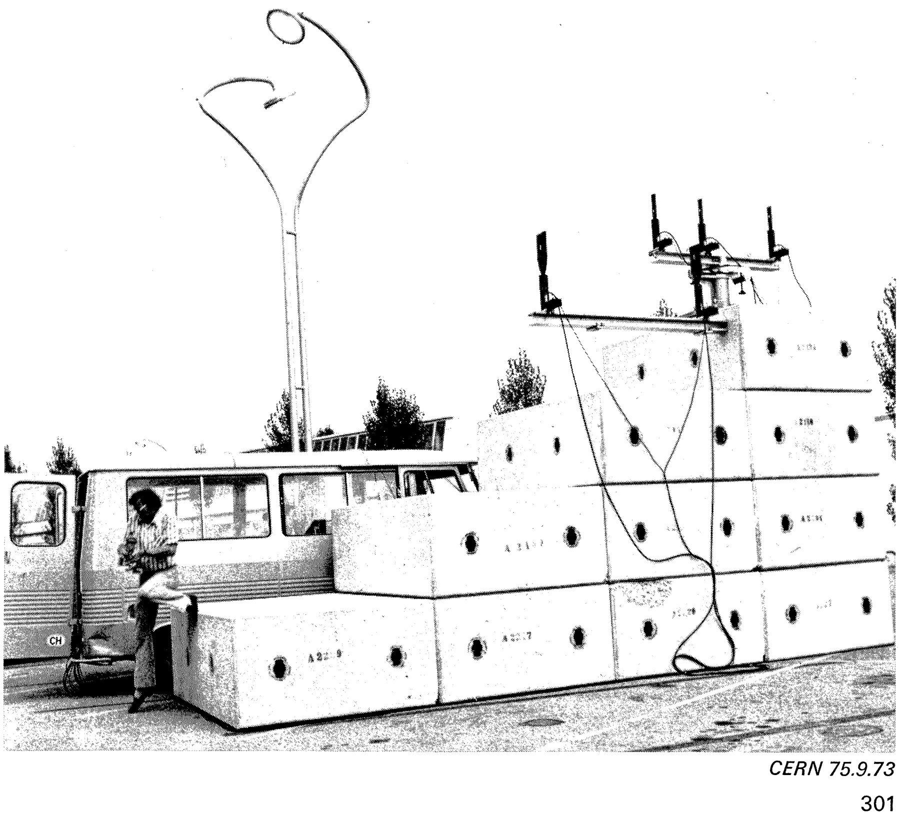
*3. The number of particles detected by the DISC counter plotted as a function of the gas pressure in the vessel. The width of the peaks is determined by multiple scattering of the low energy test beam by the gas filling of the counter.*



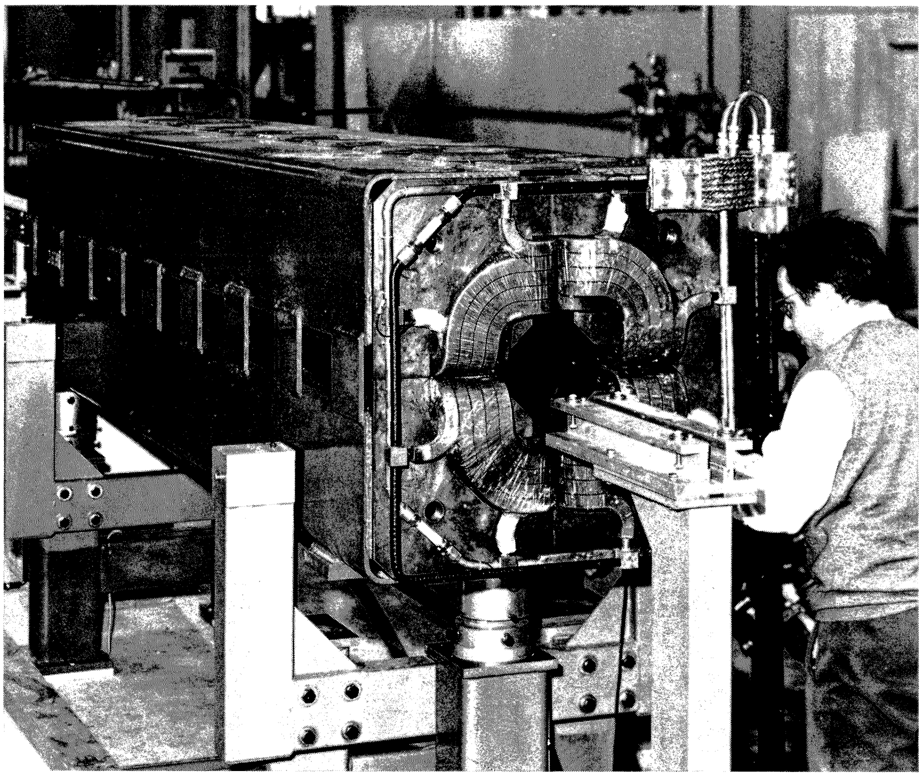
*The muon hunting telescope, which consists of three small scintillators fitted on a support bar. The two large scintillators in the foreground are the reference counters. The equipment is placed on top of the concrete blocks in order to find out whether the radiation rate at this height is greater than at ground level. The telescope can be moved around the site in the van which contains its associated electronics.*

*CERN 75.9.73*

*With some relief 'the mole' bored its way into the gallery of straight section 3 of the SPS on the night of 1-2 October. Since it was last seen in straight-section 2, mid-June, it had run into pockets of gas (methane and carbon monoxide) which delayed tunnelling for a week while extra ventilation was installed. The mole has about 2300 m behind it and is likely to be half-way around the ring by the end of the year.*

*The first production quadrupole for the SPS reached CERN at the end of September. Half-cores for the bending magnets are mounting up in the large assembly Hall and coils for the bending magnets are arriving, though at a somewhat slower rhythm. In the November and December issues we will be covering progress in SPS construction in more detail.*

*CERN 23.10.73*



*CERN 142.10.73*

were determined and its sensitivity to the direction and to the intensity of a muon source was found. The telescope proved to be a high precision instrument.

In theory it is always possible to estimate the muon doses which are likely to be met outside the experimental halls but the calculations are often found to be inexact because of their complexity. In fact, it is necessary to take into precise account all the obstacles in the paths of the particles and the difficulty of such a procedure will be appreciated when one has passed through the chicanes formed by the blocks of concrete, lead and iron which abound in the experimental halls. The telescope makes it possible to locate the muon sources exactly and to check the theoretical calculations relating to intensities. The aim is to reduce the dose rates recorded on the site, either by making it possible to stop the pions and kaons before they decay into muons or by determining the precise points at which the shielding must be reinforced.

This muon telescope will be improved further. It operates very well when the PS is operating with slow ejection of the accelerated beam but the associated electronic equipment is too slow when the PS operates with fast ejection. The Health Physics team is investigating ways of improving the equipment so as to be able to record muons during the extremely short time taken for a single PS bunch to pass.

# Environmental Research at Berkeley

*The information concerning the Energy and Environment Programme at the Lawrence Berkeley Laboratory is based on a talk given at CERN by A.M. Sessler, one of the initiators of the Programme. (Dr. Sessler has been appointed Director of the Lawrence Berkeley Laboratory, in succession to Prof. E. M. McMillan, from 1 November.) Many of the topics mentioned merit an extended story in themselves but the purpose of this article is simply to give a sketch of what is happening.*

Berkeley is certainly not alone in working on environmental problems. In recent years several of the Laboratories where high energy physics is done in the USA have become more involved in such research and there are other centres, such as Oak Ridge, with extensive programmes of environmental research.

Some of the US Atomic Energy Commission Laboratories are multidisciplinary with Divisions devoted to such fields as Reactor research, Chemistry, Biology and Medicine. This naturally broadens the base from which research can be tackled and these Laboratories have considerable programmes of work relevant to energy and environmental problems. In addition to AEC resources, the work is sometimes funded by other bodies, a major example being the National Science Foundation which supports a 'Programme of Research Applied to National Needs'.

One large topic is that of reactor research which brings many related fields, such as radiation studies, radioactive waste disposal and so on with it. Among the Laboratories we normally cover in our pages, Argonne, Brookhaven and Los Alamos are involved in this sort of work. (We are not describing activities of other Laboratories but it should not be forgotten that other Laboratories have big programmes on reactor research and other topics.) The work on reactors includes looking at the energy contribution and at environmental effects.

The reactors are one of the pieces in the energy game where some balance has to be achieved in the developed countries before long. Other aspects of the energy game are under investigation, for example, at Argonne. They have developed a technique for burning coal deposits with high sulphur content. The technique reduces the resulting sulphur dioxide pollution by 90%. They have also worked on compact energy storage cells such as lithium-sulphur batteries which could help the electric car. Brookhaven have studied the energy game in depth taking in energy sources, conversion techniques and power transmission systems (including their environmental effects). They have done research on metal hydrides as a method of safely holding hydrogen for subsequent use in power systems. In August a broadly-based Study on energy questions was held at Brookhaven taking in costs, environmental effects and technological possibilities. It was sponsored by the BNL Department of Applied Science.

