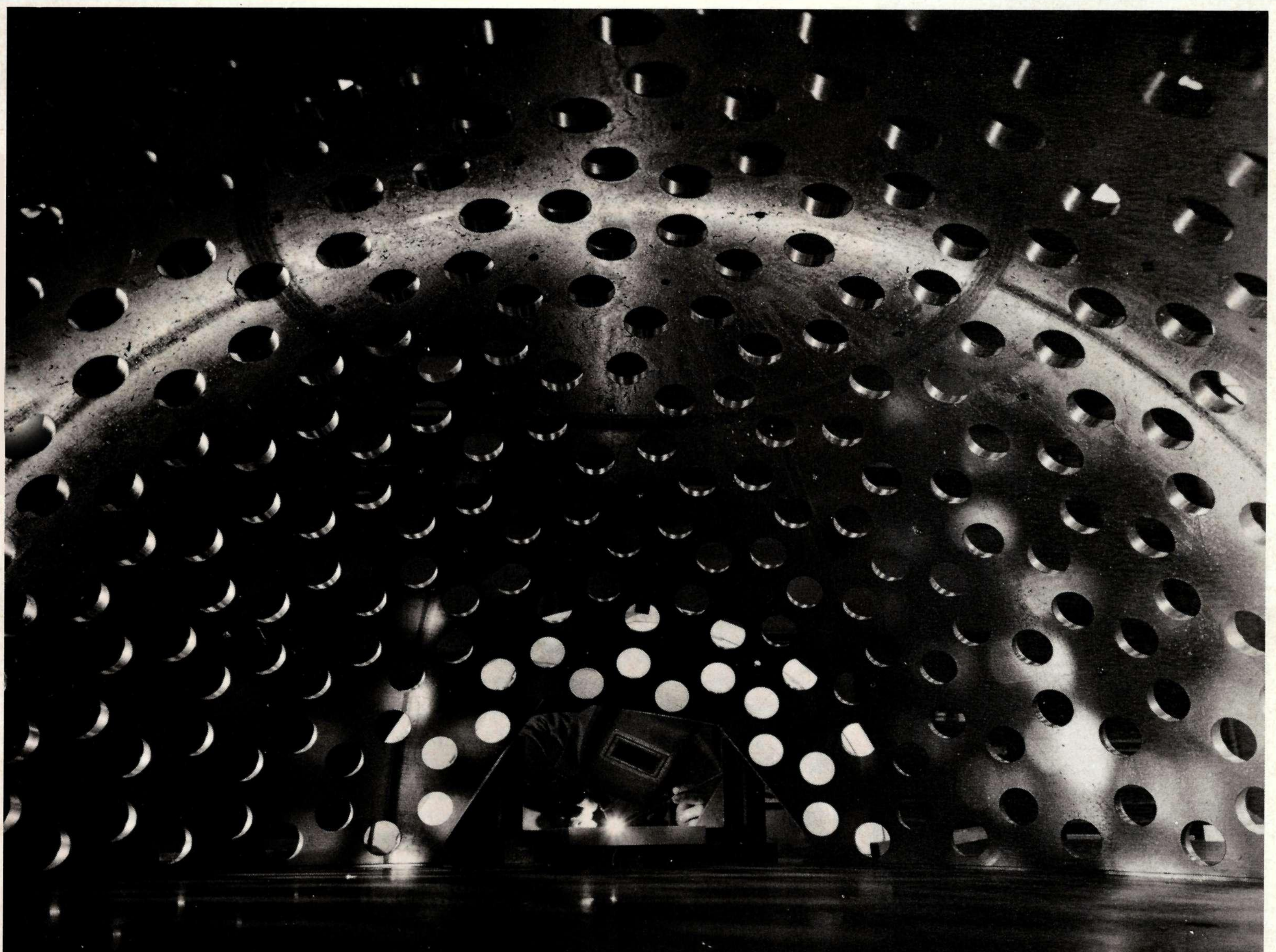
CERN COURIER

NO. 1/2 VOL. 17 JANUARY/FEBRUARY 1977



CERN COURIER, Journal of High Energy Physics, is published monthly in English and French editions.

Copies are available on request from:

Federal Republic of Germany —
Frau I. Schuetz
DESY, Notkestieg 1, 2 Hamburg 52

Italy —
INFN, Casella Postale 56,
00044 Frascati,
Roma

United Kingdom —
Elizabeth Marsh
Rutherford Laboratory, Chilton, Didcot
Oxfordshire OX11 0QX

USA/Canada —
Margaret Pearson
Fermilab, PO Box 500, Batavia
Illinois 60510

Other countries —
Marie-Jeanne Blazianu
CERN 1211 Geneva 23, Switzerland

Laboratory correspondents:

Argonne National Laboratory, USA
Ch. E.W.Ward
Brookhaven National Laboratory, USA
J. Spiro
Cornell University, USA
N. Mistry
Daresbury Laboratory, UK
J. Bailey
DESY Laboratory, Fed. Rep. of Germany
I. Dammann
Fermi National Accelerator Laboratory, USA
R.A. Carrigan
Frascati National Laboratory, Italy
M. Ghigo
GSI Darmstadt, Fed. Rep. of Germany
H. Prange
IEKP Karlsruhe, Fed. Rep. of Germany
F. Arendt
INFN, Italy
A. Pascolini
JINR Dubna, USSR
V.A. Biryukov
KEK National Laboratory, Japan
K. Kikuchi
Lawrence Berkeley Laboratory, USA
W. Carithers
Los Alamos Scientific Laboratory, USA
O.B. van Dyck
Novosibirsk Institute, USSR
V. Balakin
Orsay Laboratory, France
J.E. Augustin
Rutherford Laboratory, UK
G. Stapleton
Saclay Laboratory, France
A. Zylberstejn
SIN Villigen, Switzerland
G.H. Eaton
Stanford Linear Accelerator Center, USA
L. Keller
TRIUMF Laboratory, Canada
M.K. Craddock

Editor: Brian Southworth

Assistant Editor: Henri-Luc Felder

Advertisements: Micheline Falciola

Printed by: Cherix et Filanosa SA,
1260 Nyon, Switzerland
Merrill Printing Company
765 North York, Hinsdale,
Illinois 60521, USA

Published by: European Organization for
Nuclear Research
CERN, 1211 Geneva 23,
Switzerland
Tel. (022) 83 41 03
Telex 23698

Contents

Around the Laboratories

FERMILAB: Dileptomania 3
Description of experiments on dilepton production at high energies with some results and interpretations

SIN: Design intensity exceeded 5
Cyclotrons at the Swiss meson factory top 100μA for the first time in a December run

RUTHERFORD: Energy Research Support Unit 5
Laboratory formalises help to UK Universities working on energy projects

ARGONNE: Crab-Eye Cherenkov Counters 6
Large counter arrays with compound parabolic light collectors used in sigma hyperon experiment

LOS ALAMOS: Materials study for fusion reactors 7
800 MeV protons could simulate neutron bombardement in investigations of materials properties for fusion

SACLAY: Helium ions for radiography 8
Beams from Saturne 1 used in promising studies on the use of ions in medicine

DESY: A busy year at DORIS 9
New records in 1976 for luminosity and reliability at the electron-positron storage rings

CORNELL: Streamer chamber experiment 10
DESY/CORNELL collaboration continue the study of electron scattering at higher energies

CERN: Colliding deuterons in the ISR/Joys and chagrins at the SPS/New computer performing well 11
Successful deuteron physics runs in the storage rings/Further performance advances and an accident at the 400 GeV synchrotron/IBM central computer undergoing acceptance tests

ORSAY: New vector meson 14
Evidence for a new particle decaying into pions seen on the DCI electron-positron storage ring

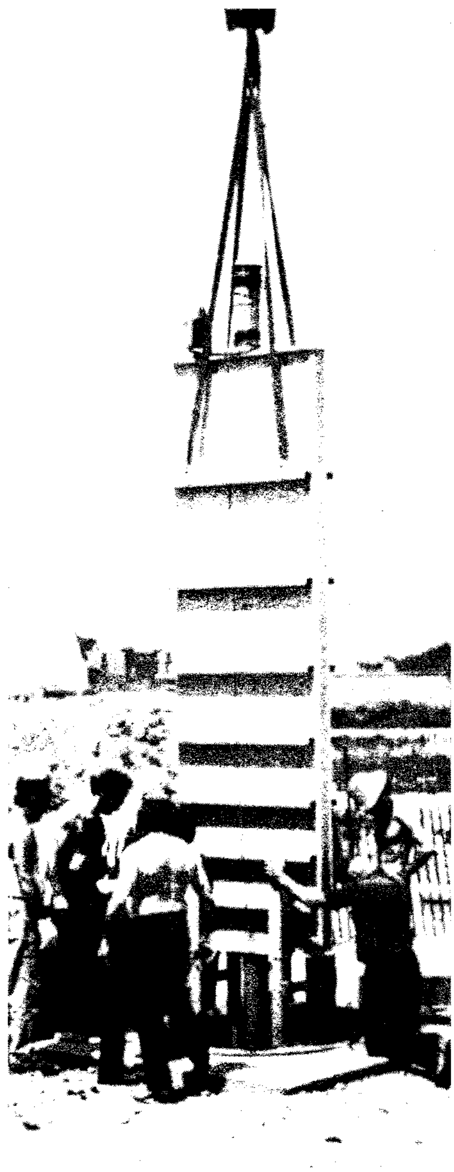
Experimental programme at ISOLDE 15
Description of the wide range of nuclear physics experiments being carried out at the isotope separator on-line at the CERN 600 MeV synchro-cyclotron

People and things 21

Leon and the Lady 25
Epic saga of the quest for two metric tons of beryllium

Cover photograph: An experiment planned to come into action at the Stanford SPEAR electron-positron storage ring in about a year's time involves a 5 ton, 672 element array of sodium iodide, NaI(Tl), known as the 'crystal ball'. This is a major component of the detection system which will surround a SPEAR interaction region. The photograph shows one of the outer aluminium hemispheres which will hold the crystal ball. The holes will allow light, generated in the elements by charged particles emerging from the interactions, through to phototubes. The larger aperture is the gap where the SPEAR beams will pass. The experiment is to be carried out by a Cal. Tech./Harvard/Princeton/ Stanford HEPL/SLAC collaboration. (Photo Joe Faust)

Around the Laboratories



One of the counters for the Chicago/Princeton 'multihole spectrometer' slides into place. Liquid scintillators have been positioned in an array of holes around a central magnetic spectrometer to look at dilepton events.

(Photo Fermilab)

FERMILAB
Dileptomania

Pioneering work on the production of pairs of charged leptons by hadrons began ten years ago at Brookhaven when a Columbia group led by Leon Lederman showed that there was a significant continuum production of dileptons at large effective masses. Part of this continuum turned out to be the famous J/psi particle later discovered by Sam Ting and his collaborators. Knowledge of this continuum was recognized to be important since cross sections for the production of hypothetical particles, such as the intermediate vector boson, can be related to the dilepton production.

More recently, Drell and Yan have developed theoretical ideas which allow useful predictions to be made of dilepton production in hadron-hadron collisions. This was the first concrete link between purely hadronic collisions and lepton-hadron collisions.

Several years ago at Fermilab, Columbia/Fermilab and Chicago/Princeton collaborations found convincing evidence for prompt lepton production in hadron-hadron collisions and the relation between these single leptons and high mass lepton pairs or other new phenomena has excited wide interest. Experimenters set out to determine the mechanism, or mechanisms, that lead to this prompt lepton production.

In the past year a number of experiments at Fermilab have been studying dilepton production and they have already yielded considerable insights into these processes. Explanations of the dilepton production touch on leptonic decays of vector mesons, an unexpectedly strong low mass continuum spectrum, possible production from charm particle decays, the efficacy of the Drell-Yan mechanism and internal conversion of gamma rays. Each experiment has shed some different light on these questions.

The Proton Laboratory, site of the original prompt lepton work, is now host to many of the dilepton projects. The Chicago/Princeton group has extended its prompt lepton work to a dilepton scan by coupling one of its magnetic spectrometers with a device called a multi-hole spectrometer — a number of large liquid scintillators placed in an array of holes in the ground on the opposite side of the beam from the magnetic spectrometer. The idea is to look at direct muon production in the magnetic spectrometer and then see what shows up in the multihole spectrometer.

The counters are arranged in such a way that the earth around the Proton Lab filters out muons with less than about 3 GeV/c of transverse momentum. This colossal spectrometer stretches over a distance of 150 m along the Proton Lab. It covers about one twentieth of the solid angle of the centre-of-mass and the system looks at invariant masses from 7 to 11 GeV/c^2. The experimenters suggest that at least 30% of the single muons with transverse momentum over 5 GeV/c are accompanied by a second muon. Runs at 300 and 400 GeV are consistent with a universal scaling function.

Another experiment by a Yale/Brookhaven/Fermilab group in the Proton Lab has used two counter hodoscope planes separated by several hundred feet of dirt to form a threshold range detector for muons. The experiment was designed to make it largely independent of the invariant mass and transverse momentum of the muon pairs. The group has compared the single muon spectrum to the dimuon spectrum and state that the bulk of the anomalous inclusive single muon flux is derived from muon pair production. A second important measurement was the polarization of direct muons — they find no evidence for any polarization.

The Columbia/Fermilab experiment is also operating a large magnetic dilepton spectrometer in the Proton Lab. Initially the group concentrated on looking at electron-positron pairs with high resolution. The data shows the narrow J/psi peak, the ψ' at 3700 MeV, some activity in the 4 to 5 GeV region, a clustering of events near 6

GeV, about 30 events above 5.5 GeV and extends out to about 10 GeV. The experiment is sensitive to lepton pairs out to about 20 GeV but no events were observed above 11 GeV. They have now completed a run on dimuons with six times the number of events but with a factor of three degradation in resolution. The muon and electron experiments agree very well except in the 6 GeV region where the muons show no effect.

The continuum distribution of the dileptons agrees well with the three-colour version of the parton model and scales well (within a factor of two to three) from the original Brookhaven data. However, the dilepton continuum has an unexpectedly broad transverse momentum distribution. This has stimulated a series of theoretical attempts to refine the parton model by including the sideways motion of the constituent partons inside the proton. The collaboration is now re-running the electron pair experiment with better resolution and preparing an improved muon version that will yield at least twenty times the data.

Dimuon production with neutrons has been measured with a second magnetic spectrometer in a Columbia /Fermilab/Hawaii/Illinois experiment in the Proton Lab. This experiment has concentrated on invariant masses extending from the rho up to the J/psi region with a mass resolution of 4%. It gives a handle on the amount of continuum contribution of muon pairs relative to, for example, the J/psi production. Simply put, the contribution from rhos and omegas appears to be appreciably larger than the other contributions. No statement is made about the masses below the rho. The J/psi part is roughly equivalent to the contribution from the continuum below the J/psi mass region. They find that a simple Drell-Yan calculation of the continuum region underestimates the observed yield.

A second Chicago/Princeton collaboration is exploiting the very large acceptance of the Chicago cyclotron spectrometer in the Neutrino Laboratory. They have used pion and proton beams with light nuclear targets to study inclusive muon pair production. By using detectors between their target and hadron shield, they are able to maintain a mass resolution of 3% from the J/psi mass down to the rho. One important contribution has been an almost background-free measurement of the low mass muon-pair continuum. For direct single muons in the transverse momentum range of 1 to 2 GeV they find that this continuum contributes as much as the rho and omega decays and that at low transverse momentum in the forward direction, it is responsible for most of the direct muon signal.

They also find that J/psis are not produced in strong association with charmed particles, assuming a plausible branching ratio of charmed particles to muons. Such production is less than a few percent. In addition, they measure the muon-pair continuum to masses above 4 GeV/c^2 and find that negative pions are more effective than positive pions at producing pairs from a charge symmetric carbon target. The quark model predicts that at very high masses negative pions will be four times as effective as positive pions. This ratio follows simply from the square of the charges of the annihilating quarks and is an attractive way to demonstrate the existence of constituents with a charge ratio of 2. This work will be continued with increased sensitivity this year.

In the Meson Laboratory a group from Northeastern University has used an iron muon spectrometer to measure the relative production of muon pairs for negative pions and protons. They quote a mass resolution of 13% at the J/psi peak with a mass distribution ranging from below 1 to 5 GeV/c^2. This experiment was the first to show that pions are more effective at producing J/psis than protons.

Another experiment in the Meson Laboratory has been carried out by a Fermilab/Max Planck Institute (Munich) group, using two existing range telescopes set up to monitor the meson area production target. Coincidences between the telescopes suggested that there was dimuon production present. The experimenters had indications that at least some of this was coming from the J/psi and perhaps a higher energy peak.

This complex of experiments gives a much broader view of dilepton production and its relation to prompt lepton production than was available a year ago. The mass spectrum has been probed from below the rho to greater than 10 GeV/c^2. The experimenters find that, characteristically, the production by pions is substantially higher than it is by protons and neutrons. There are indications that a good part of the prompt lepton production is due to the production of vector meson resonances such as the rho, omega and J/psi and a low mass dilepton continuum spectrum. The possibility of a significant higher mass cluster now has the tantalizing quality of the smile on the Mona Lisa.

Direct measurements show that a good fraction of the dimuon production is associated with the prompt muons observed earlier. The lepton pair experimenters seem to find reasonably good agreement with the Drell-Yan process for masses above 3 GeV/c^2. At high energies (300 to 400 GeV), the data do not contradict scaling. Several experiments are yielding evidence of some possibly surprising results regarding the transverse momentum distribution of the lepton pairs that contribute to the continuum portion of the spectrum.

Overall the experiments give some confidence in the engineering capabilities of a modified Drell-Yan model. This perspective lends support

Happy operating crew at the SIN cyclotrons when 100 μA beam intensity was exceeded for the first time on 21 December. A proton beam of 112 μA was recorded at the target.

to the possibility of using the Drell-Yan receipe for extrapolating to very high energy storage ring energies for intermediate boson production.

The 4-5 GeV mass range which Columbia/Fermilab is now compiling may require a much greater effort. SLAC data indicates a complex set of peaks and enhancements here. Higher mass resolution than the about 1% now achieved and greater sensitivity than the about 5 counts per day will be required to sort this region out. This joint requirement is a formidable challenge.

Is there any indication of a residual prompt lepton contribution beyond that due to pairs of charged leptons from either some sort of parton mechanism or vector meson decay? Some earlier studies suggested that charm particle production could be neatly tucked in to account from some of the single lepton production, particularly at lower transverse momenta. Recent upper limits on charm particle production at Fermilab may now be pressing in on this point of view. There is still interest in establishing the detailed balance of mechanisms contributing to prompt lepton and lepton pair production.

Many other questions remain. How does the continuum behave at higher masses? Is the Drell-Yan mechanism still valid when the dilepton mass soaks up a larger fraction of the available energy? Are there more resonances at higher masses?

The history of dilepton experiments is a continuous contest between resolution and event rate. Some dileptomaniacs are now eager to improve substantially both the resolution and sensitivity of the dilepton experiments. They suggest they may find a sensitive handle on new physics that will extend out beyond the mass reach of the charm experiments with colliding electron-positron beams.

SIN
Design intensity exceeded

During the second half of 1976, the average proton beam intensity at the 590 MeV cyclotron of the Swiss Institute for Nuclear Research, SIN, had steadily increased to about 50 μA, with a record of 5500 μAh on target per week in November. Extraction efficiency, once considered a severe handicap in the performance of cyclotrons, climbed to peak values of over 99.9%.

By the end of the year the time was ripe for a 100 μA test run, but the accelerator people suddenly realized that all the available beam time until the scheduled January shutdown had been sold to the experimental groups. The beam development crew had therefore to sneak in on the experimenters during a physics run on the longest night of the year, 21 December. With very little time to tune the cyclotron parameters, the current was cranked up over the magic figure of 100 μA, the design intensity of the machine, and held there for about two minutes. The peak intensity recorded on a target was 112 μA. The current was limited by the output of the ion source and the duration of the test was cut short by the operation of a temperature interlock on an extraction element of the injector cyclotron. The latter problem is curable when more time is available for tuning.

SIN thus becomes the first of the three meson factories to reach its design goal (the TRIUMF cyclotron in Canada has reached the 50 μA level with its design goal of 100 μA on the horizon, while LAMPF at Los Alamos has reached 200 μA towards its very ambitious goal of 1 mA). During 1977 it is planned to include a few 100 μA shifts into the production schedule at SIN in order to accustom experimenters to high intensities.

RUTHERFORD
Energy Research Support Unit

The growing realisation that mankind is heavily dependent on limited fossil fuel resources has led to a rapid upsurge in 'energy research' in laboratories and research centres throughout the world. In the UK, activity in this field has reached a considerable level in many university departments and over a wide range of disciplines.