One of the hopes in the search for new power sources is the mastery of controlled thermonuclear fusion. Los Alamos are concentrating on the 'theta-pinch' technique of plasma confinement in the hope of achieving the necessary temperature and density conditions. (Bigger programmes on thermonuclear fusion are under way at other Laboratories – Livermore, etc.)

For power transmission, superconducting cable has been mooted for some time. Brookhaven completed a thorough study about a year ago and are continuing design work with the aim of installing, in the Laboratory electricity network, a cable about a kilometre long as a prototype. Los Alamos have gone through a similar exercise and are also working in two stages towards the construction of a one kilometre cable.

At the accelerators themselves, a considerable part of the programme with 800 MeV beams from LAMPF at Los Alamos is given to isotope production and radiation therapy (see February issue, page 42). The Brookhaven 200 MeV linac is used for isotope production and pion therapy, using high energy beams from the synchrotron, is under study. Argonne is also involved in radiation therapy. Berkeley has done a lot in biology and medicine and the new Bevalac project will contribute further to this research. Los Alamos recently organized a Symposium on practical applications of accelerator technology.

There is direct work on pollution problems. Los Alamos is involved in pollution pattern studies. Brookhaven is studying the behaviour of atmosphere pollutants (mainly the oxides of nitrogen and sulphur) emerging from the chimneys of power plants, using the isotope ratio tracer method and a portable gas chromatographic analyser which can pin down sulphur hexafluoride to a few parts in a million million. Argonne has a specific task of studying air pollution at airports and nearby O'Hare Airport gives them as good a case for study as any. In addition they are examining the ecological effect on Lake Michigan of the power stations on its shore.

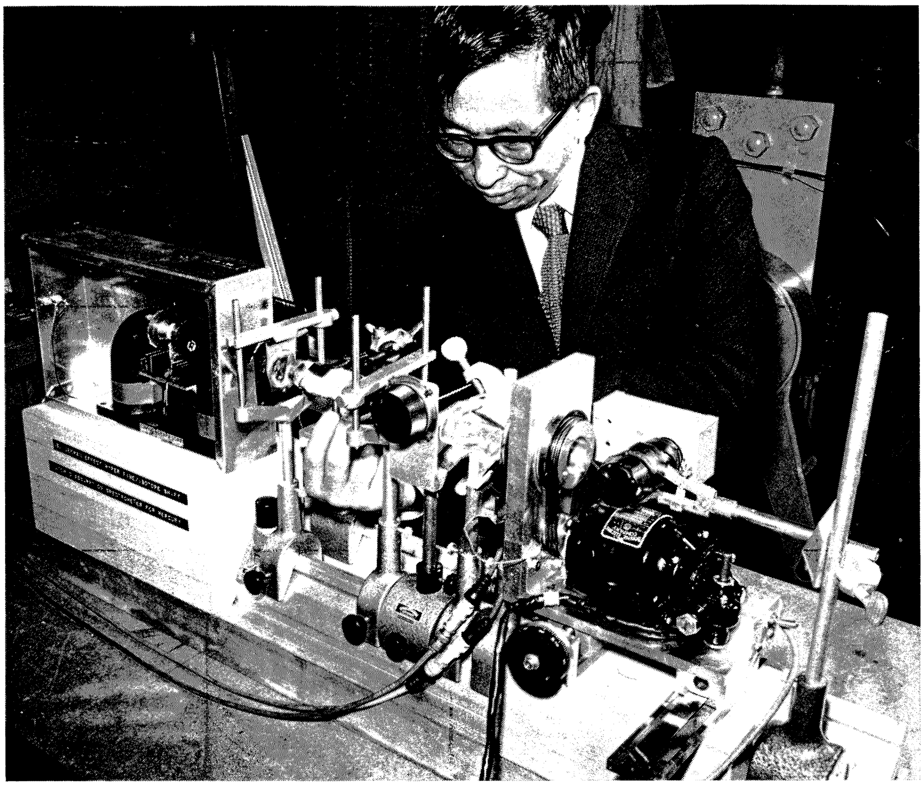
The new involvement in environmental work at the Lawrence Berkeley Laboratory emerged from the personal initiative of a few of the staff in 1970.

Behind the initiative there was obviously deep concern at the seriousness of many of the problems and a belief that Berkeley had the potentional to make significant, and possibly unique, contributions to their solution. This belief stemmed, on the one hand, from confidence in the excellent research and management capabilities in the Laboratory and, on the other hand, from appreciation that in LBL plus the neighbouring Berkeley campus of the University of California there is a wealth of interdisciplinary talent, much of it in fields of research directly related to environmental problems. At the same time it was appreciated that the money to support research in other fields would need to come predominantly from other sources than the AEC.

The first need was to build up information and a collection on environmental science was started in the library. At the same time, a series of weekly seminars began (and still continues at a reduced rate and with more emphasis on technical aspects) in which experts from the very wide range of activities involved in environmental science have been able to build up the Laboratory's awareness of what is being done, what remains to be done and where the problems lie.

In April of 1970 the staff at large were sounded out to gauge the extent of interest and to search for ideas as to the sorts of contribution the Laboratory might make. About fifty specific ideas emerged and an informal screening committee from the various departments was set up to sift through them and to select the most interesting and appropriate ones for the Laboratory to tackle. These were assembled into a booklet 'A Programme for Environmental Research'. The hunt for funding began and contacts (which have been sustained) were made with experts on the Berkeley campus.

The Laboratory management had blessed this initiative from the start and the blessing was translated into positive action at the end of 1970 when J.M. Hollander and A.M. Sessler, who had both done much to arouse interest in the programme, were appointed 'coordinators of environmental research', responsible directly to E.M. McMillan Director of LBL. Their role in the following months was to sustain interest in the work, to help in preparing definite proposals, to channel together the people with ideas, expertise and money, and generally to develop the research programme to match evident needs with the Laboratory's specific abilities. When these purposes had been fulfilled the positions of coordinator were succeeded by the appointment of Hollander as 'Assistant Director for Energy and Environment Programmes'.



*An instrument, using the Zeeman effect, developed to measure low concentrations of trace elements in organic material. Mercury can be readily detected down to the one part per thousand million range. Continuing research is demonstrating comparable sensivities for cadmium and lead.*

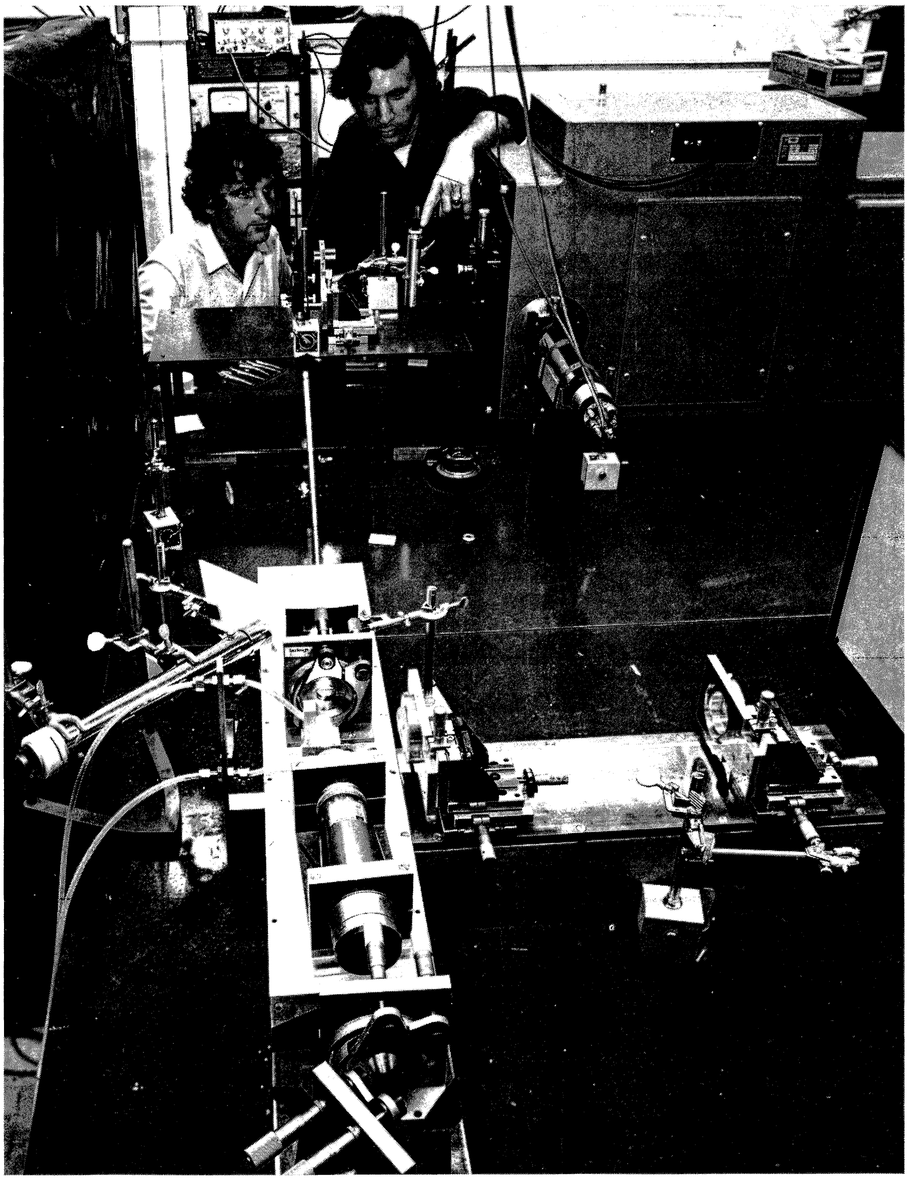
Early the following year the first project, funded by the NSF, was launched. It was a survey of instrumentation in environmental monitoring. The field of instrumentation was in some confusion at the time and yet it is obviously vital to have efficient and accurate instruments for measuring environmental conditions. It was found, for example, that continuous measurement of mercury present in the air was inadequate, that air pollution monitors were often too slow to enable action to be taken in time, that measurements of specific pollutants were often distorted by the presence of others, and so on.

The full survey is now in its third year and has resulted in a volume of information on available pollution monitoring instruments in loose-leaf form which can be readily updated. Anyone now searching for, say a sulphur dioxide monitor capable of a specific accuracy, and having other features such as cheapness, portability, etc... can now flip through the catalogue and see whether such an instrument is on the market.

Several needs which became evident in the course of the survey have been tackled in subsequent research proposals. The proposals were carefully studied and developed before being presented for approval and as a result a high proportion of those presented to the National Science Foundation in the summer of 1972 were funded. To illustrate the type and scale of the work which has been going on we pick out some (not all) of the research proposals which have been worked on.

A few years ago there was a considerable stir concerning the mercury contamination of fish, particularly tuna fish. Large stocks and incoming catches had to be dumped because their mercury level exceeded the

*Alignment of components being used in the development of an instrument using resonance Raman scattering. The incident beam comes from a tunable dye laser in the foreground; a high resolution spectrometer is to the left of the experimenters. The technique shows promise as a way of measuring, from a distance, the concentration and chemical composition of pollution in the atmosphere.*



maximum concentration (500 parts per thousand million) allowed by the US Department of Public Health. The conventional atomic absorption spectroscopy technique requires chemical separation of the mercury before measurement. Evaporation of the fish gives smoke and organic compounds which scatter and absorb the monochromatic mercury light used to illuminate the sample. There is no way to distinguish this from the absorption by mercury vapour emerging from the fish. Thus the measurement procedure is rather cumbersome and long and requires the help of a competent chemist.

The Berkeley work, led by T. Hadeishi, was prompted by one of the weekly seminars on mercury contamination of food and applied the knowledge coming from basic research in atomic physics. Using a mercury isotope lamp in a magnetic field, the light used to illuminate the fish sample, which is vaporized without chemical separation, is split into a number of wavelengths (Zeeman effect and hyperfine structure). The mercury which is present will absorb light corresponding to certain of these wavelengths but the other vapours from the fish sample do not distinguish between the wavelengths. This gives the handle to measure mercury contamination and an instrument sensitive to one part in a thousand million has been developed.

The instrument is simple to use. It involves extracting a tiny portion of fish (pin head size) and popping it into the oven part of the instrument. Within a minute the contamination can be read off in parts per million on a meter. The instrument is about the size of a suitcase and thus can be transported on a boat. It makes it possible to check a catch by testing one or two fish rapidly without drawing in the nets.

Current work is concentrating on extending the application of the instrument to the measurement of other contaminents such as lead or cadmium and to improving the sensitivity. It may also prove possible to identify chemical species by relating the measurements to evaporation temperatures.

An important study on the reactions of the oxides of nitrogen was initiated by concern for the effect of supersonic aircraft penetrating the stratosphere where an ozone blanket protects the earth from excessive ultra-violet radiation. The question was whether the nitrogen oxides in the exhaust gases of the aircraft could in any way eat up the ozone.

H.S. Johnston worried about the possibility of catalytic reactions such as —

$NO + O_3 \rightarrow NO_2 + O_2$

$NO_2 + O \rightarrow NO + O_2$

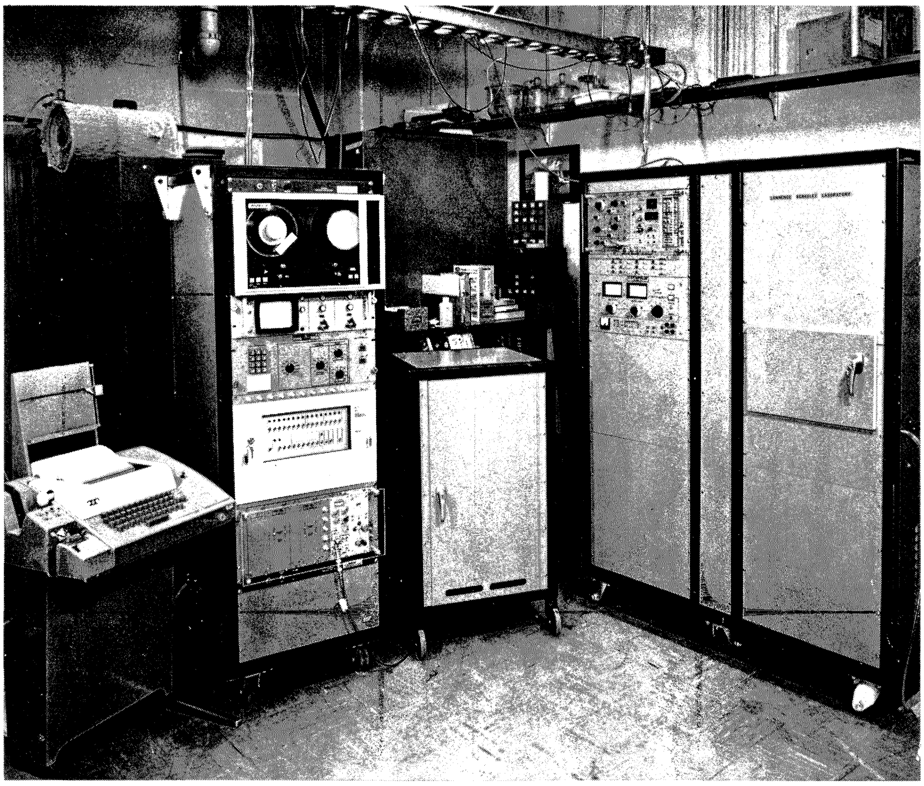
These reactions occurring in sequence could remove ozone ($O_3$) and leave the nitric oxide (NO) still free for further reactions. This has led to a detailed study of the balance of the chemical reactions in the conditions of the stratosphere.

Another topic was the study of rock shattering with pulsed high intensity electron beams. This was described in the May issue, page 149. It showed that the technique is feasible as a new method of tunnelling through rock but needs more work to specify an optimum system and then to calculate whether it is an economic competitor with other techniques.

Other new methods for measuring contamination include the use of X-ray fluorescence and the use of a resonant Raman effect. The first emerged from basic research in nuclear chemistry. It involves the use of semiconductor detectors in an X-ray

*The X-ray fluoresence spectrometer system which has been designed and built at Berkeley for the US Environmental Protection Agency. It is used for air pollution studies and consists of an automated sample collector, X-ray analysis equipment and a computer for control and data reduction. Air particulate samples can be collected automatically at time intervals of 1 to 24 hours and analysed for up to 35 elements.*

*(Photos LBL)*



fluorescence spectrometer. Under F. Goulding, an instrument has been developed which provides an extremely versatile and rapid method of identifying minute traces of elements which are present in virtually any material which can be dehydrated. Thus, for example, lead contamination in paint or human blood, mercury in the atmosphere, etc., can be immediately monitored. The Environmental Protection Agency has supported this development of a compact instrument for routine monitoring of atmospheric pollution.