A number of these university research workers have asked the Rutherford Laboratory for help. For example, architects have requested help in instrumentation, engineers have required programming support and several groups have wanted design and manufacturing help. In response to these requests, several members of the Rutherford staff made a six month

Light receptors in the eye of the horseshoe crab (Limulus polyphemus), after which the Argonne Cherenkov counters were named.

(Photo courtesy of R. Levi Setti)

study of the requirements for support of university research work in energy topics. It emerged that these requirements are as wide ranging as the needs which arise for central research facilities in high energy physics, involving computing, electronics and the design of new instruments, and also the organisation of meetings, discussion groups and conferences.

Following this study, the UK Science Research Council has agreed to the formation of an Energy Research Support Unit (ERSU) at Rutherford. Norman Lipman will be responsible for the work of the new unit in the Laboratory's Instrumentation Division, headed by David Gray.

The support that the new unit will offer to universities and polytechnics will include: assistance with the design and development of necessary equipment and instrumentation, assistance with computing and data handling, provision of additional laboratory facilities, assistance with measurements and tests, secondment of appropriate staff, provision of an information service to help researchers with common interests to exchange ideas, and the organisation of meetings, discussions and conferences on selected topics.

As well as offering this support, the new unit will use the existing expertise and facilities at Rutherford to complement the energy research work of universities and other higher education centres. This part of the unit's activities covers additional development work to enable university projects to be carried over and adopted by industry. The unit will also help universities in preliminary studies for proposed energy research programmes.

The ERSU is already giving support to a number of university groups. One collaboration involving four universities is investigating a proposed waste energy recovery system in which a high speed turbine, using heavy vapour rather than steam, drives a high speed generator. Possible applications are stand-alone generators, combined heat-and-power sources and production of electricity from waste heat. The final test programme would be undertaken at Rutherford.

Another group of five universities is interested in the development of Stirling engines. These are external combustion devices with low emission of noxious exhaust gases and with the possibility of very high efficiencies. It is hoped that by combining the resources of the five participating universities and ERSU, a research effort of considerable strength and breadth of expertise can be mounted. A useful contact with industry is already developing in this project.

The expertise of the Rutherford Laboratory in instrumentation and data handling is being sought by several groups involved in energy research in buildings. One group is concerned with energy conservation problems in a local school, while the other is investigating the effects of different levels of insulation in houses and the year-round efficiency of domestic heating boilers.

However, no energy group would be complete these days without its windmill — now sometimes called an aerogenerator. The Rutherford Laboratory has been asked to carry out the engineering design and to arrange for the manufacture of a large windmill for studies being carried out at Cambridge University.

ARGONNE Crab-Eye Cherenkov Counters

Several large Cherenkov counter arrays, constructed with a structural similarity to the compound eye of the horseshoe crab (Limulus polyphemus), have recently been put into operation at the ZGS as part of an experiment

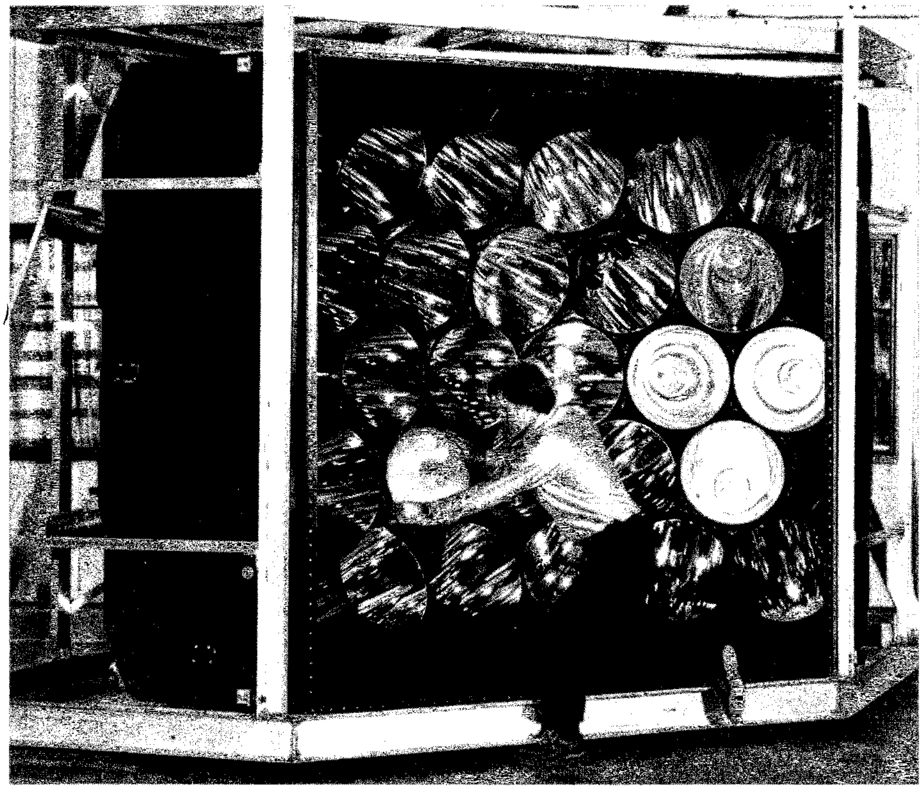
studying the beta decay of the sigma hyperon. Dubbed the 'crab-eye' counters, they contain arrays of compound parabolic collectors for gathering the Cherenkov light produced by the beta decay electrons.

These light collectors, whose design was originated by R. Winston and H. Hinterberger at the University of Chicago, are in principle ideal concentrators in which all light incident on the entrance aperture, at angles from zero out to a maximum angle from the axis, is transmitted and all light at larger angles is reflected. The shape of these ideal collectors was subsequently found by R. Levi Setti to have a striking similarity to that of the light receptors in the crab eye — another example of art imitating nature!

In the case of the ZGS experiment being carried out by an Argonne/Ohio State/Chicago group, three large counters are in use containing a total of 83 light collectors and associated photo-multiplier tubes. Freon gas at at-

One of the 'crab-eye' Cherenkov counters during final assembly. Each of the aluminized light collectors concentrates Cherenkov light onto the cathode of a phototube.

(Photo Argonne)



mospheric pressure serves as the Cherenkov radiator. The counters are arranged so as to surround, on three sides, a large-aperture magnet containing a liquid hydrogen target and wire spark chamber and proportional wire chamber arrays. Polarized sigmas are produced in the target by a beam of 430 MeV/c kaons, and the decay products are observed and their momenta measured by the wire chamber arrays.

The Cherenkov counters are used to identify the electrons from the beta-decay among the much higher level of hadronic particles coming from other interactions and from the normal sigma decay into a neutron and negative pion, which occurs a thousand times more frequently than the beta decay.

A further unusual feature of the 'crab-eye' counters is that, for the experiment to achieve a rejection of heavier particles to a level of one part in 10^4, all particles must penetrate through the counters and be detected in scintillator hodoscopes mounted on the rear wall of each counter. Definite particle identification can then be made by relating counts in the scintillators to the presence or absence of a count in related light collectors.

This penetration requirement implies that the counter be of very low mass. Thus, each collector is a 2 mm thick shell of epoxy resin, aluminized on the inner surface and imbedded in a hexagonal cell of rigid urethane foam. Many cells are cemented together to form the rear wall of the counter. A particle traverses an average of only 2.2 grams/cm^2 of material before striking the scintillator hodoscope.

The objective of the experiment is to determine the relative sign of the vector and axial vector form factors governing the sigma beta decay. The magnitude of the form factors has been well determined in earlier experiments but the relative sign can be determined only by observing the up-down asymmetry of the decay relative to the sigma spin, using polarized sigmas. The hitherto successful Cabibbo theory of weak interactions would predict that the electron should prefer to be emitted opposite to the direction of the sigma spin, while previous experiments, each with only a few events, appear to favour emission of the electron along the spin direction. The new experiment is designed to observe the electron asymmetry directly, with good statistics, in order to check the Cabibbo theory as applied to baryon beta decays.

LOS ALAMOS
Materials study for fusion reactors

The research programme at the Los Alamos 800 MeV proton linear accelerator, LAMPF, has always emphasized practical applications such as biomedical research and treatment. An interesting new topic is the use of the direct 800 MeV proton beam to simulate neutron radiation damage such as will be experienced in fusion reactors particularly by the first wall around the reaction region.

Among the expected damage mechanisms are void and gas formation due to neutron induced nuclear reactions. Calculations show reasonable similarity to the damage produced by medium energy protons and, to carry out materials studies for future fusion reactor design, the use of the intense LAMPF beam can produce more rapid radiation damage than existing neutron sources. It also gives a better distribution of damage in sample depth than does a beam of heavy ions.

In the first experiment, a Los Alamos/University of Cincinnati collaboration irradiated three high purity aluminium foils to a damage level of a few displacements per atom (dpa) in thirty hours at 250 μA/cm^2 resulting in the formation of voids with a density of about 10^{15}/cm^2. In comparison, the void concentration in aluminium irradiated by neutrons from fission reactions is approximately 3.2×10^{14} at comparable sample temperature and level of displacement damage. Thus the high gas production rate concurrent with the proton irradiation did not change the observed void density greatly in comparison to the softer fission reactor irradiation. This is an important result for controlled thermonuclear fusion technology since there has been speculation that high helium production per dpa could increase the void nucleation rate.

Another experiment is using superconducting materials in the comparison of proton and neutron radiation damage. The idea here is that the transition temperature and current carrying capacity of superconductors is sensitively dependent upon radiation damage at a radiation exposure below that required to create other observable changes. Should the comparability of medium energy protons and fusion neutrons be borne out by this experiment also, materials development for fusion reactors can begin immediately rather than waiting for completion of intense neutron sources.

One of the great advantages of using protons from LAMPF is the relative ease with which irradiations can be made. A proton irradiation station is now under construction which will facilitate insertion and removal of specimens. The station will be just upstream of the first meson production target where the highest beam current density is available and where long exposures can be made. It is estimated that the rate of radiation damage is several times that which would be experienced in a fusion reactor wall, thus making it feasible to test metals with exposures comparable to those which will be experienced during normal fusion reactor lifetimes.

SACLAY Helium ions for radiotherapy

The interest in the use of heavy particles for radiotherapy is based on their dose distribution which makes it possible to irradiate a deep seated tumour with good geometrical selectivity, while restricting the dose received by neighbouring tissue to low values. There is also reasonable hope of increasing the biological selectivity in certain types of tumour and destroying the malignant cells.

A programme of study (technical, dosimetric and biological) began at the Saclay Saturne synchrotron in January 1973. It was undertaken by a group from the French Atomic Energy Authority (Saturne Department, Ionising Radiation Measurement Laboratory and Protection Department) and from outside Institutes (Gustave-Roussy Institute, Villejuif; Tumour Centre, Louvain; Radiobiological Institute T.N.O., Rijswijk). They worked together on experiments carried out during fifteen periods, each lasting a week, through to October 1976.

The energy of 650 MeV was selected to match the particle penetration to the size of the human body. In order to equalise the energy over a depth of about 5 cm, the energy could be modulated between 650 and 530 MeV by a variable thickness absorbing disc rotating in the beam.

Various human, animal and vegetable biological systems were studied to determine the differences in biological effectiveness depending on the type of cell, on which the biological selectivity of the radiation used may be based. Care was taken to make these measurements in conditions applicable to radiotherapy, with special attention to the volume treated and the dose per session. This differed from the previous studies at Princeton and Berkeley.

Helium ion beams are important because of the 'ballistics' of the irradiation and of their biological selectivity. At a given radiation dose, the microscopic energy transfer (on which the biological effect depends) is ten times higher for helium ions than for conventional radiotherapeutic radiation such as cobalt gamma rays or X-rays.

At relatively low doses, the biological effectiveness is markedly greater than was generally expected. A 20% difference in effect on cancerous growth compared to healthy tissue was seen.

This difference (equivalent to a 20% increase in the dose) could be therapeutically significant. It is well known that both the sterilisation of a tumour and the clinical reactions of healthy tissues depend to a great extent on the dose. With a 20% difference in dose, the rate of tumour sterilisation can increase from 20 to 80% while lesions inflicted on healthy tissues can become irreparable. Such a difference was seen between tumour EMT 6 and healthy tissue. This certainly does not mean that it will be observed for all tumours and all healthy tissue but it is reasonable to expect similar effects in clinical treatments.

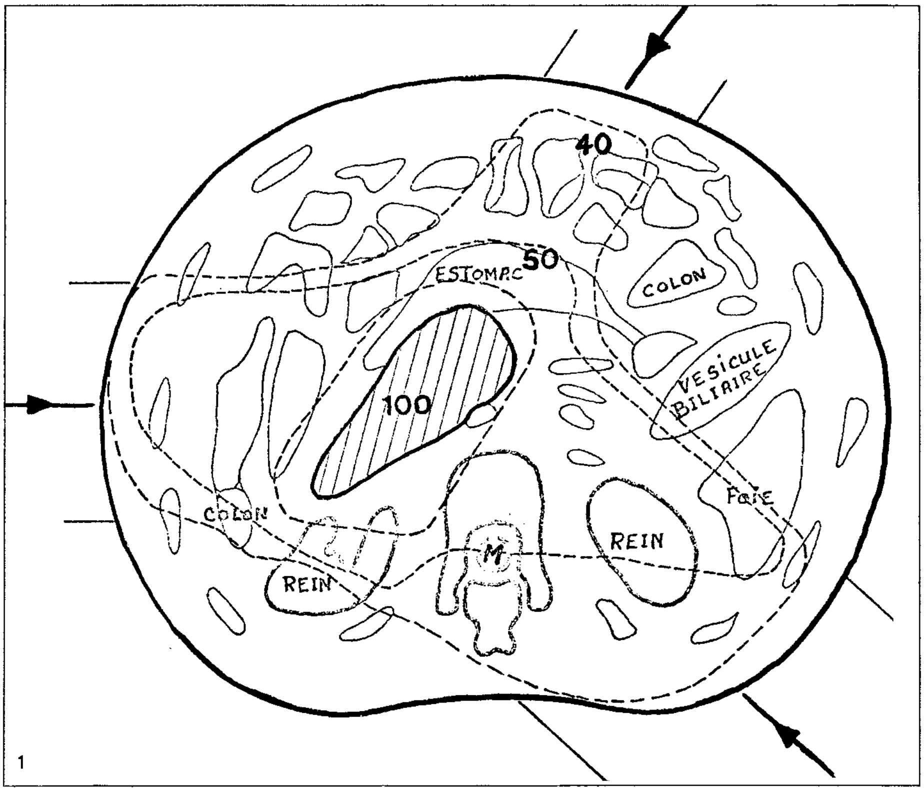
It will be interesting to investigate the use of beams of heavier ions, where greater biological effectiveness may be seen since the energy transfers are ten to a hundred times higher. It might then be possible to reduce significantly the resistance to radiation of hypoxic cells (those deficient in oxygen) to which some radiotherapeutic setbacks have been attributed.

The programme using Saturne's helium beams is due to terminate in the Spring of this year when the accelerator is closed down. However, it

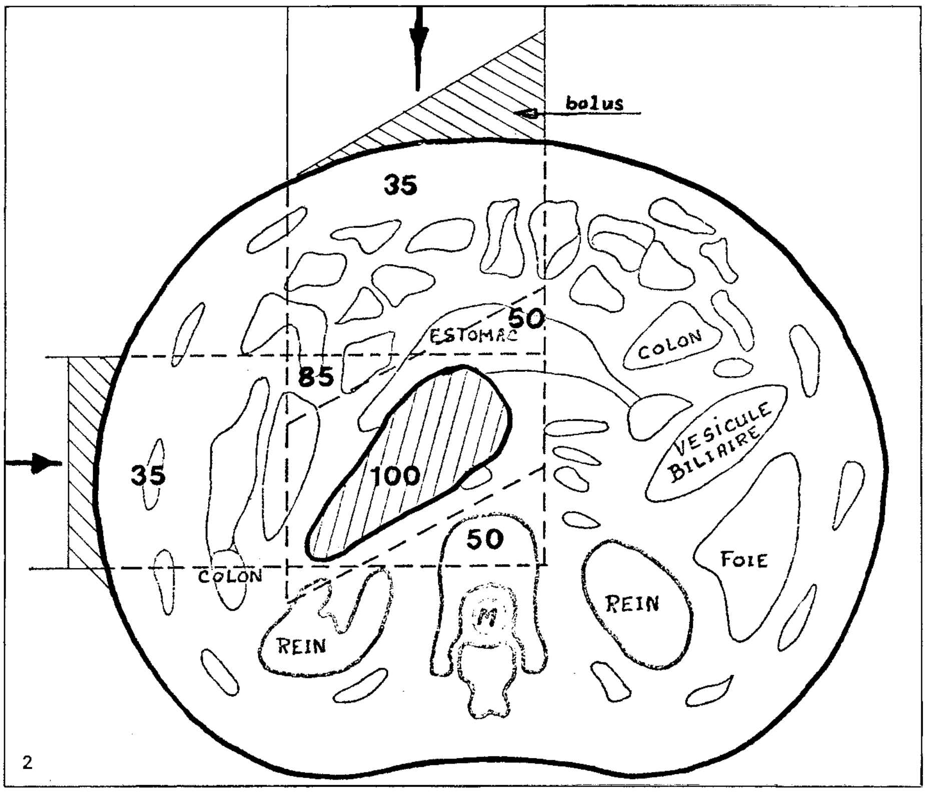
Irradiations of a deep abdominal tumour (pancreas) which is indicated by the hatched area in the section through the patient. Isodose lines are drawn in, expressed as a percentage of the dose received by the tumour.
1. Using 25 MeV X-rays and irradiating from the three positions indicated by the external arrows. The three beam technique minimizes irradiation of healthy tissue (especially bone marrow and kidney) as far as possible.

2. Using two helium ion beams from the Saturne synchrotron at Saclay (the beam from above had an energy of 450 to 590 MeV and from the left an energy of 400 to 600 MeV). The in-depth dose distribution is modified by introducing material (indicated 'bolus') in the beam, external to the patient.

is only the initial phase in an operation which is to be continued with the heavy ions which will be available from Saturne 2. The new accelerator is designed to accelerate ions up to neon with extracted beam intensities of the order of 10^9 ions/s, which are adequate for radiotherapy. It is intended to catalogue the radiobiological properties of ions (such as nitrogen) in this range in the same way as for helium in order to assess their effectiveness in tumour treatment and, in general, to confirm the radiotherapeutic importance of radiation with high energy transfers.



1



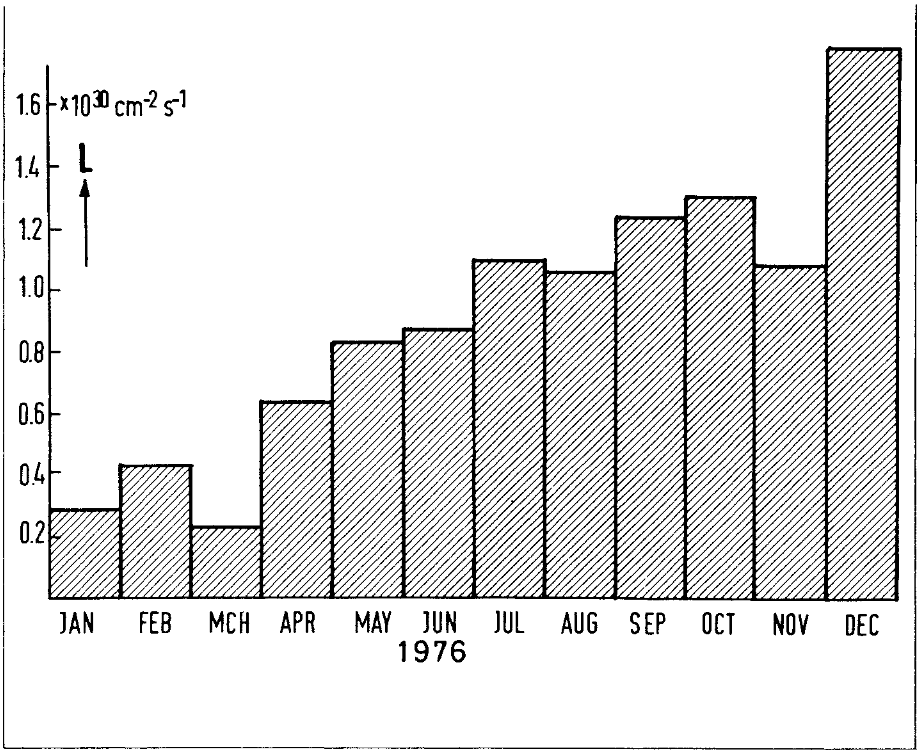
2

DESY
A busy year at DORIS

At the end of a very busy and successful year, the DORIS crew met on 17 December to empty a few bottles of champagne provided by Gus Weber, head of the physics research department at DESY. On behalf of the physicists he thanked the operating crew for their efforts in running DORIS during the past three years and in particular for the improvements achieved during 1976. Average luminosities higher than 10^{30} $cm^{-2}s^{-1}$ have been available regularly during the last months in the energy range between 4 and 5 GeV.

In 1975, the emphasis in the experimental programme was on clarifying the decay channels of J/ψ and ψ', and in 1976 it swung to the search for charmed particles and heavy leptons. First results were reported at the Tbilisi Conference and the outcome of the most recent runs, finished just before Christmas, were communicated at the Coral Gables Conference.

1976 was an exceptional year since the usual long annual shutdown was cancelled to gain time for physics. Thus DORIS was operated for a total of 6500 hours, of which 4800 hours were running time for experiments.



Luminosity records from the DORIS electron-positron storage rings at DESY during 1976. Average values are taken over the time scheduled for experiments. The energy was 3.1 GeV in January, 5.0 GeV in December, and between 4.0 and 4.4 GeV in February through November.

About a quarter of the operating time was used for machine development. DORIS, being the first electron-positron system with two separated rings is a rather complex machine. Hence this rather large fraction of time for development. It was used quite successfully — Donatus Degèle, who is in charge of the operation of DORIS, reported records of luminosity and reliability.

At the end of November the average luminosity could be increased to more than 90 nb^{-1} per day per interaction point, at an energy of 4.5 GeV to be compared to a value of 10 nb^{-1} at the beginning of the year. The peak value after a new injection is usually about 2×10^{30} $cm^{-2}s^{-1}$. These results are achieved with beams of 2×200 mA in 2×120 bunches.

Which are the effects that now limit luminosity? In electron-positron storage rings the luminosity is normally limited by the space charge effect and the intensity of this effect is measured by the shift of the operating point (Q-shift) that one beam exerts on the particles in the other beam. In different storage rings maximum values between 0.025 and 0.06 have been observed.

The large crossing angle of 2×12 mrad between the two beams at the interaction points is one of the main differences between DORIS and other storage rings. It causes additional asymmetric forces which, even at smaller Q-shifts, decrease the lifetime of the stored beams. The maximum Q-shift observed at DORIS is only 0.01, which of course is more than offset by the large number of bunches in each ring as far as luminosity is concerned.

The effects that appear at the space charge limit have been investigated experimentally and can now be understood analytically as well as by computer simulation. It appears that in the crossing geometry, satellite resonances are excited which limit the operating region in the Q-diagram. This kind of resonance excitation does not exist in storage rings with head-on collisions and explains the reduced space charge limit of 0.01. It should be possible to achieve higher limits in this crossing geometry by going to a different operating point in the Q-diagram; this is presently being investigated.

The higher luminosities in a multi-bunch double storage ring can only be obtained at the price of considerably larger average currents, which, however, can excite parasitic cavity modes and lead to beam instabilities. Ferrite absorbers which were installed two years ago in the beam pipes next to the cavities were very successful in damping these parasitic cavity modes. This allowed considerably larger beam currents which in turn began to heat up these ferrite absorbers to temperatures of more than 200°C. The gas thus produced by the ferrites effects the vacuum and now limits the maximum current to values of about 220 mA in each beam. In order to improve the situation, newly developed damping antennas without ferrites near the beam were mounted at the cavities in January 1977.

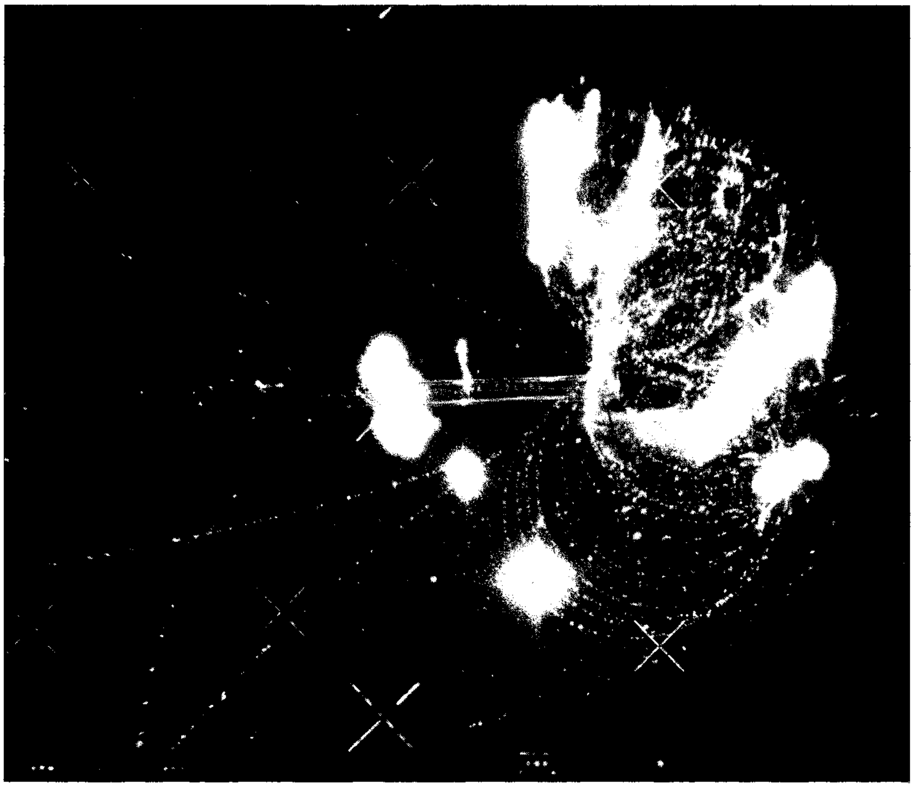
Machine studies at DORIS this year will include tests of intermediate positron storage and retransfer from DORIS to the DESY synchrotron which is part of the injection system for PETRA, the 19 GeV storage ring now under construction. Special components for this intermediate positron storage and subsequent fast ejection back to the synchrotron have been installed during January and injection tests into PETRA are scheduled for late Spring. DORIS resumed operation at the beginning of February.

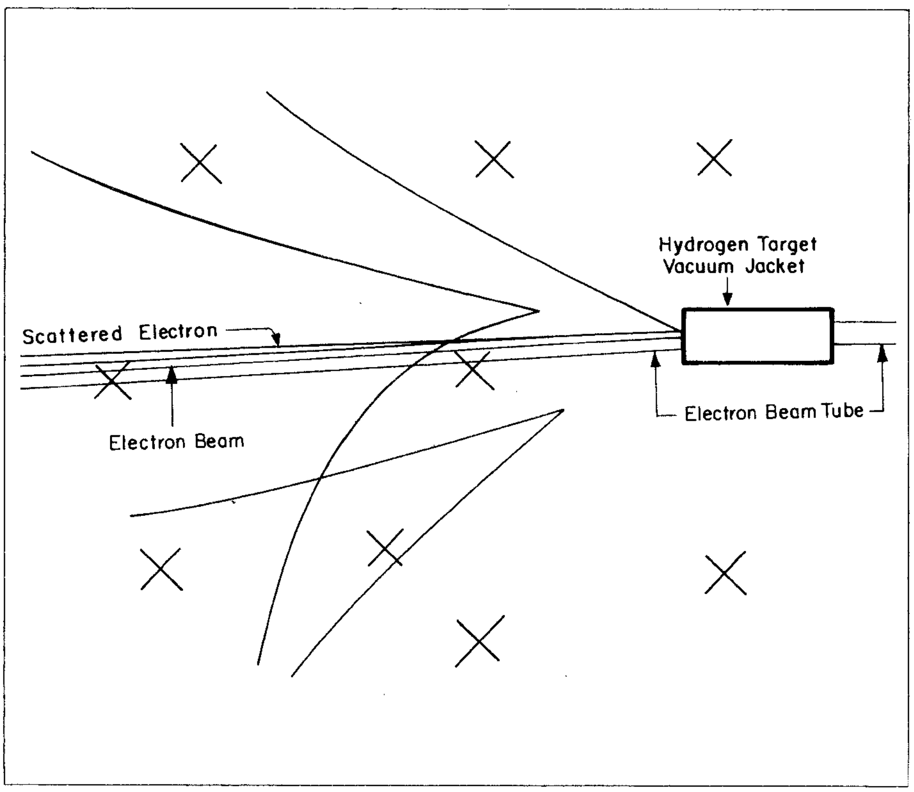
CORNELL Streamer chamber experiment

A detailed study of the particles emerging from inelastic electron scattering is under way at the Cornell electron synchrotron. A DESY/University of Hamburg/Ithaca College/Cornell collaboration are using a streamer chamber system to detect the scattered electron and the hadrons produced in electron-proton collisions. The experiment, known as 'DECO' (from condensing DESY and Cornell), grew out of the successful application of a streamer chamber to the study of inelastic electron scattering at DESY, the aim being to extend the study to the higher energies available at Cornell. The streamer chamber and magnet come from DESY and are very close duplicates of the system used in the DESY experiment.

The chamber has a 1 m long sensitive volume with a 10 cm long hydrogen target 25 cm from the upstream end of the chamber. The target vacuum jacket and a small tube surrounding the unscattered electron

Streamer chamber picture of an inelastic electron-proton interaction, yielding two neutral strange particles, from the DECO experiment at Cornell. The tracks in the target region are delta rays from the hydrogen and the incident beam intensity is limited so as to keep the number of such tracks reasonably small.





beam are the only obstacles to a full 4π detection solid angle. Scattered electrons are detected in a proportional chamber and one of two shower counter systems 3 m from the target. The energy threshold of the shower detectors is set at 2.5 GeV so that with an electron beam energy of 11.5 GeV, virtual photon energies up to 9 GeV can be accepted.

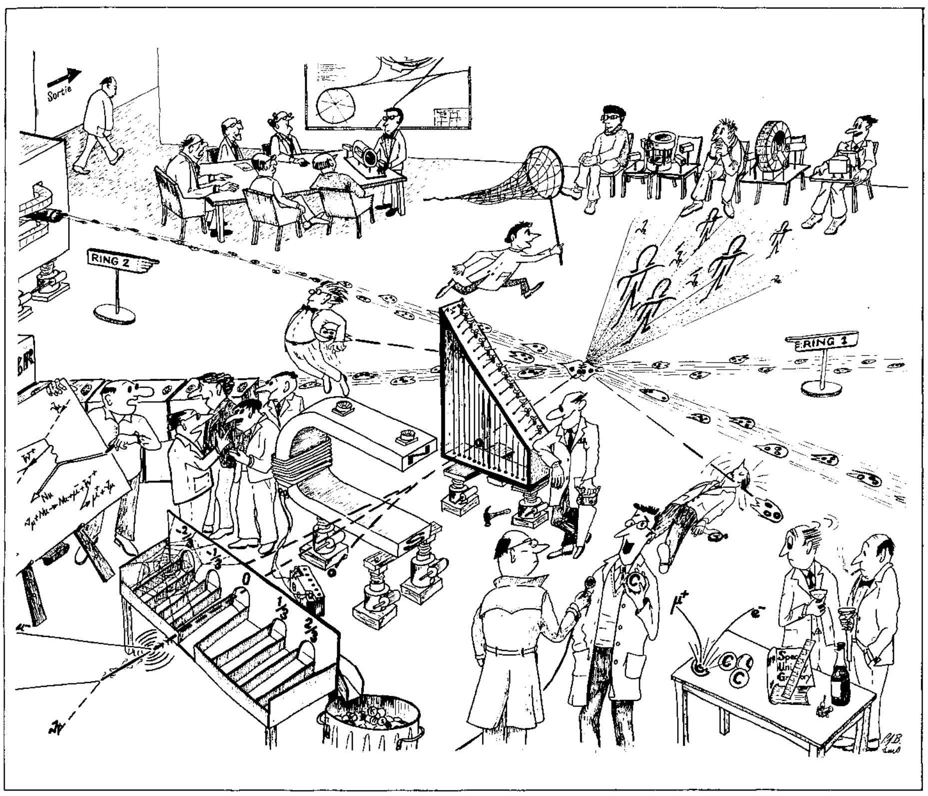
To date almost 100000 deep inelastic electron scattering events have been photographed. The film is scanned at the University of Hamburg and at DESY and is measured on the DESY HPD. The electronics are set to select high Q^2 events and most of the 100000 photographs are for Q^2 greater than 1 GeV^2. Analysis of the measurements is under way at Cornell and DESY and the first results are expected in Summer.

CERN
Colliding deuterons in the ISR

With the CERN Proton Synchrotron and Intersecting Storage Rings both on top form in December (the PS, in fact, achieved a reliability record of 95.1 % in 1976 despite all its new duties), two fine physics runs were possible with colliding deuteron beams in the ISR. There had previously been short runs with deuteron beams, when experimenters took some data during a machine development period (see April issue 1976), but these were the first scheduled physics runs.

A Pavia/CERN team wanted to look at neutron diffractive scattering where the neutron converts to a proton and a negative pion. They used the detection system of multiwire proportional chambers in the Split Field Magnet at intersection I-4. With this system the track of the spectator proton from the deuteron and the produce of the break-up of the neutron can be observed.

Philip Bryant from the ISR Division summed up activities around the storage rings during the past year with this cartoon.



Double diffractive scattering, when two colliding neutrons break up, was also observed. A CERN/Saclay/Zurich team, whose main aims are charmed particle and electron pair searches, took some data in intersection 1-7.

In a run at the beginning of December, the PS became a DS feeding about 4 A into each ISR ring and then switching back to protons for its own experimental programme and for injection into the 400 GeV synchrotron. The ISR operated for about 30 hours with deuteron-deuteron collisions before the beam in Ring II was dumped and 18 A of protons were fed in instead so as to look at deuteron-proton collisions. Some 30 hours later the run was ended.

Just before the switch off the machine physicists did some clever tricks mainly aimed at ensuring that deuterons could be accelerated to 31.4 GeV/c as required for the mid-December run. They fed in more protons into the deuteron ring and held 5.5 A of protons and 3.3 A of deuterons for an hour both at 26 GeV/c. The beams behaved independently of one another. The deuterons were then selectively accelerated leaving the protons behind to be scraped off. No problem - a 2.1 A beam of deuterons, over three days old, orbited at 31.4 GeV/c.

Mid December, the achievements were even more impressive. Deuteron currents of 9.06 A and 8.55 A were stored giving a luminosity of 1.6 × 10^{30} per cm^2 per s which is 40% of the design luminosity for protons! A power failure after four hours snuffed out one of the beams but the PS did its transformation into a DS in less than half an hour to restore the situation, giving a 6.9 A beam which was used for the next 18 hours. Acceleration to 31.4 GeV/c then went smoothly and physics at the peak energy went on with 6.9 A against 4.6 A.

A day later one deuteron beam was dumped, as in the earlier run, so that protons (20 A) could be substituted. By the time the deuteron-proton run was terminated, those deuterons had been orbiting the ISR for a record 74 hours and no doubt many of them would still be there yet if the power had not been switched off.

Joys and chagrins at the SPS

The smooth commissioning of the CERN 400 GeV proton synchrotron has continued over the past two months compounded with a set-back as the experimental programme began. The formal start of the programme was on 7 January (within the timescale laid down six years ago), though most experimenters had had a taste of particles before then.

Protons can now be delivered to all West Area targets. The three targets T1, T3 and T5, which are the source of secondary beams in the West experimental hall are fed simultaneously with protons during an intermediate flat top at 200 GeV usually at the rate of 1 × 10^{12} per pulse. The r.f. separated beam to the 3.7 m European bubble chamber (BEBC) can also be fed, via target T7, at 200 GeV. The neutrino beam to BEBC, a counter experiment and the heavy liquid bubble chamber Gargamelle can be fed, via target T11, at 400 GeV usually at the rate of 3 × 10^{12} protons per pulse. All these manoeuvres are possible in the same machine cycle.

This operating cycle is being run with fair reliability at present (some periods at 90%) though reliability is likely to oscillate quite a lot early in an accelerator's life. The peak extracted intensity at 400 GeV has been 8 × 10^{12} protons per pulse early in

January. The major instability which is limiting higher currents is known to be the 'head-tail' effect and more powerful sextupoles will be installed to overcome it.

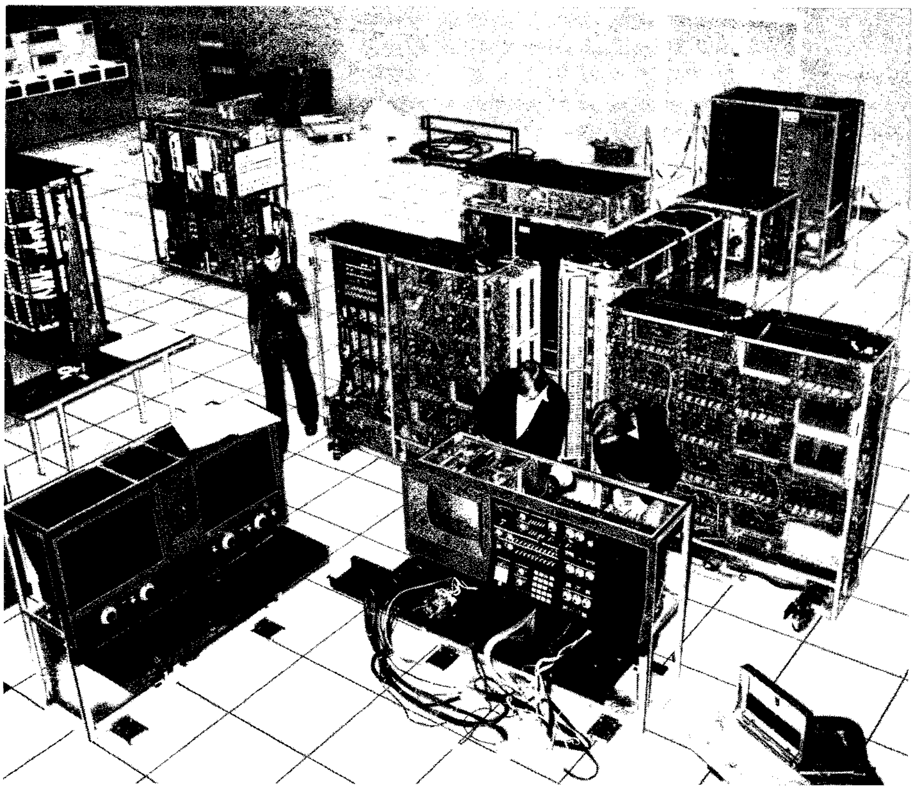
The initial experimental programme was described in detail in the October issue, 1976. The experimenters are, in general, happy with the quantity and quality of the beams they are receiving (though no-one would complain about more and better). One satisfying result has been the performance of the CEDAR Cherenkov counters (described in the September issue, 1975) which perform particle identification in beams. The first test of such a counter on 5 December in beam H3, showed good light collection (3.4 photoelectrons with the diaphragm wide open) and a mass resolution in perfect agreement with computer predictions. Pion rejection was nearly 10^{-5} when the counter was operated in the eight-coincidence mode.

The counter computer controls operated well. Particle masses were found accurate to within 20 MeV by calculating the index of refraction from pressure and temperature measurements (prior calibration having been made with a refractometer). Pressure and temperature were stable and will not need frequent adjustment. Counter performance is, however, very sensitive to the accuracy of alignment of the optical axis in the beam and this may require some feedback system to sustain peak efficiency. Five CEDAR counters are being used in the West Hall.

At the end of November, BEBC operated for the first time with a heavy liquid mixture of neon and hydrogen. The tests went well until a refrigerator problem forced a shutdown and the emptying of the chamber. BEBC came back on mid-January with a liquid mixture (76 mol% neon) taking pictures with antineutrinos. No magnetic field was used in that run so as to reduce complications in checking the EMI (External Muon Identifier). A neutrino run then began with the field on. Both picture quality and bubble chamber performance are good.

The one big set back which has marred progress so far, occurred on the night of 7 January. A fire broke out in the West Hall in the area where experiments WA3 (an Amsterdam/ CERN / Cracow / Munich / Oxford / Rutherford study of two body hadron reactions) and WA7 (a CERN / Genoa / LAPP Annecy / Niels Bohr Institute Copenhagen / Oslo / University College London study of large momentum transfer two body interactions) are installed. It seems that power did not cut off completely from their two large spectrometer magnets under alarm conditions. The magnets and detection systems were badly damaged.

Substitute equipment has been found within CERN for WA3 but it will be out of action for some weeks. The WA7 team is having to look further afield and they are likely to be out of action for some months.