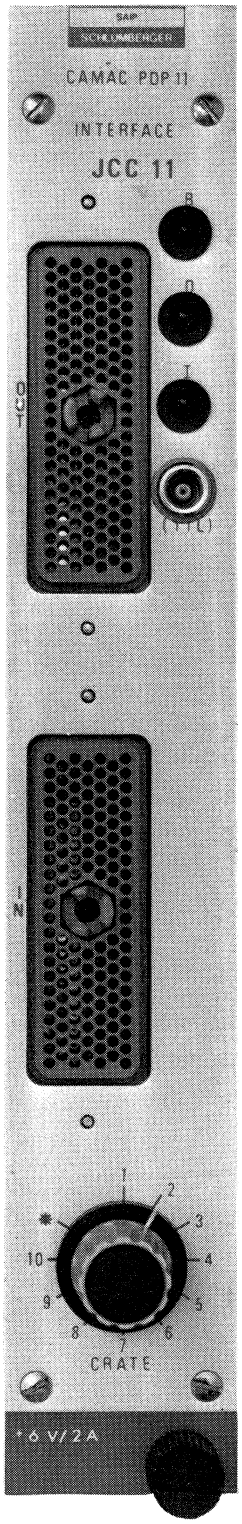
The Raman effect is essentially a scattering process where scattered light has the initial frequency of the incident monochromatic radiation and frequencies shifted by the vibrational spectra of the molecules exposed to the light. The idea is to use this phenomenon for the 'remote sensing' of atmospheric pollutants. Directing laser light at the smoke from factory chimneys and looking at the back scattered Raman lines identifies the molecules and thus the chemical composition of the smoke. It is obviously vital to monitor this and to provide legally acceptable proof of abuses.

An instrument based simply on the Raman effect could only be used at night (since solar light would interfere with the measurements) and have a range of about 50 m. The work, led by O. Chamberlain, aims to produce an instrument with a range of several kilometers which can be used round the clock. It uses the fact that the Raman scattering efficiencies can be enhanced many thousands of times by selecting a frequency close to that at which the molecule absorbs light (the resonance Raman effect). Using a tunable laser the difficulties should be overcome.

The environmental research programme has so far concentrated on developing individual ideas which seemed relevant to environmental problems. With this base programme established, the philosophy is moving more towards looking at the nation's urgent problems in the field of energy and environment to see where the Laboratory can help. The AEC is now in a position to consider non-nuclear work and has a Division concerned with Biomedical and Environmental Research. This also encouraged a broader approach.

Proposals were drawn up on such topics as geothermal energy, solar energy and the biomedical effects of non-nuclear energy sources. These proposals were presented to the Atomic Energy Commission but the President's Office of Management and Budget pruned non-nuclear work from the AEC programme for the present fiscal year and none of the proposals has got off the ground.

Nevertheless, the Lawrence Berkeley Laboratory now has a significant programme concerned with environmental problems. It involves an expenditure of about a million dollars per year and forty scientists are committed to the programme. Coming from the personal concern of a few people three years ago, this is no small achievement.



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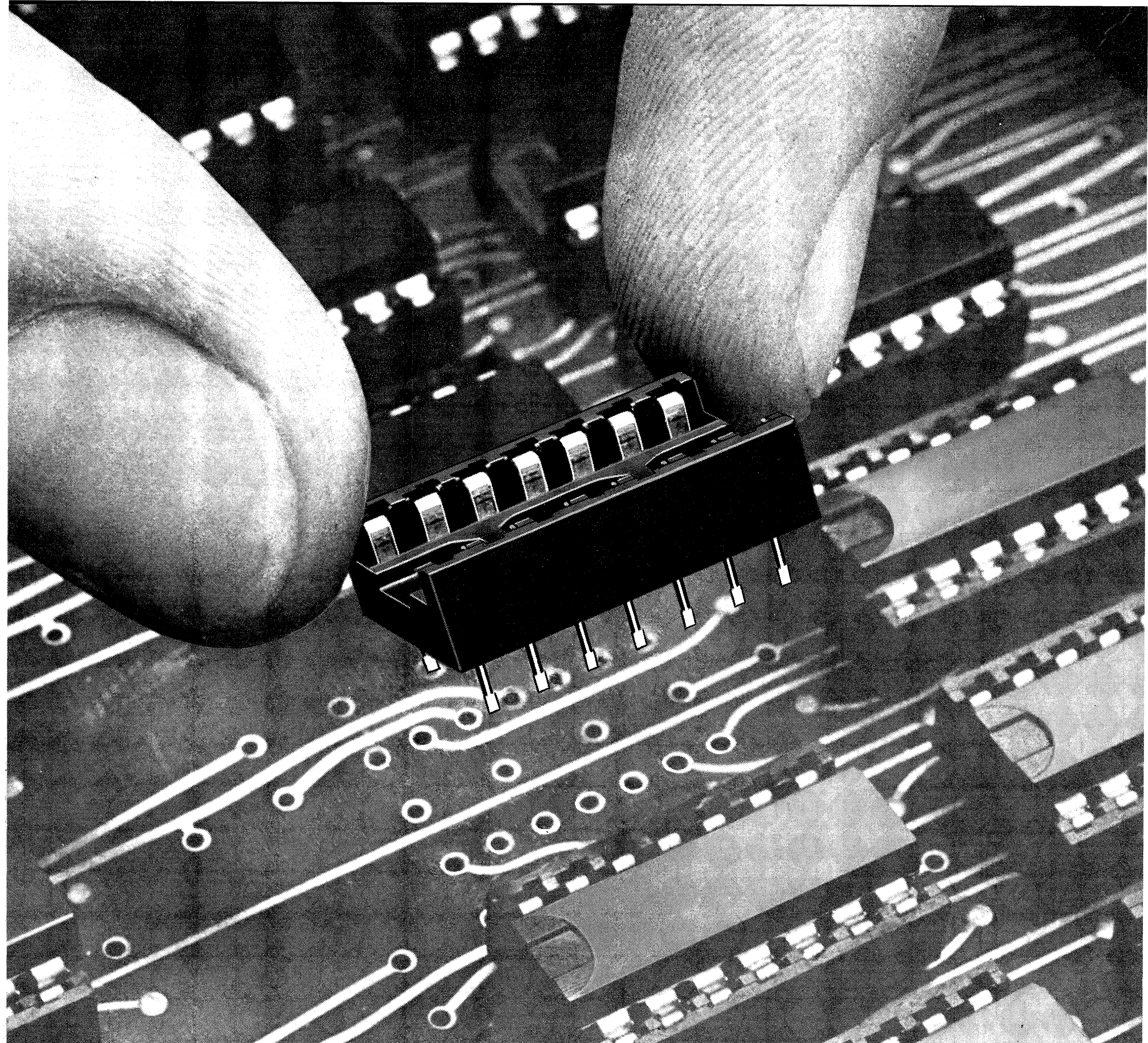