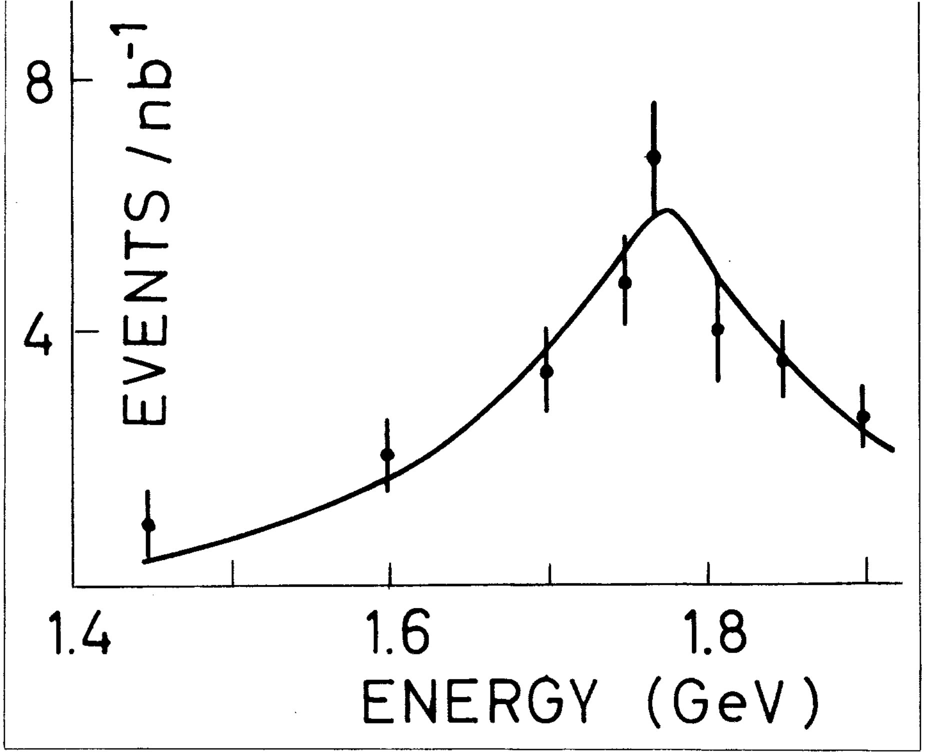
Components of the IBM 370/168 coming together in the CERN computer centre. The new computer is currently undergoing acceptance test and, up to now, all is going smoothly.

(Photo CERN 45.12.76)

New computer performing well

At the end of last year CERN's new large computer, an IBM 370/168, was installed in the computer centre. At the time of writing, acceptance tests are under way — since 3 January, the machine has been running round the clock, seven days a week and in the first three weeks has suffered less than 45 minutes 'down time' with only one failure of the operating system.

The IBM was brought to CERN after a rather agonizing appraisal of the future computing needs which had to trim back considerably from the initial proposals because of budget cuts. Three needs were identified — (1) more computing capacity since the



Data from the DCI electron-positron storage ring at Orsay which indicates the existence of a new vector meson. The data shows 180 events of decays into four charged and one neutral pion.

existing CDC 7600 central computer was 'saturated', (2) the implementation of a network to make computing power more easily accessible to experimenters and (3) the bringing in of a new computer manufacturer. The IBM machine complements the CDC in that CERN users can select between the two and are more likely to find a computing system equivalent to the one they have at their home station. It also has more advanced peripheral devices and is likely to be more easily adaptable to the computing trends. (For a fuller exposition on computing needs see the March issue, 1975.)

The IBM 370/168 model 3 has 3 Mbytes of main memory. It has 5 channels, 6 disk drivers of 200 Mbytes each and 6 disk drivers of 317 Mbytes each. Out of 10 magnetic tape units, 6 are capable of taking high density tapes (6250 bits per inch). Other peripherals include 2 line printers, a card reader, 7 keyboard terminals and 2 low speed printers.

The computer arrived in three batches - cables, peripherals and the central processor with its console; the final delivery was on 29 November. It is installed in the same room as the CDC 7600 and only one extra operator is needed to run the two systems. The IBM was powered for the first time on 3 December. Formal 'hand over' of the completed installation was on 20 December and the 30 days worth of acceptance tests started after the Christmas break. Actual production work for several experiments is being run during the tests and the computer is also linked to one RIOS (Remote Input Output Station) and can be accessed from there.

The machine is coming into service initially for batch processing and during its first year there will be constant improvements to increase user convenience and enhance operator control. A terminal time sharing system called WYLBUR (developed at SLAC) will be introduced by the end of the year. It will become the standard way for users to access the computer via some forty of the computer centre's terminals. The IBM will also be linked to the CERN network to provide on-line support for experiments (particularly SPS North Area experiments).

Immediate improvements on the computer itself will be an increase of the main memory to 4 Mbytes and the addition of two more channels. The desirability of adding a mass storage device will be studied further.

ORSAY
New vector meson

An experiment at the Orsay electron-positron storage ring, DCI, has seen a new vector meson at an energy of 1780 MeV with a width of about 150 MeV. The experiment M3N was described in the September issue, 1976. It is particularly well adapted to the observation of decay modes giving neutral pions and photons. The detection system consists of wire proportional chambers and optical spark chambers, separated by scintillators and lead radiators, plus an iron absorber as a muon filter. There is no magnetic analysis of charged particles. This equipment spotted the J/psi soon after the DCI ring began operation.

The data collected since October corresponds to an integrated luminosity of 70 nb^{-1} between 1.45 and 2 GeV. While analysing the recorded events progressively as they were being collected, the Orsay team spotted a strong anomaly in the event rate for electron-positron annihilation into five pions in the energy region between 1750 and 1800 MeV (total energy). When further data was collected, it became apparent that there is a resonance which decays particularly into four charged and one neutral pion. The graph shows the accumulated data from 180 such events.

The new particle also seems to appear in other decay channels and these modes are now being analysed. It is, therefore, a vector meson, probably belonging to the omega meson family or possibly to the phi meson family. (It has been a bit of a mystery for some time that the charmed quark - charmed antiquark combination in the J/psi can exist in several energy states, giving us the J/psi family of particles, while a corresponding family for the strange quark-strange antiquark combination in the phi has not been identified). The Orsay team is continuing the search for other mesons of the same type.

DCI in its completed version will have two rings operating under the space change compensation principle (see December issue 1969) in order to achieve high luminosities. The second ring is now being tested and a beam was injected for the first time in December.

Experimental programme at ISOLDE

For the past ten years, the Isotope Separator On-line (ISOLDE) has been in action at the CERN 600 MeV synchro-cyclotron. It is the finest facility of its kind in the world providing a wide range of intense secondary beams of short-lived nuclei for experimental investigation. Its experimental programme involves some 100 scientists from 15 research centres.

The physics interests and experimental techniques were described in the February issue 1967 when the separator began operation. It is now in its 'second generation', and is sometimes called ISOLDE-2 since a series of improvements were introduced at the time when the SC was being rebuilt to provide higher beam intensities (see February 1973).

ISOLDE-2 can provide unstable nuclei with half-lives down to a few milliseconds, to as many as ten experiments in a typical run. This is achieved by applying several new experimental techniques. New target and ion-source units make it possible to use proton beam intensities of up to 10 μA and they have increased the range of elements available for study to about forty. A remote handling system allows a quick change from one element to another. Beams of six elements only have been used during the first two years of operation of ISOLDE-2.

There is a versatile beam handling system that supplies ion beams of different nuclei to four measuring stations simultaneously. The heart of this system is a newly developed electrostatic switchyard with four sets of deflector plates which move along the axis of the outgoing beams, so that each of the four beam tubes has a free choice of a wide range of isotopic beams without displacing the mass spectrum in the separator. Six experimental set-ups are installed in the lower experimental room.

This does not meet the demand and, in addition, background problems are becoming severe in this region, not because of inadequate shielding from the target but because several experiments are using the full available ion beam intensity of 6 nA (a very high figure for a radioactive particle beam corresponding to a Curie at saturation for an incident proton beam of 1 μA). In the near future, some of these problems should be solved by installing a vertical ion beam tube to the two rooms above. By using a second analyzing magnet as the vertical deflector it should be possible to improve the isotopic purity of the beam and on-line operation in these low background regions should, in favourable cases, bring the detection limit for rare decay modes down to a reaction cross section of 10^{-40} cm^2.

Target and ion-source development

A key feature in an on-line isotope separator is the target and ion-source. The target should assure a fast, continuous liberation of the radioactive nuclei produced in large amounts of target material. Together with the ion source, the unit selectively forms an ion beam which preferably should contain only the isotopes of the chemical element under study.

The development of this experimental technique is a field of radiochemistry which also involves metallurgy, high temperature chemistry and surface physics. At ISOLDE, production methods for the isotopes of about forty elements have been developed through a systematic investigation of possible target and ion source configurations. Most of the targets consisted of molten metals held at temperatures between 700 and 1400°C, problems of containment and/or volatility of the target material preventing operation at higher temperatures. The delay in the release of the reaction products from the liquid targets is characterized by a typical time constant of 30 s.

Recently a new target concept using refractory metal in powder form or fibrous carbides has proved to release a variety of elements on a very short time-scale. Due to the combined effect of short solid diffusion paths and temperatures above 2000°C, the delay distributions have components in the region of 1 s.

For example, high yields of rubidium nuclides are obtained by irradiating a 50 g/cm^2 niobium powder target at 2200°C with a 1 μA 600 MeV proton beam. Usable yields extend down to ^{74}Rb with a half life of 65 ms which is the heaviest nuclide produced to date in which the number of protons equals the number of neutrons. ^{73}Rb is not observed and the cross section for its production must be at least a thousand times lower than ^{74}Rb. This probably indicates that the limit of stability has now been reached.

Like most other target materials the niobium powder liberates several product elements simultaneously (Sr, Rb, Kr, Br and Se). A variety of techniques have been developed to assure chemical selectivity. Often this is obtained by ionizing only one element out of the mixture. In the case of the alkali metal rubidium, isotopically pure beams are formed by means of positive surface ionizing effect on the inside wall of a tantalum tube heated to 1200°C.

Likewise the halogens fluorine, chlorine, bromine, iodine and astatine can be selectively ionized by means of the negative surface ionization effect. Such systems are under development and a recent test showed promising yields of bromine ions.

The experimental programme

The following experiments are at present under way:

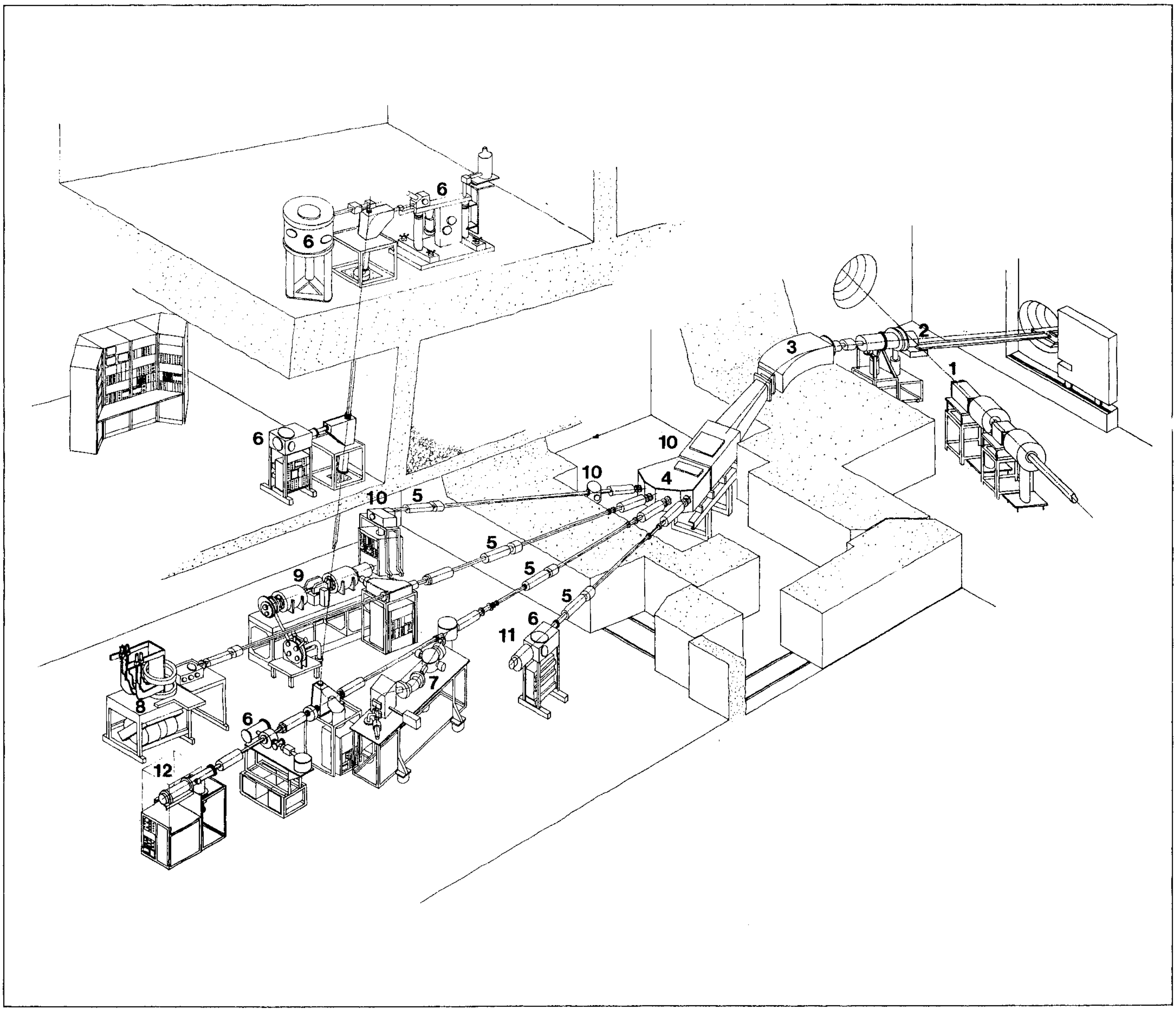
1. In 1972, a sudden change in the shape of the mercury nucleus was

Perspective view of the isotope on-line separator, ISOLDE. The 600 MeV proton beam (1) from the CERN synchro-cyclotron is focused on the target ion source unit (2). A beam of radioactive ions is formed by a 60 kV acceleration stage and is mass analyzed in a magnet (3). Individual masses are then selected by electrostatic deflection in the switchyard (4) and distributed through the external beam-lines (5) to the various experiments. These are:

(6) Nuclear spectroscopy (α, β, γ)
(7) High resolution mass spectrometer
(8) Optical pumping and laser spectroscopy
(9) Atomic beam magnetic resonance
(10) Collection of radioactive sources for off-line work (hyperfine interactions in solids, determination of shifts in X-ray energies, targets for nuclear reaction studies)
(11) Beta delayed particles
(12) Range measurements of ions in gases

detected when the number of neutrons decreases from 107 to 105 (i.e. from ^{187}Hg and ^{185}Hg). This discovery was achieved using the RADOP (Nuclear Radiation Detected Optical Pumping) technique described in the November issue 1971 and it was possible because of the intense beams of these short-lived isotopes available at ISOLDE-1. Since then extensive experimental and theoretical work has been concentrated on this unexpected finding. The interpretation now accepted is that of a shape transition from a slightly oblate nuclear shape for ^{187}Hg to a strong prolate deformation for ^{185}Hg.

Information on the charge radii of the even-even mercury isotopes for ^{192}Hg and below was still missing because the RADOP method is not applicable to nuclei with zero spin. To find this information, a laser experiment was set up at ISOLDE-2 involving a dye laser, pumped by a pulsed nitrogen laser which serves as a tunable light source. As laser action cannot be obtained in the ultra-violet region, it is necessary to start with a beam of visible (green) light. The frequency is then doubled by using the non-linear effects in a crystal and the resulting ultra-violet beam can induce transitions between the electron energy levels of the mercury isotope under investigation. If the frequency of



The equipment of the tunable laser experiment which is giving measurements of the radii of zero spin isotopes. The predecessor of this experiment, using optical pumping, discovered the abrupt change in radius of mercury nuclei as the number of neutrons is reduced.

(Photo CERN 324.10.76)

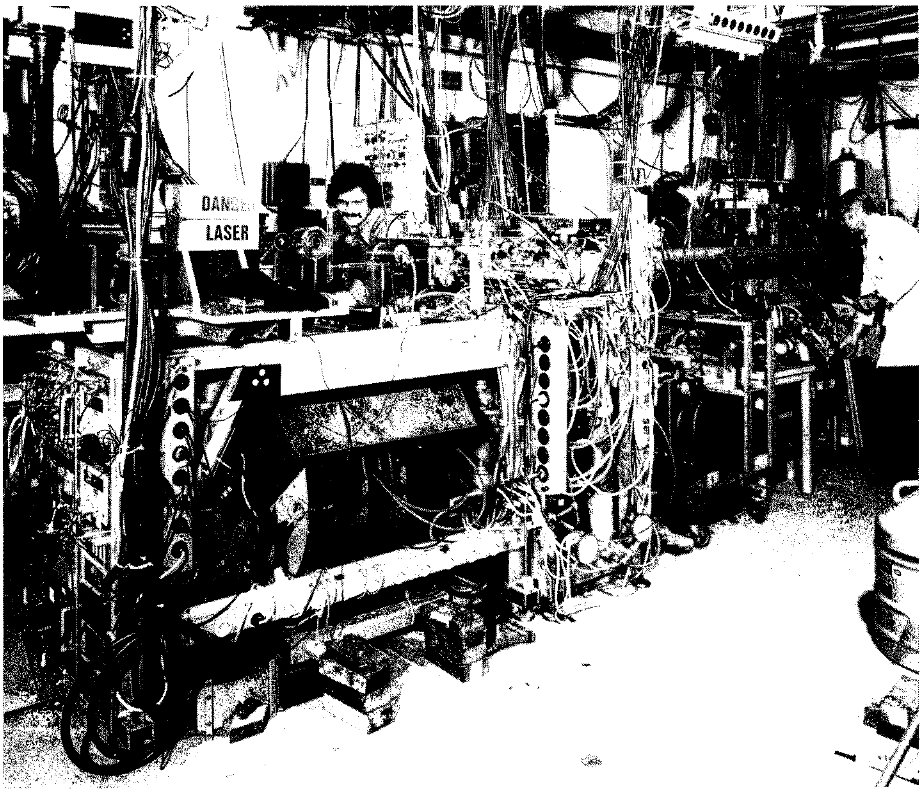
A graph of the charge radius of mercury isotopes plotted against atomic number ranging from A = 205 (125 neutrons in the nucleus) to A = 181 (101 neutrons in the nucleus). The abrupt change at A = 185 was discovered by the optical pumping, RADOP, technique. The new laser spectroscopy experiment has already added some measurements and the interesting value for A = 184 will be published shortly.

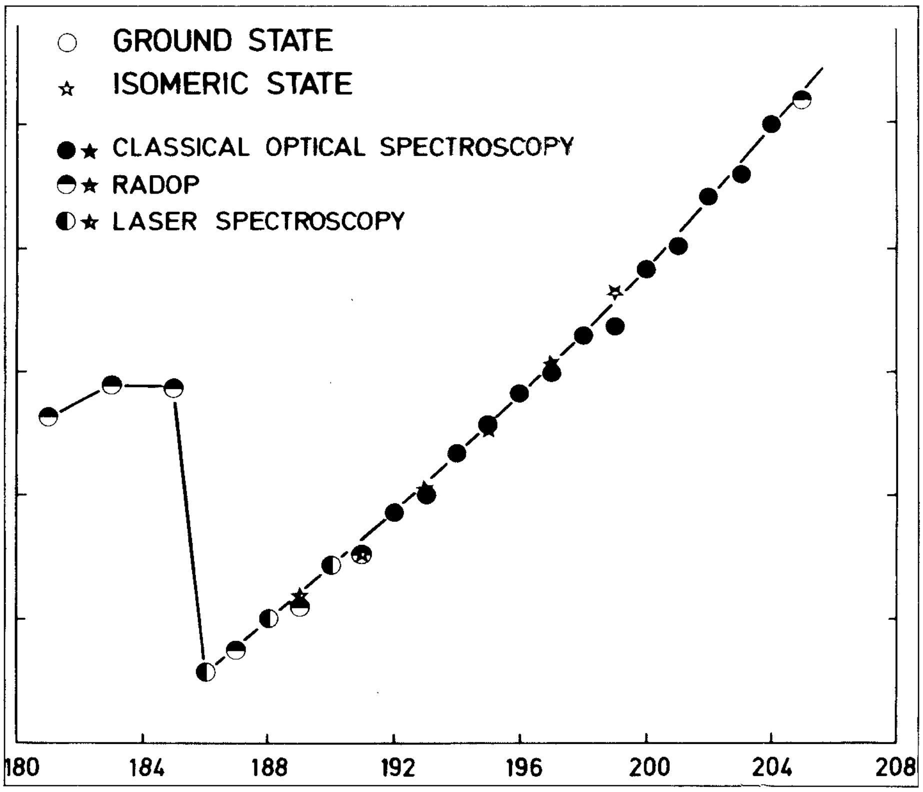
the laser (about 10^{15} Hz) is adjusted so that the energy conveyed by the light coincides with the atomic transition energy, fluorescence radiation is observed. By simultaneously measuring the resonance radiation of a stable mercury isotope in a magnetic field, the isotope shift is determined with an accuracy of about 100 MHz.