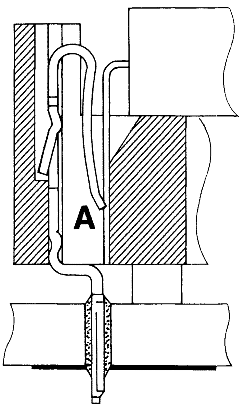
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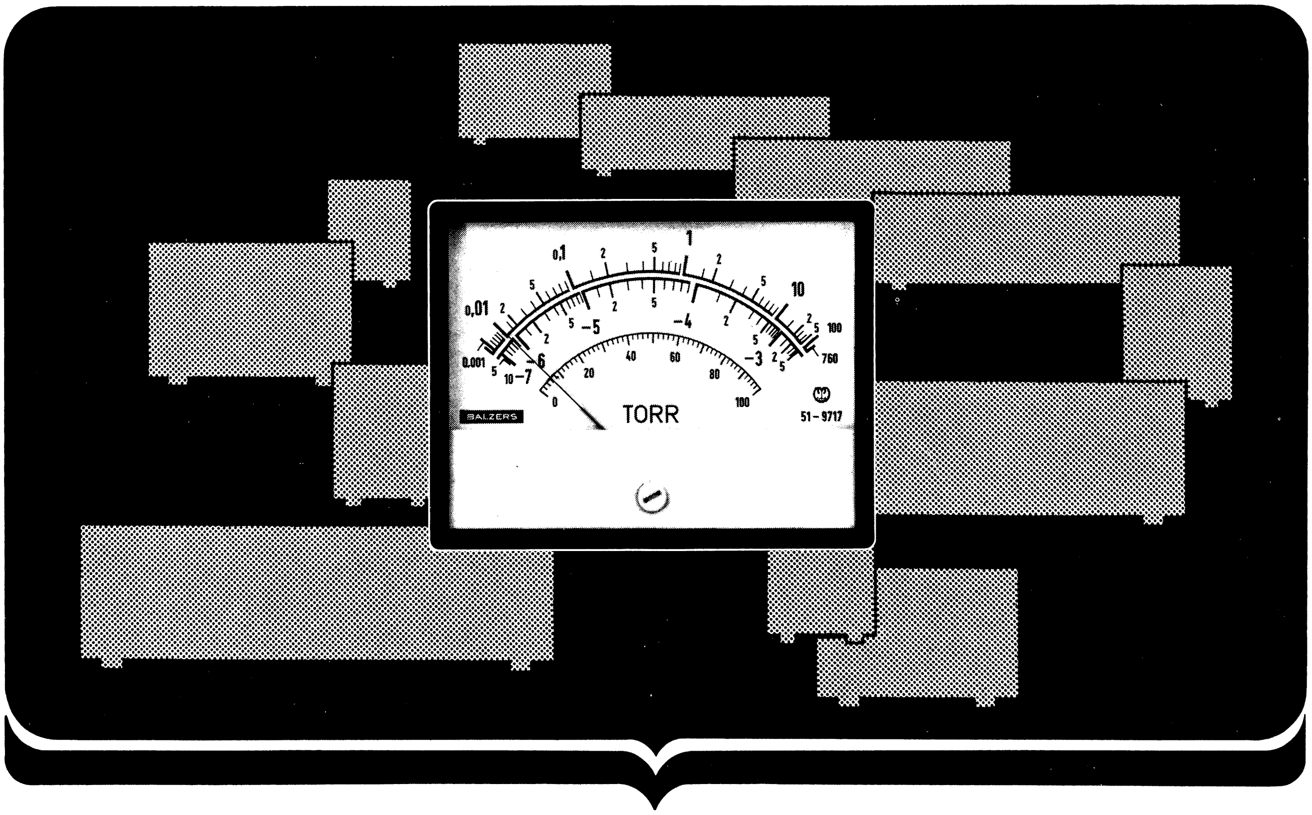
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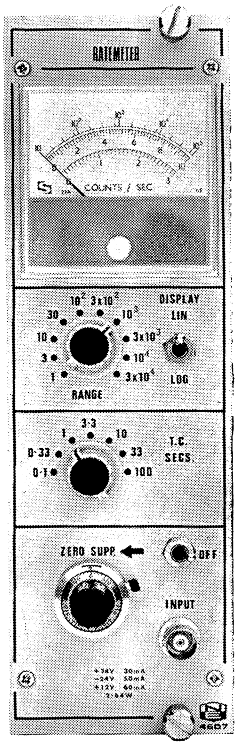
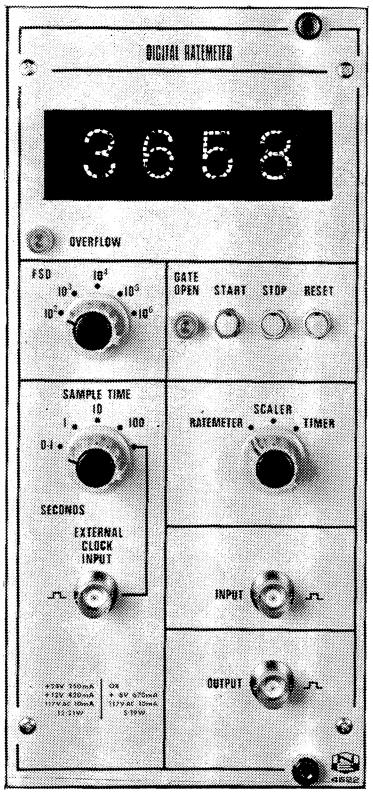
# NIM RATEMETERS



## Combined Lin-Log Ratemeter NE 4607

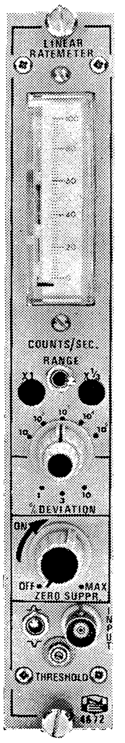
- Linear FSD up to 3 x $10^4$ cps
- Log FSD up to $10^5$ cps
- Zero Suppression up to 100% FSD
- Recorder Output Lin-Log 100mV or 1mA



## Digital Ratemeter NE 4622

- Display 4 digit decimal
- Functions Ratemeter or Scaler or Timer
- Outputs Analogue or Digital

**Write for full details and 1973 50-page NIM International Series Catalogue No 65 containing specifications of over sixty modules and a 12-page Systems Design Guide. NIM units are readily integrated with CAMAC modules.**



## Low-cost Linear Ratemeter NE 4672

- Range up to $10^5$ cps
- Zero Suppression up to 100% FSD
- Recorder Output 100mV or 10V or 1 mA
- % Deviation 1, 3, 10%

NUCLEAR
ENTERPRISES
LIMITED

**SIGHTHILL, EDINBURGH EH11 4EY, SCOTLAND**
**Telephone: 031-443 4060**
**Cables: Nuclear, Edinburgh Telex: 72333**

Bath Road, Beenham, Reading RG7 5PR, England,
Tel: 07-3521 2121 Telex: 848475.
Cables: Devisotope, Woolhampton.

Associate Companies
Nuclear Enterprises GmbH, Schwanthalerstrasse 74,
8 München 2, Germany. Tel: 53-62-23. Telex: 529938.

Nuclear Enterprises Inc., 935 Terminal Way, San Carlos,
California 94070. Tel: 415 593 1455. Telex: 348371.

**Switzerland:** High Energy & Nuclear Equipment S.A.,
2, Chemin de Tavernay, Grand-Saconnex, 1218 Geneva
Tel: (022) 98 25 82/3 Telex: 23429

# For all those lucky PDP-11/45 owners.

# Announcing timesharing and real time software.

**Powerful new software.** It's hard to make owners of our PDP-11/45 any happier. What with 300 nanosecond cycle time. Solid-state and core memory to 248K bytes. 64-bit, multi-accumulator, floating point hardware. Hardware memory management, and more. At an unbelievably low price. Well, we did. By introducing powerful new timesharing and real time software.

**Timesharing.** The RSTS-E software system. It handles up to 32 users at one time, each with up to 16K words. With RSTS-E, everyone can use the peripherals on line. Large scale peripherals like 20-million-word disc packs and high-speed line printers. Plus magnetic tape drives, paper tape and card equipment.

In addition, an expanded form of BASIC allows string operations. On-line files as big as 30-million characters each. Matrices. ALGOL-like statements. And data processing aids.

**Real time.** That's RSX-11D. An integrated real time software system that can control a whole process or automate an entire laboratory with power to spare. Real time response is measured in microseconds. Even with hundreds of tasks going on simultaneously.

Memory is used with maximum efficiency. RSX-11D is the first low-cost system to use dynamic memory management. Yet security is absolute because every task is individually hardware protected.

And RSX-11D has full ANSI FORTRAN IV. With ISA Real Time Extensions. Plus a FORTRAN IV compiler, macro-assembler, and full utility programs all running on-line simultaneously with real time operations.

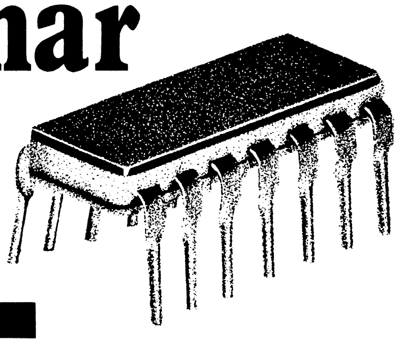
RSTS-E and RSX-11D are also available on the PDP-11/40.

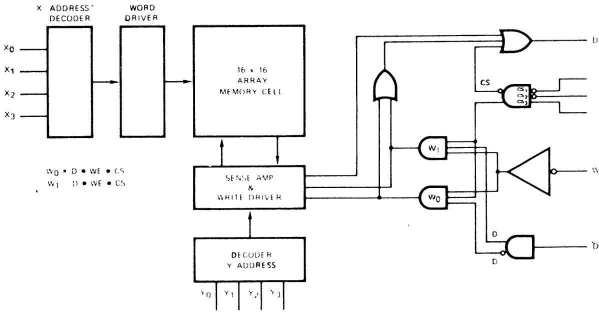
**Learn what this new software can do for you.**

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

Offices in Reading, London, Manchester, Birmingham, Bristol, Edinburgh, Munich, Cologne, Frankfurt, Hannover, Stuttgart, Vienna, Stockholm, Oslo, Copenhagen, Helsinki, Paris, Grenoble, The Hague, Brussels, Zurich, Milan.

digital




X ADDRESS DECODER
WORD DRIVER
X0
X1
X2
X3
16 × 16 ARRAY MEMORY CELL
SENSE AMP & WRITE DRIVER
DECODER Y ADDRESS
Y0
Y1
Y2
Y3
W0 • D • WE • CS
W1 D • WE • CS
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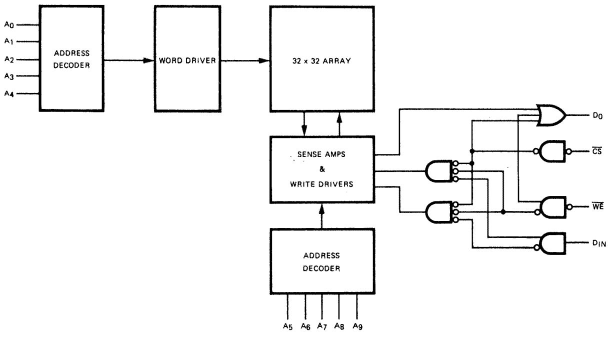
A0
A1
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A4
ADDRESS DECODER
WORD DRIVER
32 × 32 ARRAY
SENSE AMPS & WRITE DRIVERS
ADDRESS DECODER
A5
A6
A7
A8
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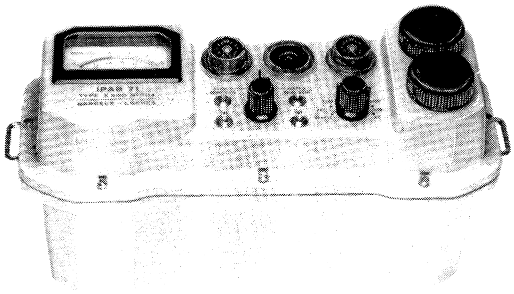
D0
$\overline{CS}$
$\overline{WE}$
DIN

RADIO PROTECTION



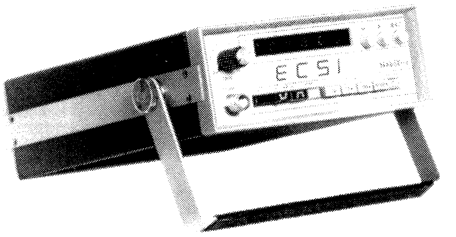
PORTABLE POLYRADIAMETER

IPAB 71 Réf. 500
**Self-powered, waterproof, warning**

ELECTRICAL CHARACTERISTICS

- High voltage : can be regulated from + 200 to 2200 Volts
- Ranges : 10 - 100 - 1000 - 10000 cps
- Accuracy : better than 5 %
- Limit operating temperature : - 10° C + 50° C
- Discriminator threshold : 1 volt
- Equivalent capacities : GM - PM - 0.6 pF
  CPA - BF3 - semi conductor detectors 0.04 pF

COUNTING



ELECTRONIC COUNTING SCALE

E.C.S. 1 Réf. E.521
**Portable, self-powered, six decades**

ELECTRICAL CHARACTERISTICS

- Pretime : 1 - 10 - 100 - 1000 s (accuracy $10^{-3}$)
- Resolution time : < 5 µs frequency > 200 KHz)
- Input pulses : positive or negative, duration ≥ 100ns
- Threshold adjustement : 0.1 à 10 V
- Input impedance : 1000 Ω
- Working temperature range : - 10° C to + 50° C

**NARDEUX**

85 Bd Gabriel Péri 92240 MALAKOFF - 656-65-35 +
Usine : 37600 Loches - FRANCE

**PEARSON**

Very High Voltage

**PULSE TRANSFORMERS**

Pearson Electronics, Inc. specializes in the development, design, and manufacture of very-high and super-high-voltage, high-power pulse transformers and related modulator components. Typical pulse transformers manufactured by Pearson Electronics, Inc. range in output voltage from 40 kV to 600 kV. Other Pearson pulse-modulator components include precision current transformers, voltage dividers, and charging inductors. Inquiries regarding specific requirements for these components are welcomed.

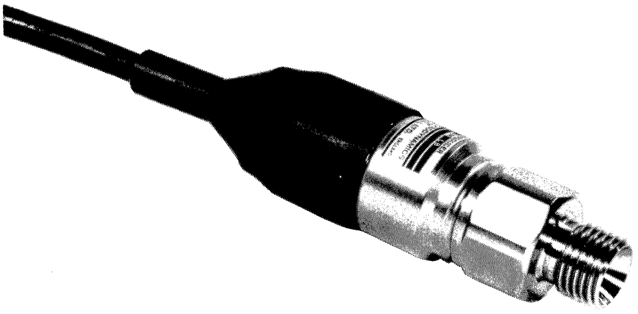
**PEARSON ELECTRONICS, INC.**

4007 Transport St., Palo Alto, California 94303, U. S. A.
Telephone (415) 326-7285

BELL & HOWELL

**4-366 PRESSURE TRANSDUCER**

GENERAL PURPOSE



- Small, light weight
- Easy to install and use
- 40 mV direct output
- 350 OHMS source impedance
- Non-linearity and hysteresis: < ±0.5% F.R.O.

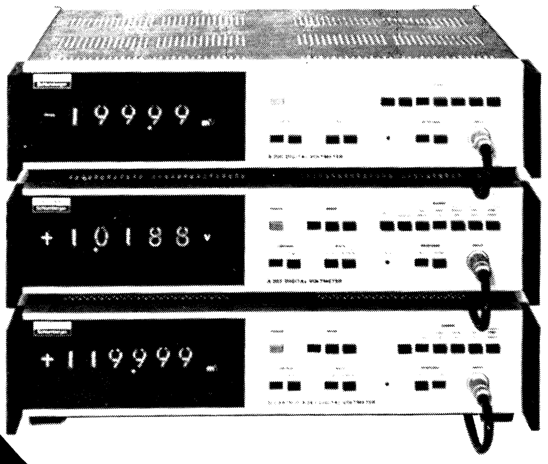
**MANY OTHER MODELS IN THE PROGRAM**

Please ask for more information or a demonstration 7015 RO

Industrievertretungen
Junkholz 333 – CH-8968 Mutschellen
STOLZ AG
Tel. 057 5 46 55

**Schlumberger**

**Pour chaque application le voltmètre qui convient**



**Il existe maintenant 17 modèles de voltmètres numériques de la «Master Série»pour DC, AC, Ω ou ratio conçus pour travailler indépendamment ou en système à 10, 25 ou 100 mes/sec.**

- Affichage ± 19 999 ou ± 119 999
- Précision 0,01 % jusqu'à 0,003 %
- Résolution 10 µV ou 1 µV
- Intégration double rampe asservie au secteur
- Messures AC en valeurs moyennes ou efficaces
- Adapteur de courant, sortie sur imprimante et programmation livrables en option.

**Mesurez consciencieusement avec les appareils de la «Master Série».**

**Schlumberger**

**8040 Zürich**
**Tel. 01 52 88 80**

**1207 Genève**
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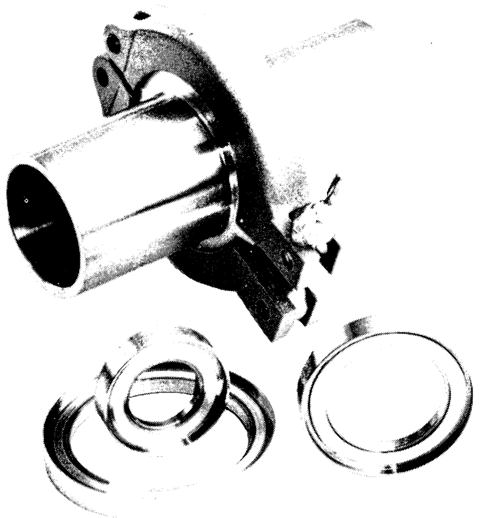
VAT

**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

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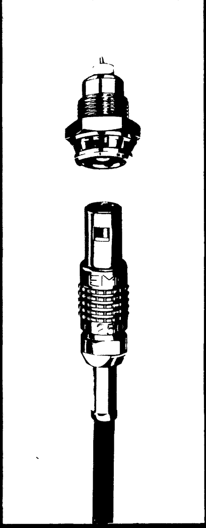
TECNIDATA

# 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)

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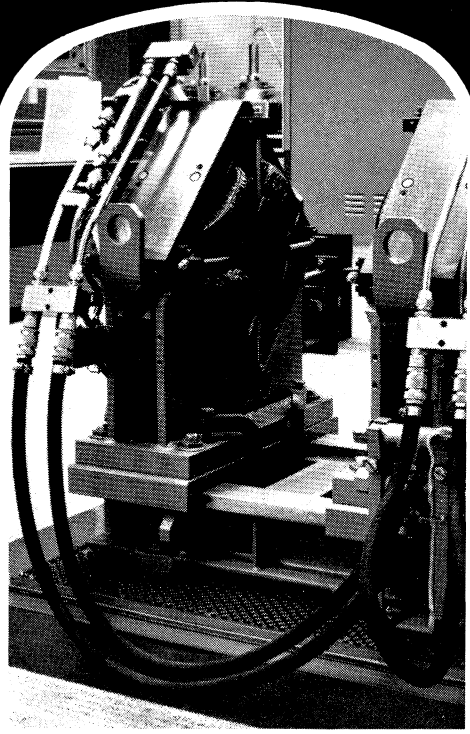
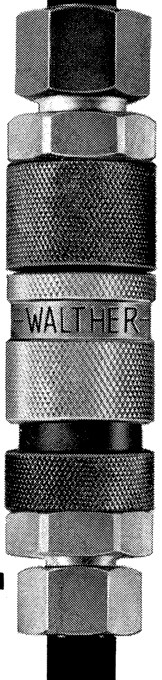
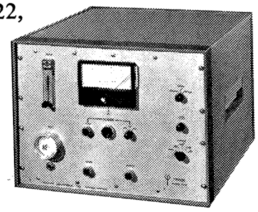


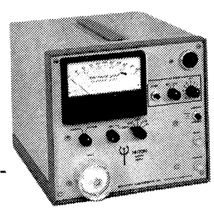

WALTHER

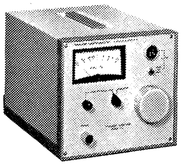
# Reliability

## ...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: $10\mu Ci/M^3$ 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 ($50\mu Ci/M^3$, full scale). Features rechargeable nickel-cadmium batteries. The 1055 can be operated (and its batteries recharged) on standard line current. Has recorder output.