The combined results of experiments to date are shown in the diagram. As a function of decreasing neutron number, a regular shrinking of the charge radius is observed starting from the nearly doubly-magic nucleus ^{205}Hg down to ^{186}Hg. The three odd isotopes ^{185}Hg, ^{183}Hg, ^{181}Hg exhibit the anomalous charge radius corresponding to that of ^{196}Hg which has 10% neutrons more. A measurement of the isotope shift of ^{184}Hg is being analysed to see whether the charge radius jumps to a value similar to those of the odd neighbouring isotopes or, as indicated by gamma spectroscopy on ^{184}Hg, continues to follow the trend of the heavier isotopes. The latter would mean a drastic odd-even staggering corresponding to an adding and subtracting of about eleven neutrons. Such an effect is completely unknown in other mass regions.

2. A double focusing mass spectrometer has been installed to measure isotope masses with an accuracy better than 100 keV (i.e. a relative accuracy of 10^{-6} for A = 100). It is a continuation of the very fruitful spectrometry measurements carried out for many years by the Laboratoire René Bernas from Orsay (see, for example, June 1973). The mass spectrometer at ISOLDE has a spherical electrostatic sector and a homogeneous magnetic sector combined according to the Mattauch-Herzog geometry.

The method of measurement is based on the well known property that the product of the mass of the ion and the voltage applied to the electrostatic



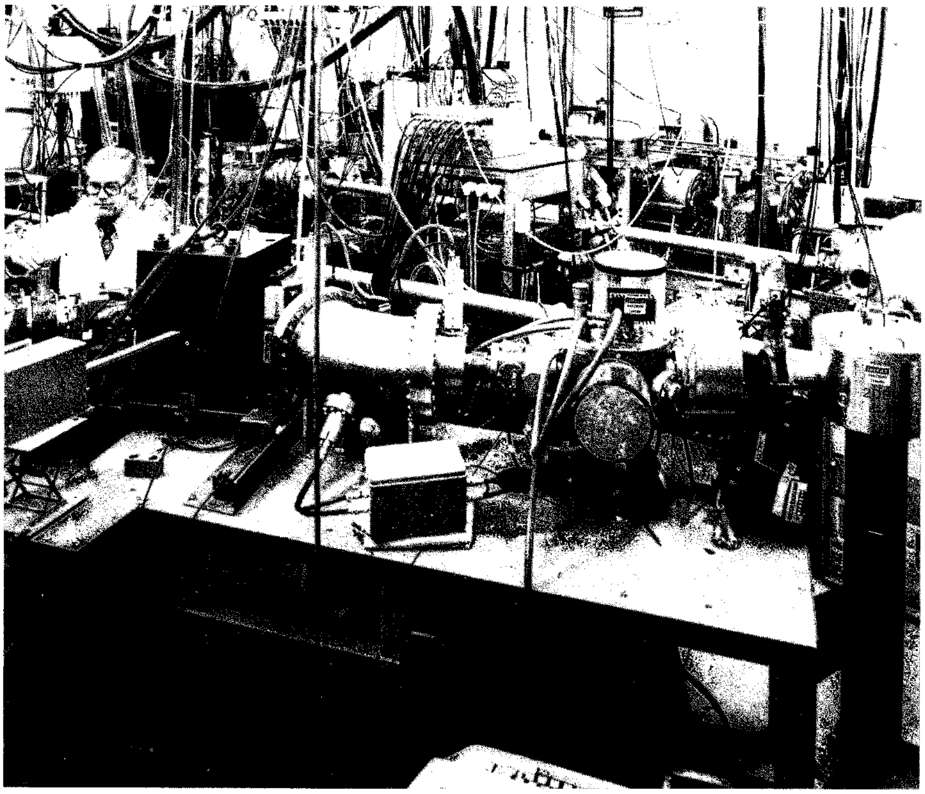


The double focusing mass spectrometer which is yielding very accurate measurements (better than one part in a million) of rubidium and cesium isotopes.

(Photo CERN 325.10.76)

sector is constant if the magnetic field is kept constant. This means that $M_A V_A = M_B V_B$ for different isotopes A, B of the same element. Jumps have to be made in the experimental conditions on changing from one isotope to another. When the ions from ISOLDE are stopped and reemitted in the ion source of the mass spectrometer, these jumps are performed by modifying at the same time the magnetic field of ISOLDE and the applied voltages in the mass spectrometer.

The accuracy of the measurements depends on the counting rate and on the resolving power of the spectrometer. Up to now, the best conditions have been obtained when the resolving power is 10000 (twenty times higher than the previous experiment at the PS) while the efficiency is better than 10^{-4}. The accuracy then obtained is better than 10^{-6} for all studied isotopes.



Measurements have concentrated on isotopes of rubidium and cesium; these are the isotopes $^{75-81}$Rb and $^{117-128}$Cs produced by spallation. The results obtained for rubidium are in good agreement with the mass formula from Seeger; those for cesium are being analysed. A measurement of the mass of ^{74}Rb isotope, mentioned above as the heaviest known N = Z isotope, would be a very good test for the isospin dependent terms and this experiment began in December.

3. The hyperfine structure (the effect of nuclear spins on electron energy states) of free atoms is investigated at ISOLDE using an atomic beam magnetic resonance (ABMR) apparatus. The ion beam from the separator is focused at an oven from where the radioactive isotopes are continuously evaporated in the form of free atoms. A sextupole magnet polarizes the atomic beam and atoms with negative effective magnetic moment are focused in a homogeneous field where the moment can be flipped positive by applying an r.f. field of the right frequency. A quadrupole deviates the flipped atoms to the collector. Knowing the resonant r.f. frequency it is possible to calculate the nuclear spin and the magnetic moment.

The first determination of the spins of gold isotopes using an off-line system was reported in the November 1975 issue. Since then, the on-line system has been brought into operation and the nuclear spins and magnetic moments of several short-lived isotopes of the elements rubidium, cesium, francium and gold have been determined.

A common feature of these elements is that they have stable isotopes close to a neutron shell closure (N = 50, 82 and 126, respectively), with the neutron-deficient isotopes extending into regions with expected nuclear deformation. The measured nuclear spins and moments may be used to probe the change in structure as one goes from spherical to deformed nuclear shapes.

4. The extremely neutron deficient nuclei that are produced at ISOLDE, are characterized by very high nuclear beta decay energies. At the same time the daughter nuclei have low charged particle (proton or alpha decay) separation energies so that the beta decay may feed excited states where these particles are unbound. The de-excitation process may then proceed via particle emission rather than gamma emission which normally dominates.

From the start of the ISOLDE project, the study of beta delayed proton emission has been one of the main lines of the research programme. The delayed particles provide a very sensitive tool for obtaining information about nuclear properties at very high

Atomic beam magnetic resonance (ABMR) apparatus which is being used in the study of the hyperfine structure of free atoms. It has given new spin measurements for many isotopes.

(Photo CERN 339.10.76)

excitation energies. For example, the fluctuations observed in the particle spectra reflect the densities of nuclear levels at 3 to 10 MeV excitation energy.

The increased ion beam intensity that has become available at ISOLDE after the reconstruction of the facility and the improvement of the SC has opened the possibility of observing the even rarer decay mode, beta delayed alpha emission. New results on such alpha events were reported in the June issue 1975. For example spectra of delayed protons and alphas have been collected for the cesium isotope with mass 116 (17 neutrons less than the stable ^{133}Cs). At present six cases of this kind have been identified and these results provide the first estimate of the alpha strength function for highly excited nuclear levels.

5. The binding energy of the most bound electron in the atom reflects, to a small extent, the nuclear size. As the X-ray lifetime in heavier atoms is very much shorter than nuclear lifetimes, it might be possible to measure radii of excited nuclear levels by detecting the X-rays originating in the electron-capture beta decay giving rise to the excitation. A first experiment of this type is now being attempted at ISOLDE.

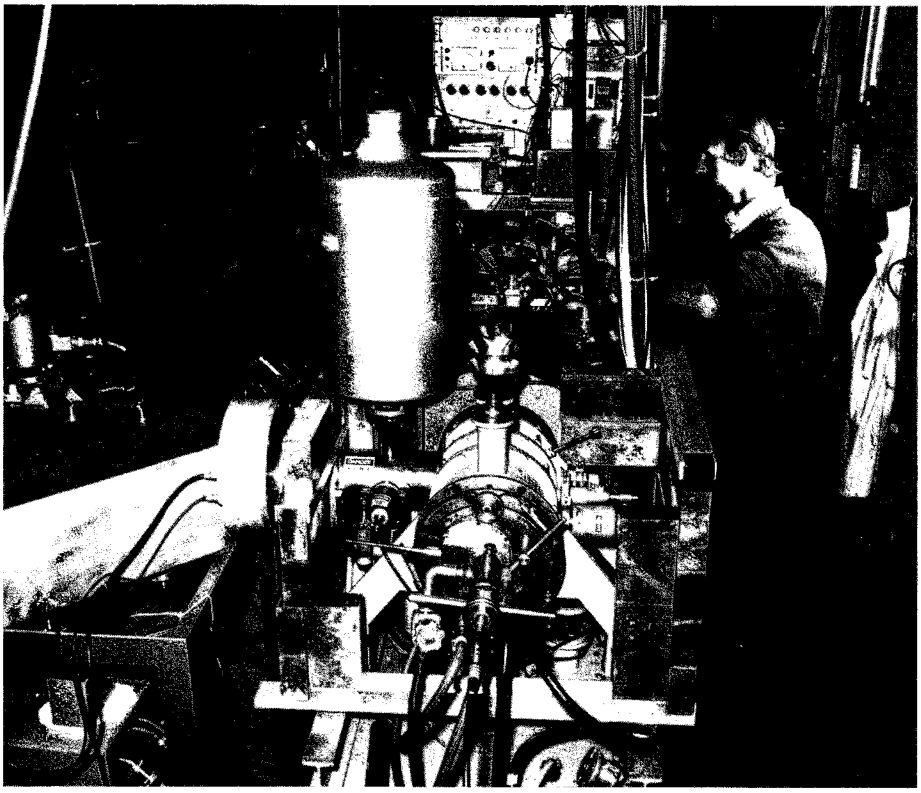
A high resolution crystal diffraction spectrometer with 4.6 m focal radius has been installed. As this instrument has a transmission only of the order of 10^{-7}, it is important that very strong mass separated samples are available. A special feature of the instrument is that two samples can be scanned simultaneously so that extremely small shifts can be detected by a comparison technique.

Appreciable shifts, an order of magnitude higher than those predicted by theory, have already been detected with errors of about 15 meV for xenon X-rays which have an energy of 30 keV and a natural width of about 15 eV. More experiments are under way to establish with certainty that the effects are due to the nuclear size.

6. The study of nuclear excited states in radioactive decays at ISOLDE involves the observation of emitted photons or particles using a number of experimental techniques. Energies and intensities of lines are extracted from direct spectra with high resolution spectrometers (high efficiency Ge and Si detectors and magnetic spectrographs). Level schemes are built on evidence from energies (Ritz principle), intensities (weak constraints) or coincidence experiments. Additional information on spin, parity, multipole order, mixing ratios, static and transition matrix elements, come from measurements of internal conversion electrons or of half-lives, and the more sophisticated angular correlation experiments (directional, or with polarization, or with time delay).

All these measurements can be performed off-line (involving collection in ISOLDE beams followed by transfer to a detection system) for long-lived isotopes, or on-line, for example using programmable tape collection and transport which allows preferential study of the parent/daughter/... activities.

Beyond the mere cataloguing of nuclear levels, the study of radioactive decays has potential for the study of nuclear excitation. While the highly deformed collective states are rather well understood, others such as the lighter nuclei, still present problems. The real challenge however concerns transitional nuclei, which should display some gradual change from spherical (near closed shells) to strongly deformed (middle of shells). No comprehensive description can be given yet and hence there are no predictions. Some modes of excitation (perhaps octupole states in heavy



An adventurous experiment which is attempting to measure, with a bent crystal spectrometer, small shifts in X-rays emitted from the lowest electron energy levels to see whether they can be used to extract information on nuclear size.

(Photo CERN 361.10.76)

nuclei) and/or their interplay (type of coupling) may still be undiscovered.

Nuclear shape transitions were observed at ISOLDE-1 with even A platinum isotopes as well as with mercury isotopes using the optical pumping technique, and confirming in studies of neighbouring odd A isotopes at Orsay, Grenoble and ISOLDE-2. One problem under study is the possible shape transition and related problems in light even xenon isotopes from decays of cesium. Rotational-like bands are observed in several isotopes and systematic behaviour has been clearly demonstrated. An interesting by-product is the evidence of metastable states with beta decay half-lives very similar to the cesium ground states. The band structure in neighbouring odd isotopes, to be studied in xenon and cesium, should help to understand the couplings in transitional nuclei.

These results are also needed for the interpretation of heavy ion reactions, and some experiments should yield data of fundamental importance to the problem of beta decay far from stability. First experiments at ISOLDE dealt with gross properties of high energy beta decay (see the article on strength-function phenomena in the January issue 1970).

7. A new line of investigation on hyperfine effects in solids has yielded some preliminary results. The properties of interest are — the magnetic and electric moments, and the magnetic and electric hyperfine fields in solids. These experiments are in a borderline field between solid-state and nuclear physics.

Two experiments have been set up. One looks at nuclear orientation in a magnetic field at very low temperature. This technique can be applied to the study of isotopes with fairly long lifetimes (over an hour). The ground state magnetic moments of two platinum isotopes, ^{189}Pt and ^{191}Pt, have been determined in this way.

The second experiment looks at the time differential perturbed angular correlation for excited states of the isotopes. This is possible with isotopes of short half-life (from 10 ns to 10 μs). So far it has been possible to look at the electric field gradient resulting from the implantation of cadmium in gallium and antimony and to confirm the existence of a substitutional lattice site. It is planned to use the technique to measure quadrupole moments of special interest.

8. The high intensities at ISOLDE make it possible to collect sufficient long-lived radioactivity for use as a target in other experiments. In a joint experiment in collaboration with the ILL high-flux reactor team in Grenoble, a target of ^{84}Rb (32 day half-life) was bombarded with a beam of thermal neutrons. Proton groups were observed from the (n,p) reaction which cannot be observed on a stable target. Experiments using radioactive targets in tandem Van de Graaff accelerators are in preparation.

9. A number of experiments have dealt with the alpha-decay mode, which becomes prominent for extremely neutron-deficient nuclei, and have studied the systematic features of transition probabilities and decay energies. The new target systems now available should make it possible to extend these studies above all to the rare-earth region, where alpha emission occurs systematically above the N = 82 neutron shell.

10. One pure atomic-physics experiment makes use of the steady supply of radioactive ions to study their ranges in gases. As this experiment requires a variable ion energy it has been necessary to place the experimental measuring equipment at high tension so that the incident beam is decelerated before entering the equipment.

Plans for the future

The next major step in the ISOLDE programme will come when 900 MeV helium ion beams are sent to the separator targets by the synchrocyclotron. An internal ^{3}He beam has already been accelerated in machine tests and it is hoped to have beams into ISOLDE-2 in the near future.

It is expected that helium ions will deposit more energy in the target and also increase the range of ions which it will be possible to draw from the targets. Elements such as tellurium and thallium, which are of special interest because they are close to the 'magic' proton numbers of 50 and 82, will become available.

People and things

The camera of Jeanne Ting caught Burt Richter (left) and Sam Ting in inhabitual splendour on the occasion of the Nobel Prize ceremony in December. Below is the text of Sam's speech at the Ceremony.

国王，皇后陛下，皇族们，各位朋友：

得到诺贝尔奖，是一个科学家最大的荣誉。我是在旧中国长大的。因此想借这个机会向在发展国家的青年们强调实验工作的重要性。

中国有一句古话："劳心者治人，劳力者治于人。"这种落后的思想，对在发展国家的青年们有很大的害处。由于这种思想，很多在发展国家的学生们都倾向于理论的研究，而避免实验工作。

事实上，自然科学理论不能离开实验的基础，特别，物理学是从实验产生的。

我希望由于我这次得奖，能够唤起在发展国家的学生们的兴趣，而注意实验工作的重要性。

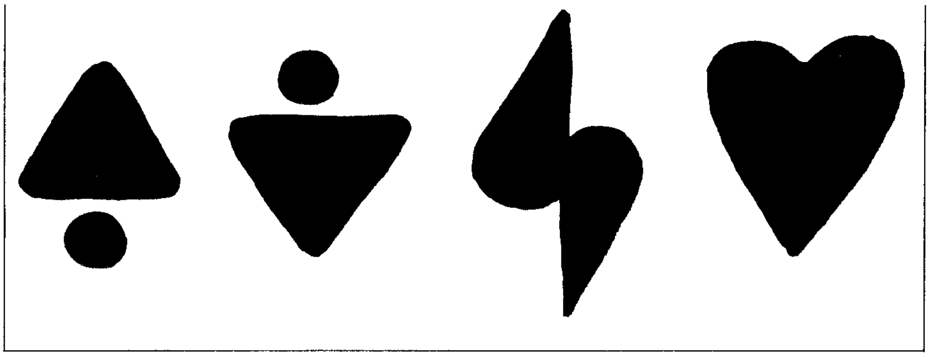
Heisenberg Medal

The Board of the High Energy and Particle Physics Division of the European Physical Society has decided to create a 'Heisenberg Medal' in memory of Werner Heisenberg who died in 1976. The medal will be awarded to a scientist or research group for a recent outstanding contribution to the understanding of the fundamental laws of Nature or for reshaping thinking about Nature. It will be given every second year on the occasion of the European Particle Physics Conference. The first award will therefore be at the next Conference in this series which will be held this year at Budapest from 4-9 July. Recommendations concerning the award should be forwarded to the Chairman of the Board of the EPS-HEPP Division, Professor George Marx, Department of Atomic Physics, Roland Eotvos University, 1088 Budapest, Puskin utca 5-7, Hungary.

Physics Film

A television documentary entitled 'The Key to the Universe' is now reaching the screens of viewers in four countries. The programme (two hours long) reports the recent excitement in high energy physics and relates it to the effort to understand the universe on its largest and smallest scales. It is possibly the most ambitious attempt ever made to present the discoveries and theories of modern physics to a wide lay audience.

In the preparation of the documentary during the whole of 1976, film crews travelled to Brookhaven, Brussels, CERN, Fermilab, SLAC and University College London, as well as various astronomy research centres. Theorists offering their opinions to the camera include Richard Feynman, Murray Gell-Mann,



While working on the television film 'The Key to the Universe' the producer, Alec Nisbett, needed to invent some graphical representation of the four quarks. The result is (left to right) — up, down, strange, charmed.

Sheldon Glashow, Stephen Hawking, Gerard 't Hooft, David Politzer, Abdus Salam, Steven Weinberg and Kenneth Wilson. The programme attempts to deal in plain language with neutral currents, quarks, coloured gluons, charm, particle formation by the 'Big Bang' and black holes.

The documentary is the latest from the very successful British Broadcasting Corporation team of Nigel Calder (science writer) and Alec Nisbett (TV producer). It follows other 'science specials' such as 'The Violent Universe', 'The Restless Earth' and 'The Weather Machine'. As an international coproduction, the programme has been completed in three forms (though with only slight variations) — a Dutch-Flemish version for KRO (Netherlands) and BRT (Belgium) screened in both countries on 4 January, a BBC version screened on 27 January and an American version, made with WTTW (Chicago), which is expected to be networked by the Public Broadcasting System in the Spring.

First J/psis from the SPS

A Birmingham/Rutherford/CERN/Ecole Polytechnique/MPI Munich/Neuchâtel collaboration in experiment WA12 using the Omega spectrometer in the West Hall, spent the first two physics runs of the SPS setting up their detection system. A negative pion beam (3 $\times$ 10^6 particles/burst) is fired at a copper target 20 cm long and data is taken of muon pairs coming from the decay of resulting massive particles. At the time of writing, data from 4 hours of running has been processed and in this short time some 30 events corresponding to the decay of the J/psi have been seen, in excellent agreement with the predictions from the currently accepted cross sections. The experiment will compare J/psi cross section using positive and negative pions, kaons and protons with emphasis on anti-protons which are not being studied elsewhere.