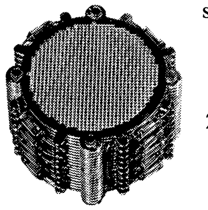
**TRITON 1125** — Mil-spec quality. Portable, rugged, rainproof. $100\mu Ci/M^3$ full scale for $H^3$.

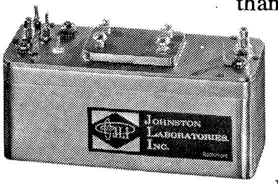
**TRITON Calibrator (CL-1) and Remote Alarm (RA-1)** — A calibrator (with enough tritium gas for 1000 or more calibrations) and a remote alarm (with both visual and audible systems) are also available.

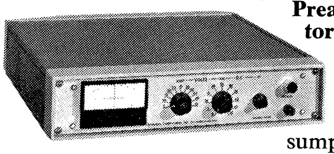
**RADON SYSTEM** for low-level analysis of radon samples from human respiration, mine, or water supply effluents, air. Includes Radon Concentrator (RCTS-2) which purifies, concentrates, and transfers samples to Radon Counter (LAC-2). Its scintillations produced by Radon gas are counted by photomultiplier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

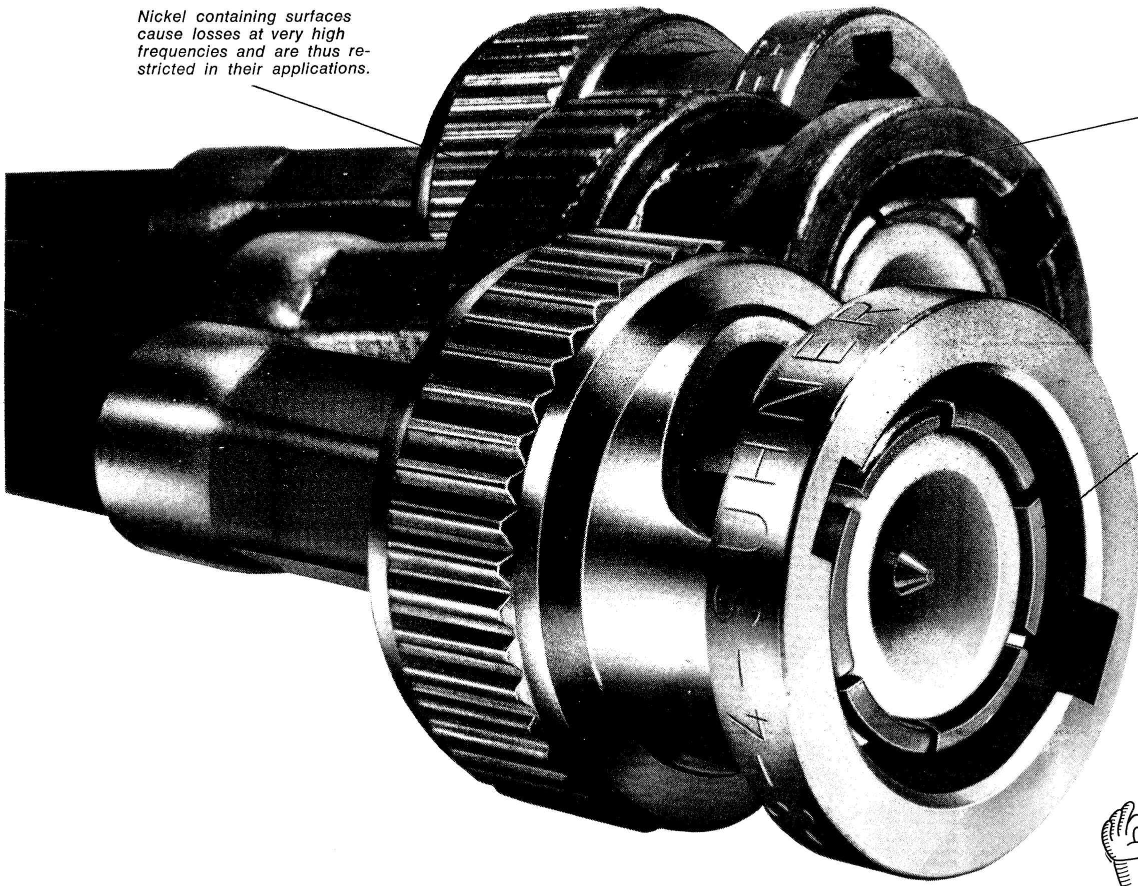
**BACTEC Model 225, fully automatic; BACTEC Model 301, semi-automatic.** For bacterial detection in clinical samples of blood, urine, spinal, synovial, and pleural fluids. And for sterility testing of pharmaceuticals, foods, drugs, radioisotopes and other products.

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"

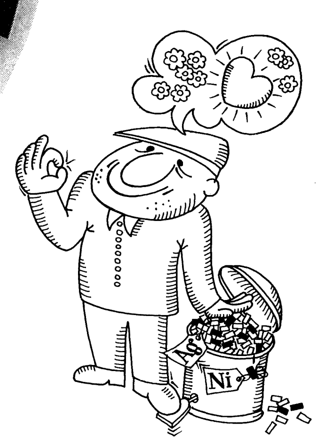
**Huber + Suhner have the answers to all connector and cable problems in the entire field of RF-communications. For instance:**



*Nickel containing surfaces cause losses at very high frequencies and are thus restricted in their applications.*

*Silver discolours easily through chemical influences and shows quickly signs of wear.*

*SUCOPLATE® has the shiny appearance of fine satin-finished steel, not affected by chemicals, free of discolourings, oxide and other corrosive layers. It is highly scratch resistant with optimum high frequency transmission characteristics.*



# Sucoplate® for RF-Connectors banishes Silver and Nickel to the Old Iron!

**RF-connectors should transmit every signal with negligible RF-losses, they ought to be price-right and appear always neat and gleamig despite corrosive influences. Silver manages one thing, Nickel the other, SUCOPLATE® achieves both:**

**RF**-connectors with SUCOPLATE® finish meet all requirements of MIL-C-39012. SUCOPLATE® combines high conductivity with minimal RF-losses: the conductivity exceeds up to multi-fold the values of nickel and is comparable to performances achieved by galvanically applied silver layers. With a relative permeability $\mu r$ of 1, SUCOPLATE® is non-magnetic and does not cause losses even at high frequencies.

The pleasing appearance is maintained even in an agressive industrial atmosphere: unlike silver, SUCOPLATE® does not discolour, there is no build up in oxide and other corrosive layers as is usually the case in nickel containing surfaces — not even at high temperatures and in excessive humidity. Not surprisingly, SUCOPLATE® has passed all internationally normed salt spray tests with flying colours!

The hardness of SUCOPLATE® is double that of silver: its resistance to scratch and wear more than ten-folds the life expectancy compared to a silverplated connector. SUCOPLATE® is readily solderable and is available in the entire range of SUHNER RF-connectors.

**HUBER+SUHNER AG**

Werk Herisau
Kabel-, Kautschuk-, Kunststoff-Werke
CH-9100 Herisau. Tel. 071/53 15 15

## FREE:

one SUHNER-connector with SUCOPLATE® finish, plus the relevant information. You will receive both upon return of this coupon.