Computer network investigations

A Network Unit is working at the Rutherford Laboratory, under Mervyn Williams, studying the requirements of the UK Universities and the Science Research Council Laboratories as regards computer networks. It is being joined at Rutherford by the Secretariat of the Department of Industry's National Committee on Computer Networks under the chairmanship of Jack Howlett, former Director of the Atlas Computer Laboratory. This Committee has a broad mandate to look into national requirements for computer networks through to the 1980s.

Relativity confirmed again

Einstein's prediction on the bending of light in gravitational fields was confirmed to still higher accuracy on 25 November when radio signals were bounced off four spacecraft at Mars when the earth and the planet were about 100 million miles apart with the sun in between. The effect of the sun's gravitational field increased the path length of the waves. Irwin Shapiro of MIT reported at the Jet Propulsion Laboratory in Pasadena that the measurement (accurate to 5 foot in 200 million miles) was in excellent agreement with Einstein's theory of relativity.

Physics Inventory

The Office for History of Science and Technology at Berkeley is undertaking a world-wide survey of archival holdings related to physics in the 20th Century. The resulting inventory will record correspondence and unpublished papers of approximately a thousand physicists active between 1900 and 1950. Of particular interest is documentation on contacts between physicists and intellectuals outside the domain of academic physics.

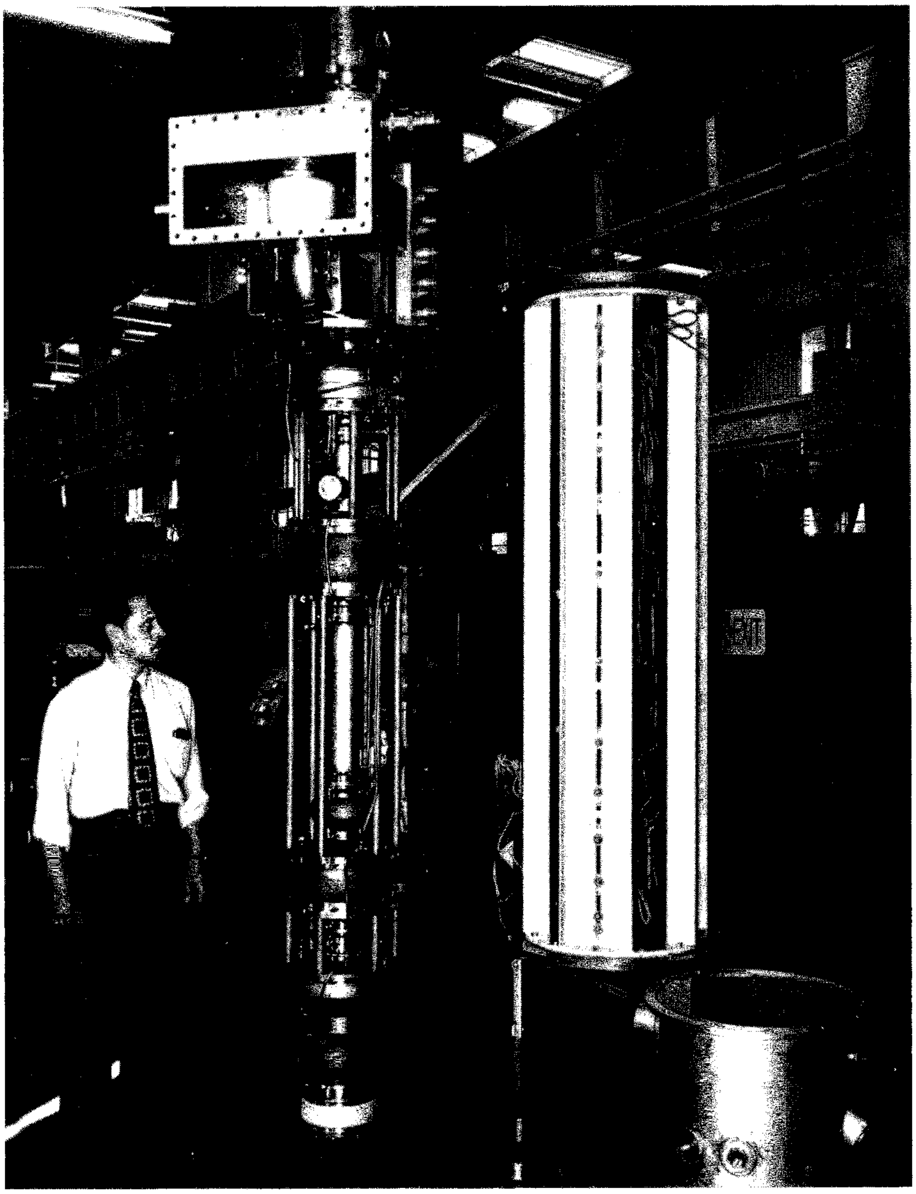
Anyone with special knowledge of unpublished correspondence with physicists (particularly items in private hands or in archival collections associated primarily with non-physicists), of letters to or from a physicist published in journals or books not likely to be well known to historians of science, or of archival holdings of papers of little known physicists, are invited to relay this information to the 'Survey of Archives' Office for History of Science and Technology, 470 Stephens Hall, University of California, Berkeley, California 94720.

Serial CAMAC at the ISR

The ISR's first serial CAMAC highway has been in service since the last autumn shutdown; it is dedicated to the collection of data on the ultra high vacuum system. Ten CAMAC crates are used on a loop of total length 2.4 km operating in bit-serial mode at 5 MHz. Much of the hardware has been obtained from commercial sources following specifications prepared by ESONE and NIM committees. Some developments, a crate bypass unit and a line repeater with full galvanic isolation and de-skewing, were done at CERN.

Commissioning was not without its problems but a test module in each crate allowed steady progress to be made and since the ISR start-up there have been no faults or data errors. Use of the highway has been restricted to collection of some 3000 bits of digital status information and to driving associated displays in the control room but analog scanners and special processors for measurement of clearing current are being installed, together with facilities

Gerry Konrad stands alongside the prototype high power klystron, 3.6 m high, developed at the Stanford Linear Accelerator Center for the PEP electron-positron storage ring project. The magnet for focusing the electron beam is on the right. Twelve such tubes will be used on the ring. The operating voltage is 62 kV with a beam current of 12 A and an operating frequency of 353.2 MHz. A pulsed version has been operated up to 500 kW and the prototype in the photograph reached 400 kW c.w. on 14 January.



for handling interrupts (L.A.M. encoders).

The entire serial highway will be transferred from an Argus 500 computer to a Nord-10 and the Argus will then operate a second highway. The serial highway, with its very simple interconnecting cables, seems to be well suited to control system uses, and may prove important in widening the industrial acceptance of CAMAC.

419811 becomes 836111

On 18 March there will be changes in the telephone system operating at CERN. Advantage has been taken of an offer by the Swiss PTT, who are installing new equipment for the Meyrin telephone exchange, to introduce direct entry to internal numbers. A number within CERN will be reached by composing 83 followed by the internal number; thus the COURIER Editor, with internal number 4103, will be reached by dialling 834103. The CERN telephone exchange will be reached by dialling 836111 (rather than 419811 as at present).

The new system will benefit callers from outside CERN, both in time and in cost, and will reduce the work load on the CERN exchange. To help make good use of the new facilities a copy of the CERN telephone directory will be made available, on request, to the telephone exchanges of Laboratories and Organizations who have frequent contact with CERN. Requests should be sent to Leon Donnat-Bouillud, Mail Office, CERN, 1211 Geneva 23, Switzerland.

Bits and Pieces

A construction firm, Ammann and Whitney of New York City, has been selected for the proposed 200 GeV proton-proton storage rings, ISABELLE, at the Brookhaven Laboratory.

On 3 December a 100 GW neodymium glass laser was successfully operated in the Laser Division at the Rutherford Laboratory. The laser, from Quantel SA in France, was operated at half power (5 joules in a 5 ps pulse) for these first tests.

New intensity records at Fermilab in December. The 200 MeV linac reached 301 mA, the 8 GeV Booster fed 3 × 10^{13} protons per pulse to the Main Ring and, on 12 December, the Main Ring accelerated 2.47 × 10^{13} protons to 400 GeV.

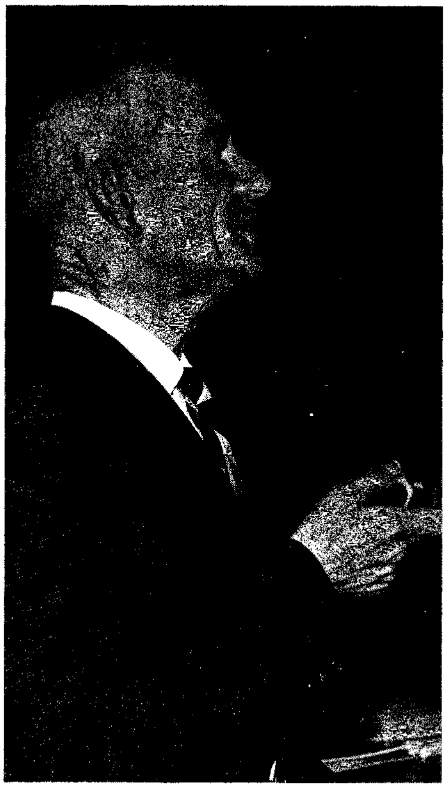
The 2 m bubble chamber at CERN took a record number of pictures, 5359864, in eight months of operation in 1976 beating its previous record of 5251352 in eleven months of operation in 1971. This is an impressive swan song from the chamber prior to being closed down this year, by which time it will have over 40 million pictures to its credit since it came into operation at the end of 1964.

On 22 December protons were accelerated to 12 GeV in the synchrotron of the Japanese National Laboratory for High Energy Physics, KEK. First acceleration to 10 GeV was reported in the April issue 1976.

The new 70 MeV proton linac built for the Nimrod synchrotron has achieved design intensity of 75 mA with a 500 µs pulse length. The linac is included in the proposed Spallation Neutron Source as a negative hydrogen ion injector.

François-Xavier Ortoli, well known European politician, has remarked that, when assessing the cost of advanced scientific and technical projects, governments need to multiply the stated estimate by

1. Louis Leprince-Ringuet
2. Willi Jentschke


1.


2.

π = 3.1416. At the Council Meeting in December, Wolfgang Paul remarked (in relation to the SPS and other projects) that at CERN π = 1.

The Banff Summer Institute on Particles and Fields will be held at Banff, Alberta, Canada, from 25 August to 5 September. More information can be obtained from the Banff Organizing Committee, Physics Department, University of Alberta, Edmonton, Alberta, TGG 2JI, Canada.

Heavy Ion Fusion Report

The 'Final Report' from the ERDA Study on Heavy Ions for Inertial Fusion, held at Berkeley in July of last year, was issued in December. The Report is edited by Roger Bangerter, Bill Herrmannsfeldt, Dave Judd and Lloyd Smith. Copies ($ 5.50 printed, $ 3 microfiche) are available from the National Technical Information Service, U.S. Department of Commerce, 5285 Port Royal Road, Springfield, Virginia 22151. A review of the ERDA study appeared in the September issue of CERN COURIER last year.

Mastering the Booster beam instabilities

A very sophisticated analysis and correction of longitudinal instabilities in the four-ring 800 MeV Booster at the CERN PS has been carried out by Fleming Pedersen and Frank Sacherer.

They have developed a full theory of the possible instabilities and have implemented an observation and feedback damping system. The five coupled bunch modes of the three lowest order (dipole, quadrupole and sextupole) can be effectively damped in all four rings with high beam intensities, 4×10^{12} protons per pulse, in each ring. The system can also be used to drive the various modes for investigating beam stability limits.

On people

On 19 December, the Prime Minister of France awarded the medal of 'Grand Officier de la Légion d'Honneur' to Professor Leprince-Ringuet. Louis Leprince-Ringuet has had a distinguished career in high energy physics and is already well adorned with scientific and national honours.

On 11 January, a Fest-Kolloquium was given at the DESY Laboratory in honour of Professor Jentschke who celebrated his 65th birthday on 6 December 1976. Willi Jentschke has a long association with DESY, including a period as Director of the Laboratory, and is a former Director General of CERN. Nobel prize winner Sam Ting payed tribute to Professor Jentschke who helped him with his first series of experiments at the DESY synchrotron from 1960-65.

The following elections and appointments were made at the CERN Council session on 16 December: President of Council — P. Levaux, Vice-Presidents — B. Gregory/ A.C. Pappas, Chairman of the Scientific Policy Committee — W. Paul, SPC Members — B. Gregory (reappointed for one year)/ J.P. Blaser (for three years), Chairman of the Finance Committee — M. Gigliarelli Fiumi (in succession to M. Lemne who had reached the end of his three year term of office), Vice-Chairman of the Finance Committee — J. Beattie (appointed to a newly created post), Leader of the CERN SPS Division — M. Crowley-Milling (for three years), Leader of the CERN ISR Division — F. Ferger (reappointed for three years).

Jim Cronin of the University of Chicago has been appointed to head a new Colliding Beam Experiments Department at Fermilab. Jim Walker will be Associate Head. The Department will study proton-proton and proton-antiproton possibilities using the existing Main Ring and implement the construction of experimental facilities. The development of beam cooling techniques and beam storage systems remains in the Accelerator Division under Russ Huson. On 14 January, Jim Cronin was one of the recipients of the 1976 E.O. Lawrence Memorial Awards for 'major experimental contributions to particle physics including work on weak interactions culminating in the discovery of asymmetry under time reversal'.

On 8 February, William Fowler of Cal. Tech., President of the American Physical Society, presented the 1977

Dannie Heineman Prize for Mathematical Physics to Steven Weinberg of Harvard University. The citation reads 'for his formulation of unified gauge theories of weak and electromagnetic interactions and his analyses of the role of spontaneous symmetry breaking in such theories, all represented by outstanding publications in the field of mathematical physics'.

ISR decisions

The CERN Research Board has approved the construction of superconducting magnets to give a low beta insertion on one of the Intersecting Storage Rings so as to study the techniques which have relevance also to any further storage ring projects. The possibility of repeating the exercise on the other ISR beam so as to have a complete high luminosity insertion will be considered later.

The Board also decided not to authorize construction of a second large general purpose magnet facility for one of the intersection regions.

High field ISABELLE magnet

In December, a high field version of an ISABELLE ring magnet was successfully tested at the Brookhaven Laboratory. The ISABELLE 200 GeV proton-proton storage ring project requires superconducting magnets providing fields up to 4.5 T. However higher field magnets have been considered and the prototype tested in December had a two layer coil structure with an 8.5 cm aperture. The magnet was 1 m long. After 23 quenches the magnet reached a field of 6.2 T with field as high as 7 T at the superconducting coil itself. Field harmonics were at the 10^{-4} level or less. The maximum critical current density was 29.2 kA/cm^2 and the maximum stored energy 261 kJ.

Leon and the Lady

Leading a charmed particle search at the Fermilab, Leon Lederman of Columbia University, called for a large quantity of beryllium to act as a muon filter in preference to steel. Tracking the muon back to its point of origin can be more accurately done through beryllium than through steel. Locating and liberating two metric tons of beryllium was, however, not easy; it was finally obtained from Oak Ridge Tennessee. The search led to the following saga from the pen of Tim Toohig appearing in Fermilab's "The Village Crier" on 6 January:

Once upon a time in the far off land of Protonia there lived a troglodyte with the unlikely name of Leon. Now Leon was very troubled. Whenever he walked into his cave he sniffed the perfume of the seductive charmed quark, but of her he never managed to catch sight. He was in a frenzy.

One day Leon decided to set a trap. He went to the court of the Prince of the Troglodytes. Right up to the throne of the Prince he went and announced in a firm voice: "More beryllium." The court was shocked; the Prince was shocked. Finally the Prince gasped, "Leon wants more beryllium". The Royal Artificer had already provided Leon with all the beryllium in the kingdom.

The Prince knew that Leon dined often with the King and had performed many valorous deeds for the kingdom. And he knew that the vision of the Charmed Quark would make Leon deliriously happy beyond all his imaginings. So he wanted to help Leon. But, what to do? He decided to seek the help of the Grand Vizier of the Kingdom.

Now the Vizier was a very wise man whose caravans had travelled to most of the Kingdoms of the world. He had consulted with the Royal Wizard, Benjamin and the Sorcerer's Apprentice Christopher, and knew that if Leon were to trap the Charmed Quark he would need beryllium. Beryllium had just the ration of nucleon interaction length to radiation length the Wizard would recommend for his magic potion.

The Vizier wanted to help Leon, so he mounted his mighty stallion, Studley, and rode out to see Squire John and his vassal, Norman. Squire John and Norman had served long in the crusades. They had many old comrades-in-arms in various kingdoms with whom they had warred and wenched. The call went out to all the old comrades, "Leon wants more beryllium."

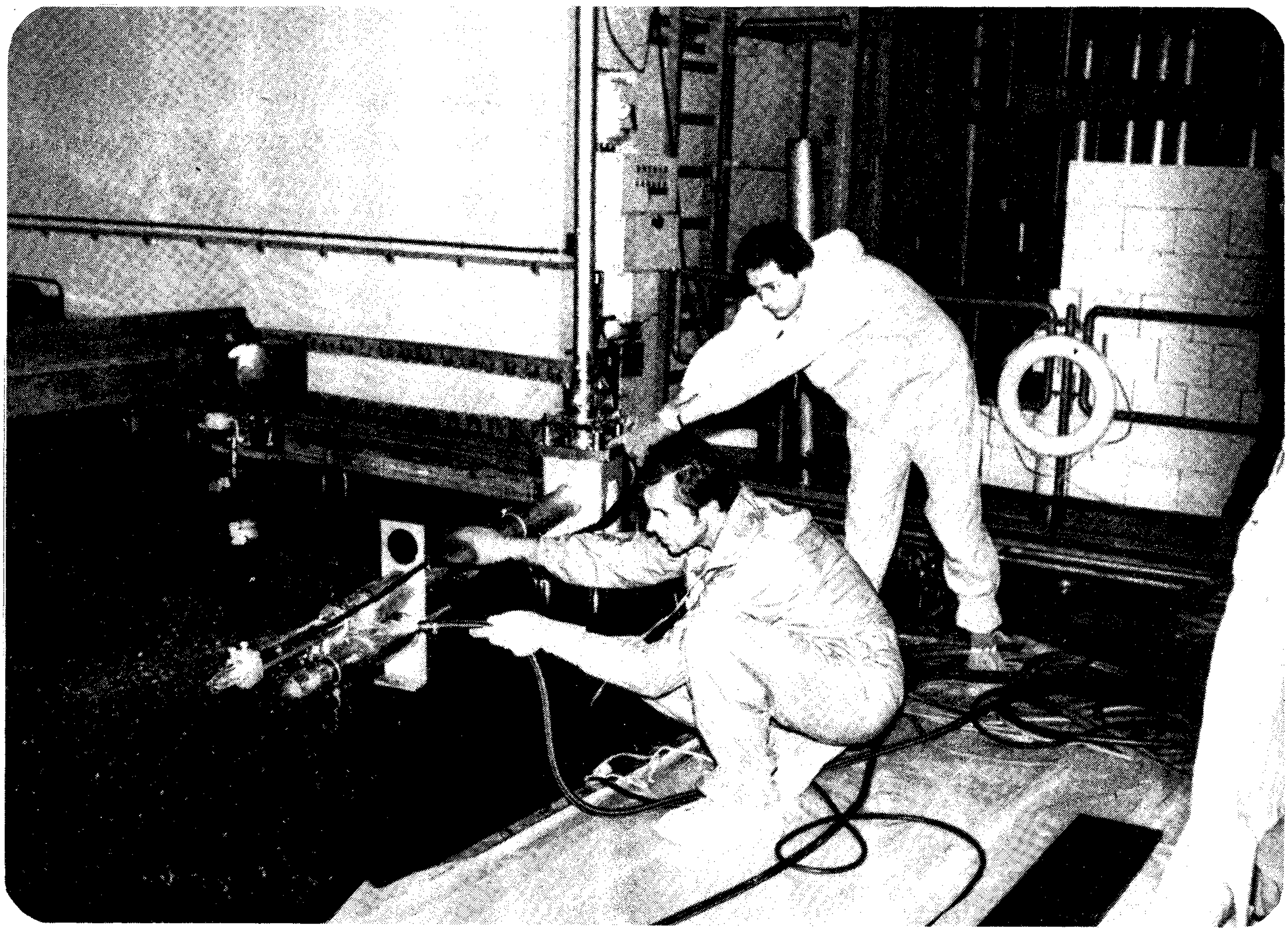
One comrade recalled that in a long-ago campain he had seen a veritable mountain of beryllium in a dusty cave in far away Tennessee. It was guarded by a fierce dragon homoensis burocraticus. But who would slay the dragon?

From high in the tower the Legate of the Emperor, Donald, espied the predicament of the Vizier's minions. "I shall slay the dragon," he proclaimed. With dexterity that revived the glorious memories of El Cid, the Legate drew his sword, and slew the dragon with one mighty stroke.

The dragon writhed in agony and finally collapsed in a great heap atop the trove of beryllium. The Vizier was at a loss as to how to proceed. Clearly the bulk of the dragon was too great even for Studley to move. Squire John surveyed the awesome scene. His Caravan Master, Raymond, with much experience in moving great loads, might be of help. Many weeks passed; the Caravan Master employed all of his ingenuity and skill. The great carcass slowly yielded and was finally dislodged from atop the beryllium.

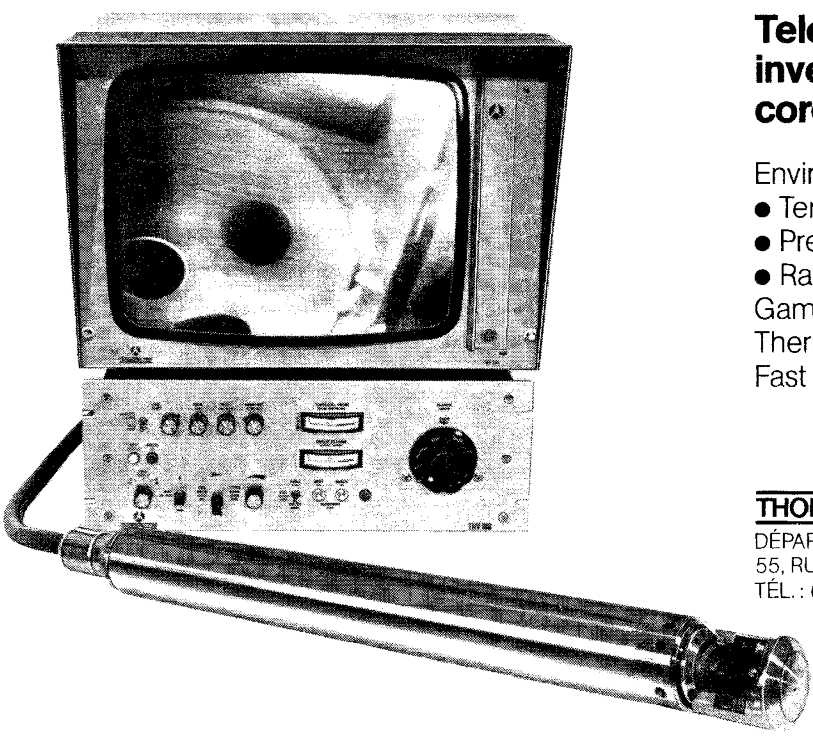
So the beryllium was brought to Leon and he withdrew with it into his cave. Occasionally, even today, travellers to Protonia bring back tales of gleeful sounds issuing from deep within Leon's cave. The natives believe that Leon still dwells there in endless hot pursuit of his fair lady.

Prince of the Troglodytes — Brad Cox
Royal Artificer — Bill Thomas
Grand Vizier — Rich Orr
Royal Wizard — Ben Lee
Sorcerer's Apprentice — Chris Quigg
Studley — played by himself
Squire John — John Colson
Norman — Norm Hill
Homoensis Burocraticus — Federal bureaucracy
Legate of the Emperor — Don Bray, ERDA
Caravan Master — Ray Lewandowski



A line of television cameras for use in radioactive environments and especially adapted for :

Control • Surveillance • Intervention



Television equipment to investigate at the core of nuclear reactors.

Environment:
- Temperature: 225 °C (437 °F)
- Pressure: 45 bars
- Radiation: (Combined dosages)

Gamma Rays: 5.10^{8} R
Thermal Neutrons: 3.10^{14}
Fast Neutrons: 3.10^{15}

THOMSON-CSF
DÉPARTEMENT AUDIOVISUEL
55, RUE EDGAR QUINET / 92240 MALAKOFF / FRANCE
TÉL.: (1) 65711.10

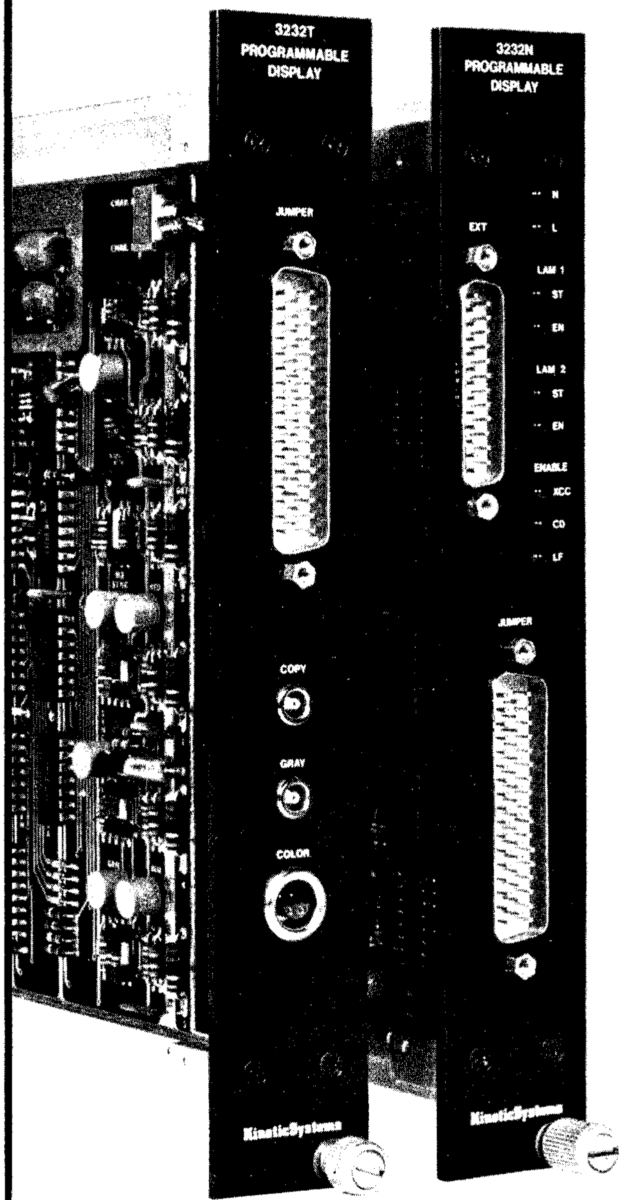
2868

Programmable Color Display Driver

CAMAC
Model 3232

Compare these features . . . .

- BLACK/WHITE AND 8-LEVEL GRAY-SCALE OUTPUTS IN ADDITION TO COLOR
- BOTH 625-LINE AND 525-LINE OPTIONS AVAILABLE
- UP TO 2048 CHARACTERS PER DISPLAY
- VERSATILE CHARACTER SET:
  - Up to 256 characters in PROM (4 sets of 64 characters each)
  - Up to 256 characters in Symbol Memory that is written from Dataway
- SELECTABLE ON A LINE-BY-LINE BASIS:
  - Width of character (64, 48, 32, or 16 characters per line)
  - Height of character (normal or double-size)
  - Spacing between lines
- SELECTABLE ON A CHARACTER-BY-CHARACTER BASIS:
  - Character color
  - Background color
  - Flashing
- POINT PLOTTING CAPABILITY WITH 256 X 128 POINT RESOLUTION
- COMMANDS TO ERASE THE DISPLAY
- COMMANDS TO ROLL THE DISPLAY
- EXTERNAL LAM SOURCE
- EXTERNAL INPUTS TO MOVE THE CURSOR BY JOYSTICK, TRACKBALL, ETC.
- SYNC OUTPUTS TO ALLOW MIXING OF 3232 VIDEO WITH CAMERA VIDEO

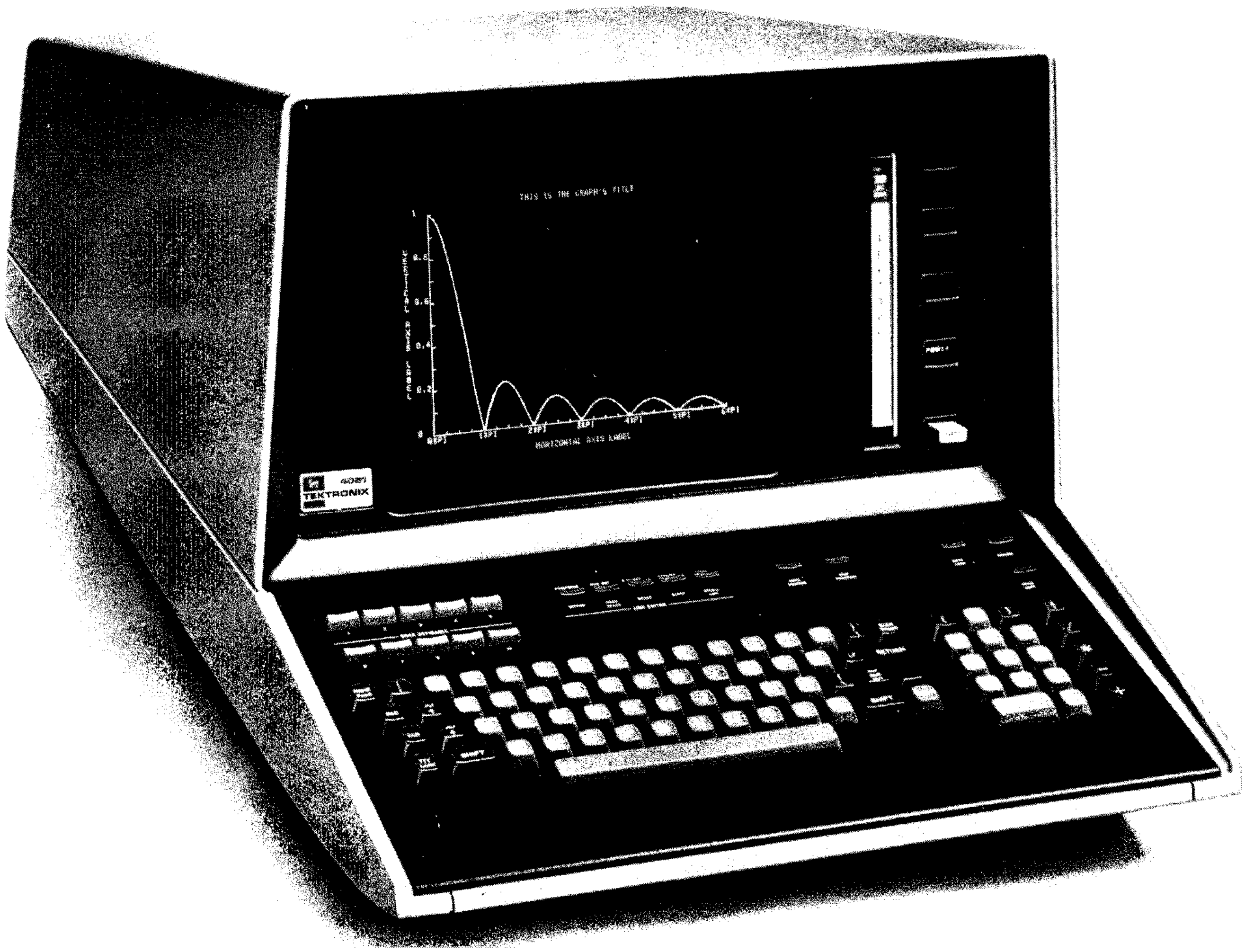


Additional information available upon request.

KineticSystems International S.A.

2 Chemin de Tavernay * 1218 GENEVE, SUISSE * Tel. (022) 98 25 82/3 * Telex 23 429

KineticSystems Corporation * 11 Maryknoll Drive * Lockport, Illinois 60441 * Tel. 815 838 0005 * TWX 910 638 2831



PERSONAL COMPUTING POWER

The 4051 Graphic Computing System stands alone: a desk-top unit that offers so many possibilities for a reasonable price.

In research and engineering, among others, the 4051 offers you personal computing power for all forms of statistics, forecasting, planning and calculating.

Use it as a:

— BASIC language computer
— Calculator
— Intelligent terminal
— Heart of a measurement system

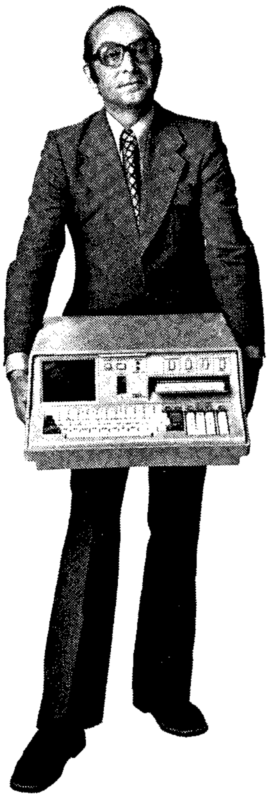
For more information on how the 4051 could work for you, call

Tektronix International AG
Postfach 57
6301 Zug / Schweiz
Tel. 042/21 91 92

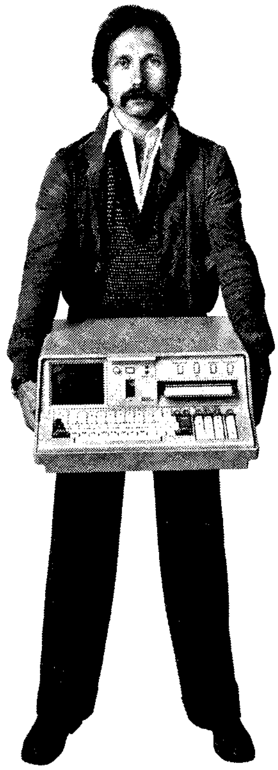
TEKTRONIX®

GGK

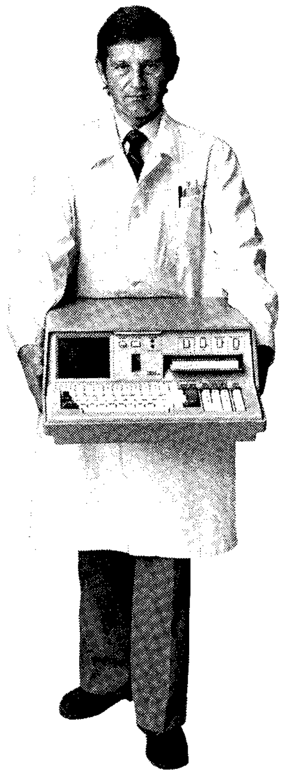
L'ordinateur portatif IBM 5100: 23 kg, mais il fait le poids.



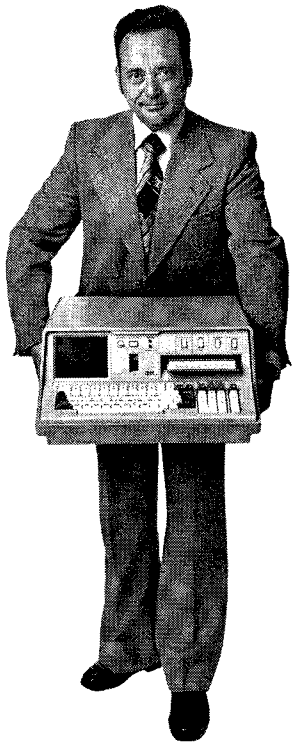
L'ordinateur portatif IBM 5100 possède un clavier classique, du type «machine à écrire», conçu pour faciliter la tâche de l'utilisateur.



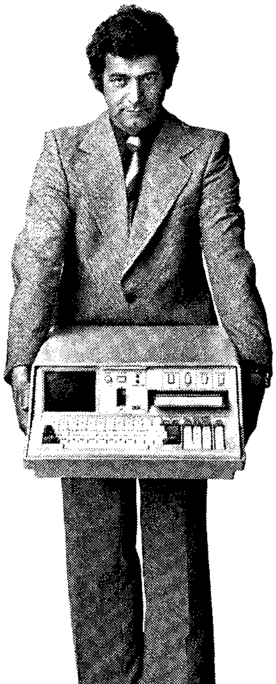
L'ordinateur portatif IBM 5100 est doté d'un écran incorporé affichant plus de 1000 caractères sur 16 lignes.



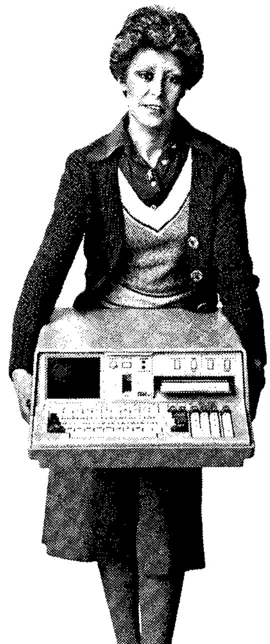
L'ordinateur portatif IBM 5100 travaille en APL et BASIC 4, deux langages de programmation éprouvés et largement répandus à l'aide desquels vous résoudrez très simplement des problèmes compliqués.



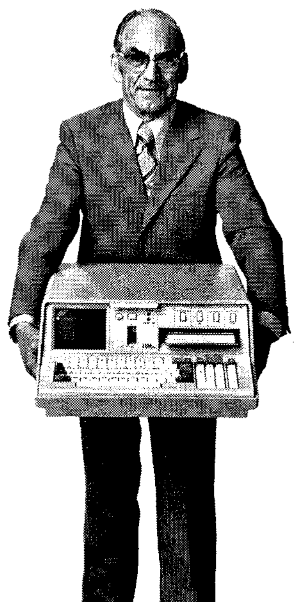
Pour l'ordinateur portatif IBM 5100, IBM a mis en cartouches magnétiques toute une série de programmes couvrant l'éventail des applications mathématiques, statistiques, financières et de gestion les plus courantes.



L'ordinateur portatif IBM 5100 permet l'écriture et l'exploitation de programmes personnels pour traiter les sujets les plus divers.



L'ordinateur portatif IBM 5100 peut être connecté à sa propre imprimante.



L'ordinateur portatif IBM 5100 peut fonctionner comme terminal et travailler avec un ordinateur IBM plus gros.

A l'attention d'IBM.

A part cela, quelles sont les autres particularités de l'ordinateur portatif IBM 5100?

- ☐ Puisque l'IBM 5100 est portatif, qu'un spécialiste IBM vienne me le présenter. Téléphonez-moi pour convenir d'une démonstration sans engagement.
- ☐ Veuillez me faire parvenir votre documentation sur l'ordinateur IBM 5100.

M'intéressent avant tout les applications:

- ☐ mathématiques
- ☐ statistiques
- ☐ financières et de gestion
- ☐ ____________________

56

Nom: ____________________

Entreprise: ____________________

Adresse: ____________________

____

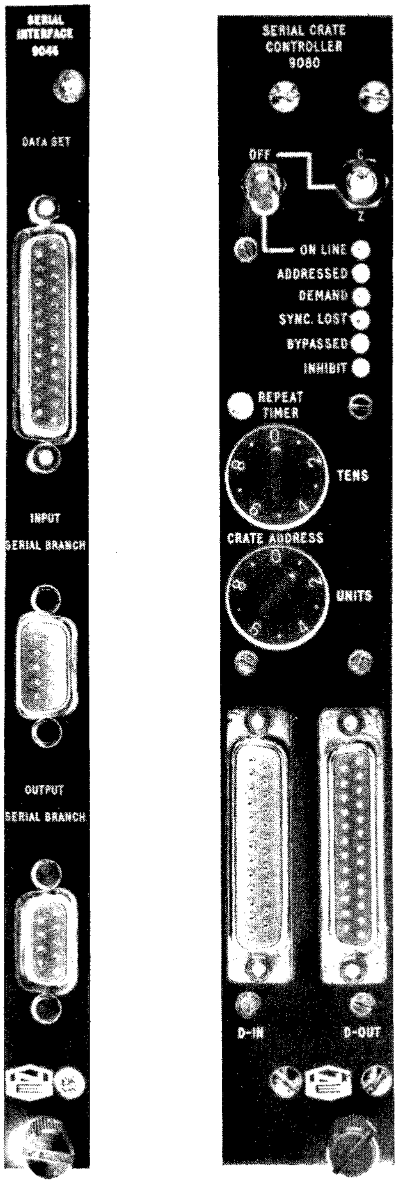
No de téléphone: ____________________

(Découper et envoyer à IBM Suisse, service d'information, Quai Général Guisan 26, case postale, 8022 Zurich.)