Company name: ______________________

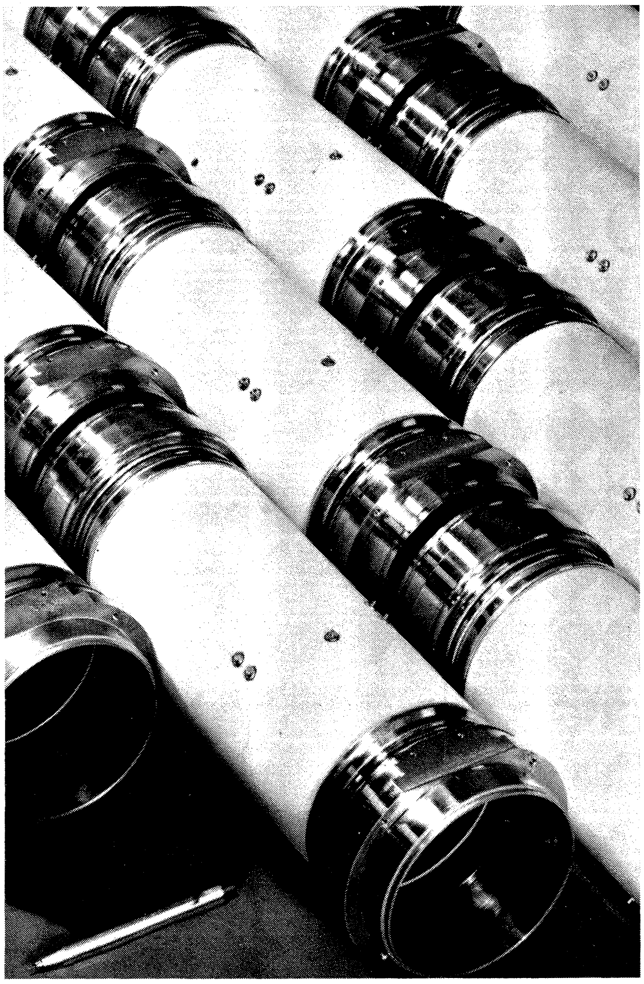
Address: ______________________

______________________

For the attention of: ______________________

______________________

Herzog AG



Electrodes Pick-up réalisées pour le Booster Service SI. C.E.R.N. - Métallisation intérieure, avec dorure. Scellement étanche céramique-titane-inox, et assemblage des embouts inox sur inox par bombardement électronique.

**FABRICATIONS DE LA DIVISION "OXYDES FRITTÉS"**

ARTICLES DE LABORATOIRE en oxydes frittés
GUIDE FILS « ZIRTEX »
BUSES DE PULVÉRISATION « ALBUZ »
PASSAGES ÉLECTRIQUES ÉTANCHES
Céramiques métallisées et brasées
PIÈCES pour MÉCANIQUE, NUCLÉAIRE, ÉLECTROMÉCANIQUE
Tubes, barreaux, plaques, disques en AF 997
Revêtements céramiques par projection
Pièces usinées rectifiées
PIÈCES pour ÉLECTRONIQUE
Radômes, fenêtres électromagnétiques
Pièces en oxyde de Bérylium « BEROXYD »
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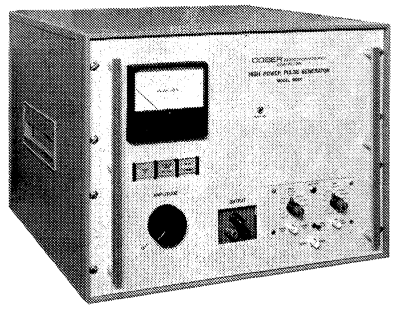
**Desmarquest et C. E. C. S.A.**

LDC 1804

DIVISION "OXYDES FRITTÉS"
Zone Industrielle N° 1
27000 EVREUX - France
Téléphone : 33.05.95
Télex : 18.573 F - DESCERAM - EVREUX

what's new?

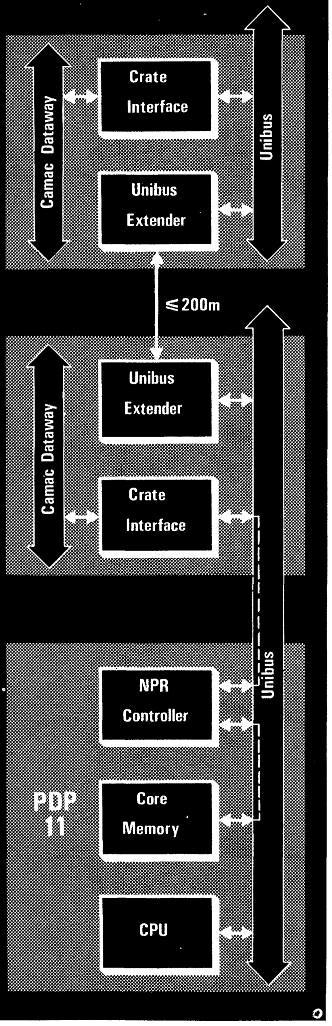


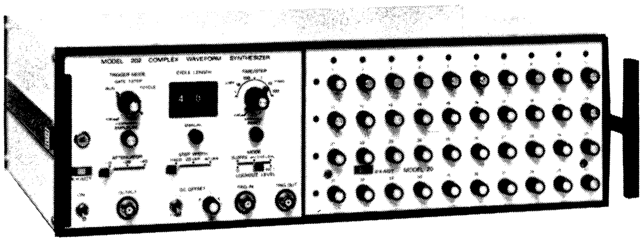
**How about a new laboratory pulse generator that puts out over 30Kw!**

Cober now produces a 31Kw pulse generator to drive plasma tubes, pulse lasers, trigger optic modulators, do non-destructive testing, nuclear research . . . anywhere that high power is demanded. The new Model 606 puts out 2500V at 12.5 amps, (or other voltage and current combinations), with pulse widths from 50ns-10ms, and rep rates from 1 shot-1MHz, with only 20ns rise time . . . all with POS/NEG polarity.

You get off-the-shelf delivery, qualified applications assistance, plus 20 years of high power test equipment experience. Write or phone today for all the facts and prices.

**Cober**
electronics, inc.
**"THE HIGH POWER PEOPLE"**
**7 Gleason Avenue, Stamford, CT 06902**
**Phone: (203) 327-0003 TWX: 710-474-3371**


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

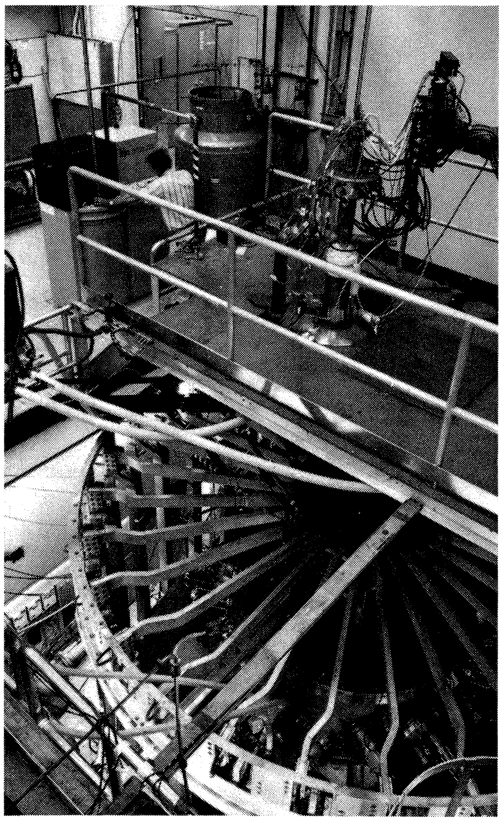


# WHAT'S COLD DOING AT LIVERMORE?

The Levitron at Lawrence Livermore Laboratory* in California represents a productive blend of plasma physics and imaginative cryogenic engineering. Its goal is a deeper understanding of the nature of plasmas, their production, and their heating, all necessary to the scientist's dream of controlling nuclear fusion for practical purposes.

The heart of the Levitron is an 80-centimeter diameter superconducting ring, "floated" in a complex of field-shaping and ring-positioning magnets, all held at 4.5K within a dewar evacuated to the $10^{-9}$ torr range.

A CTI Model 1400 Helium Liquefier supplies the liquid to an overhead dewar/reservoir for system cooldown and steady-state operation. A network of fixed piping carries liquid helium to the stationary magnets by natural circulation. The piping also serves as a cold conduit for the power and instrumentation leads. The ring is cooled by conduction (utilizing indium-coated retractable probes) prior to its levitation.



Water-cooled toroidal field coils surround the Levitron vacuum vessel. Experimental results from the Levitron are encouraging. It has demonstrated great versatility in providing a variety of toroidal magnetic configurations for plasma confinement. Plasmas with densities of $10^{11}$/cc have been confined for up to one second. Very hot electron plasmas (electron temperatures up to 0.5 MeV) have been confined for considerably longer times.

The Model 1400's performance is heartening too, as a reliable source of continuous cooling for the Levitron experiment.

The Model 1400 was designed with superconducting systems in mind, and will run for weeks between simple, routine maintenance periods. It can produce from 5 to 40 liters per hour of liquid helium, 20 to 100 watts of refrigeration at 4.5°K, 100 to 350 watts of cooling at 20°K, and can be modified for hydrogen or neon liquefaction.

Write or call CTI today for full details on versatile and reliable Model 1400 Helium Refrigeration Systems.

*Operated by the University of California for the U.S. Atomic Energy Commission

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