IBM

IBM Suisse

CAMAC



Serial Branch Highway Controller and Driver from Nuclear Enterprises

The Serial Branch Highway puts a new dimension into Camac Multi-crate Systems.

9080 SERIAL CRATE CONTROLLER
Complex systems containing up to 62 Crates can be operated at data rates of 5Mbits/second. Minimum geographical restraints are imposed using the Nuclear Enterprises Model 9080.

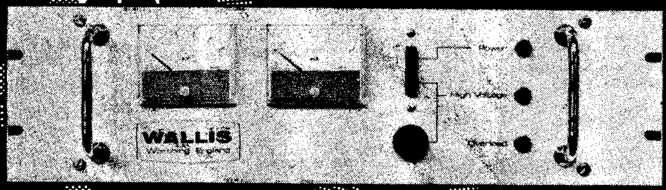
9046 SERIAL BRANCH DRIVER
The Camac Serial Highway is a uni-directional loop originating and terminating at the Nuclear Enterprises Model 9046. A Modem compatible V24 driving capability is a standard feature of the instrument.

Full details on request. New 6-page CAMAC Selection Guide also available.

NUCLEAR ENTERPRISES S.A.

25 Chemin François-Lehmann 1218 Grand Saconnex, Genève Tel (022) 98 16 61 62 Telex 289066
Nuclear Enterprises Limited, Sighthill, Edinburgh, EH11 4EY., Or phone 031-443 4060.
EMI
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

Power supplies up to 500 kV with overall stabilities of better than 10 ppm



High Voltage Specialists

We manufacture a comprehensive range of precision HV supplies for use, worldwide, in conjunction with scanning electron microscopes, X-Ray machines, precision visual displays (CRTs including colour tubes), photomultiplier tubes, insulation testing, research and industry.
Success in this field has led us to produce custom built power supplies for use in all sorts of applications. Reversible polarity, programming, high stability, short circuit and flashover proof, slow rise times, fast HV switching, safety features etc ... all are no problem with these lightweight all-solid-state units.
So ... contact us if you have HV supply problems ... we are sure we can help.

WALLIS
Worthing UK
Europe

Wallis Electronics Limited,
Bedford Row, Worthing, Sussex
(0903) 208201/2. Telex: 877112

A & D Products
P.O. Box 1113, CH-2501, Biel, SWITZERLAND
Telephone 032/23 55 82 or 23 63 12 Telex 34834

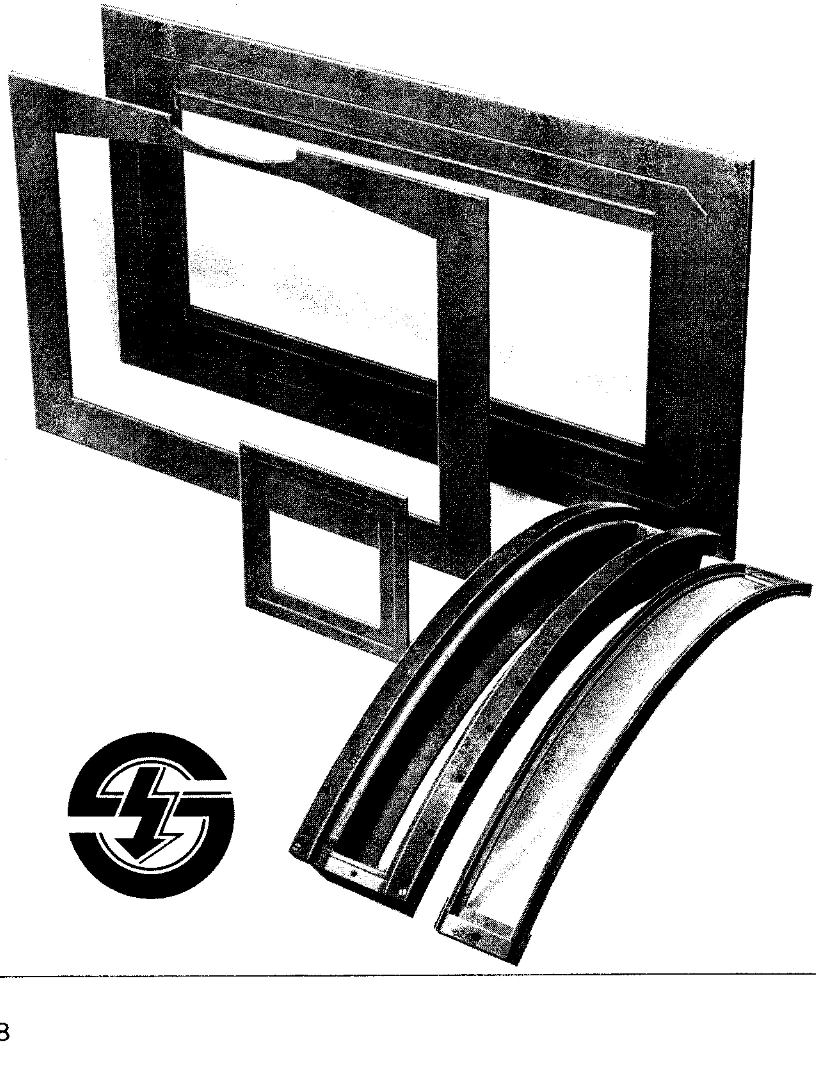
Zentro-Electrik GmbH
7530 Pforzheim, Sandweg 20, Postfach 2070, WEST GERMANY
Telephone (07231) 41212 Telex 783701

Sorelia Electronique
51/53 rue Edouard Vaillant, 92700 Colombes, FRANCE
Telephone 242-29-03 Telex 610248F

Delta Elektronika
P.O. Box 27, Zierikzee, NETHERLANDS
Telephone (01110) 3656 Telex 55349

Techniche Electroniche Avanzate SAS
20147 Milano, Via Sanatolone 15, ITALY
Telex 39202

We are also represented in AUSTRALIA, DENMARK and SWEDEN

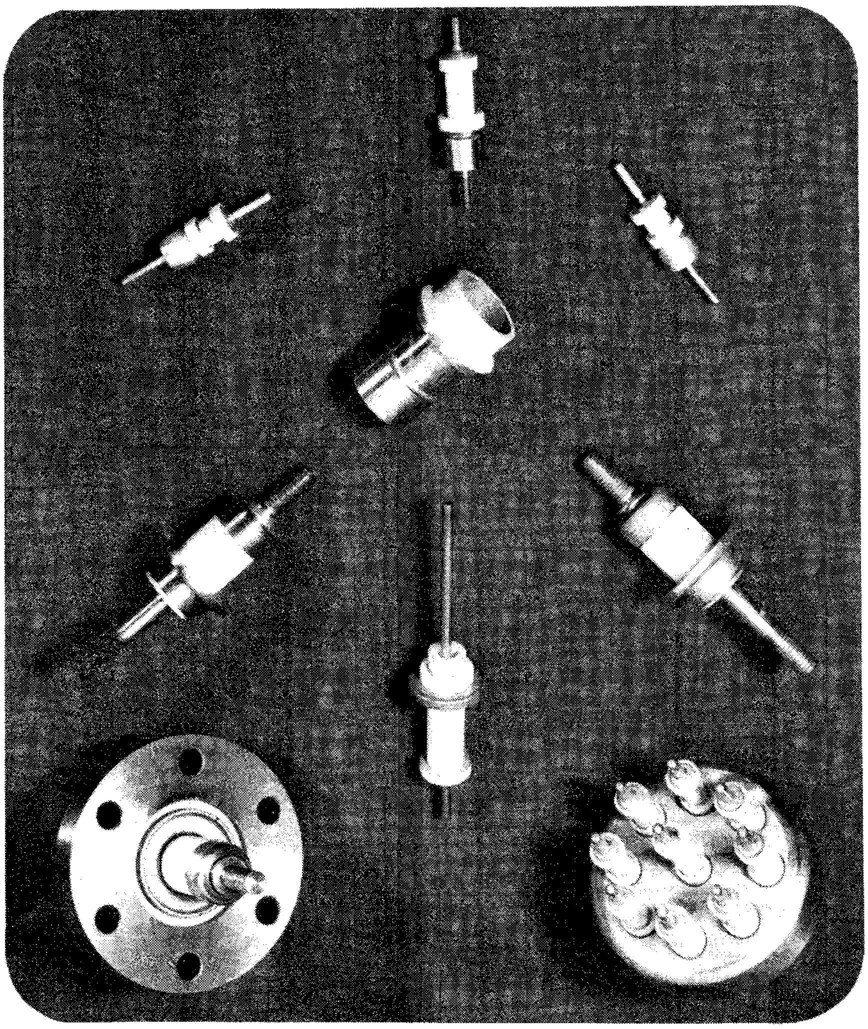


Stesalit resolves your individual problems in fiberglass construction – for science and advanced technic.

Frames for
proportional chambers
spark chambers
drift chambers
coasting boxes for Cerenkov counters
space research
and medical assistance.

Stesalit AG
Kunststoffwerk
CH-4249 Zullwil SO
Telefon 061 80 06 01
Telex 63182

Ultrahigh-vacuum feed-throughs and viewing ports



A wide range of standard models, including all of the most-required types:
- Feed-throughs of alumina-Kovar or alumina-special metals construction,
- Viewing ports of glass, sapphire or quartz.

A "specials" capability, to meet almost any particular requirements.

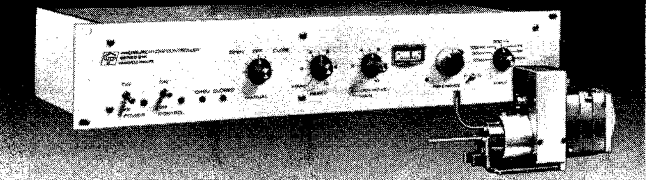
All from THOMSON-CSF, Division Tubes Electroniques. Contact us for the catalog or any further information needed.

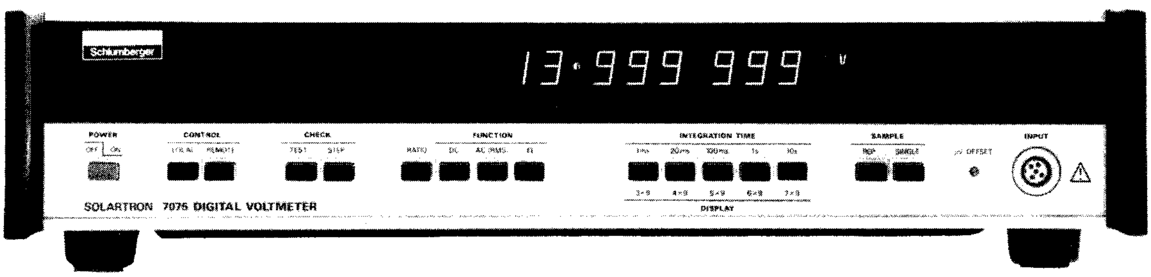
THOMSON-CSF

2880

THOMSON-CSF DIVISION TUBES ELECTRONIQUES 38 RUE VAUTHIER / 92100 BOULOGNE-BILLANCOURT / FRANCE / TEL. : (1) 604 81.75

Germany - THOMSON-CSF Elektronenröhren GmbH / Leerbachstr. 58 / 6000 FRANKFURT am MAIN 1 / Tel. : (0611) 71.72.81
Italy - THOMSON-CSF Tubi Elettronici SRL / Viale degli Ammiragli 71 / I - 00136 ROMA / Tel. : (6) 638 14 58
Japan - THOMSON-CSF JAPAN K.K. / TBR Building / Kojimachi 5-7 / Chiyoda-Ku / TOKYO / 〒102 / Tel. : (03) 264 6341
Spain - THOMSON-CSF Tubos Electronicos S.A. / Alcalà 87 / 7° Dcha / MADRID 9 / Tel. : (1) 226 76.09
Sweden - THOMSON-CSF Elektronrör AB / Box 27080 / S 10251 STOCKHOLM 27 / Tel. : (08) 22 58 15
United Kingdom - THOMSON-CSF Electronic Tubes Ltd / Ringway House / Bell Road / Daneshill / BASINGSTOKE RG24 OQG / Tel. : (0256) 29155 / Telex : 858865
U.S.A. - THOMSON-CSF Electron Tubes / 750 Bloomfield Avenue / CLIFTON NJ 07015 / Tel. : (201) 773 1004





Schlumberger
13·999 999 V
POWER
CONTROL
CHECK
FUNCTION
INTEGRATION TIME
SAMPLE
INPUT
DISPLAY
SOLARTRON 7075 DIGITAL VOLTMETER

METAUX PRECIEUX SA

- High-purity precious metals
- Evaporation discs (5N)
- Au, Pt and Pd targets (5N)
- Pt-PtRh precision thermo-couples, supplied with a guarantee or calibration certificate
- Miniature PtCo magnets, made to measure
- Electrical contact equipment

Please ask our technical advisers for further details

MÉTAUX PRÉCIEUX SA	Telephone	Telex
2, Av. du Vignoble **CH-2000 Neuchâtel 9**	038-257231	35101 35401
7, Bvd du Théâtre **CH-1211 Genève 11**	022-216377	
19, Löwenstrasse **CH-8039 Zürich**	01-278120	57783

PEARSON

Very High Voltage PULSE TRANSFORMERS

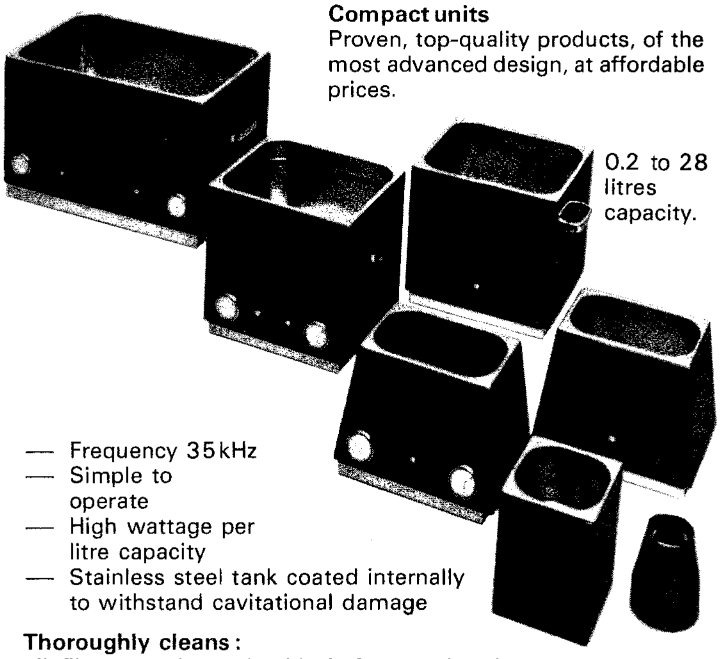
Pearson Electronics, Inc. specializes in the development, design, and manufacture of very-high and super-high-voltage, high-power pulse transformers and related modulator components. Typical pulse transformers manufactured by Pearson Electronics, Inc. range in output voltage from 40 kV to 600 kV. Other 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, CA 94303, U.S.A.
Telephone (415) 494-6444

ULTRASONIC CLEANING EQUIPMENT

Compact units
Proven, top-quality products, of the most advanced design, at affordable prices.



0.2 to 28 litres capacity.

- Frequency 35 kHz
- Simple to operate
- High wattage per litre capacity
- Stainless steel tank coated internally to withstand cavitational damage

Thoroughly cleans:
oil filters, strainers, heald shafts, nozzles, instruments, relays, counters, precision engineering components, polished items.

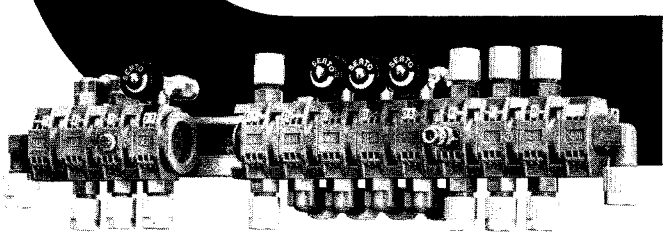
For LARGE-SCALE INSTALLATIONS:
modular generators (modules interchangeable within minutes) and immersed oscillator.

M. SCHERRER AG, CH-9500 WIL/SG
Gallusstrasse 41 (Switzerland) Phone (073) 223476

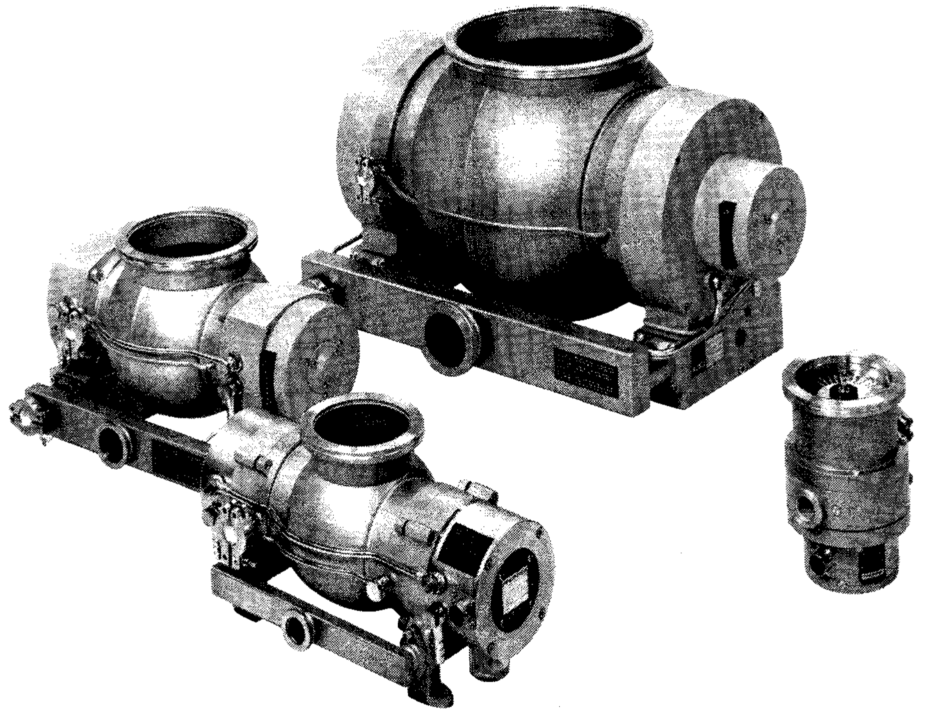
It's ELEMENTary Pneumatics: one connection leads to another!

The assembly of SERTO polyamide connecting elements could not be easier. A 90°-twist, and the bayonet catch is engaged. O-rings seal off the through-ports. Whole batteries are assembled in a matter of minutes.
Connection to the tubing is just as simple. Whether in control and monitor systems for air-conditioning, in chemical plants, or otherwise in machinery: just cut off the tube, push it in the union, and screw tight. The job is done!
Connect-up is especially easy on pneumatic panels and switch cabinets. A single hand movement, and the battery is hooked on the carrier rail. Another move, and it's off the rail again. Even the future is in-built: With the SERTO system your manifold is manifold! Modify and extend as needed.
Don't miss your connection!

SERTO



GRESSEL AG CH-8355 AADORF
phone 052/47 26 21 telex 76436 gress

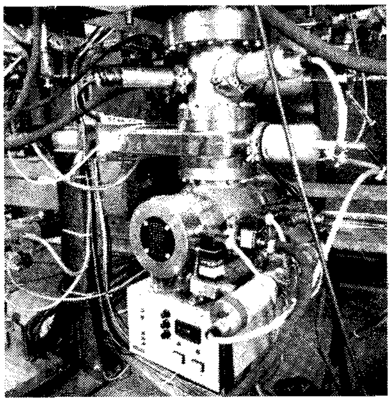


PFEIFFER-TURBO

the optimized programme to produce hydro-carbon free high and ultra-high vacuum.

Turbo-molecular pumps, to make vacuum production a mere trifle. High compression ratio for hydrogen and other light gases ● constant pumping speed over a large working range ● low vibration and noise level ● high performance/weight ratio ● easy installation due to horizontal or vertical connection ● low operating costs ● sturdy and reliable ● easy handling ● simple maintenance.

PFEIFFER TURBO for cleanest vacuum in: particle accelerators, their beam guide systems and target chambers ● neutron generators ● UF_6-technology ● plasma physics ● mass spectrometry and gas analysis ● electron microscopy and micro probes ● vacuum coating and sputtering ● optics ● semi-conductor production ● manufacture of high-frequency quartz crystals ● manufacture of incandescent bulbs and tubes ● space simulation ● calibration systems ● metallurgy ● production of hydrocarbon free «fore-vacuum» for other HV and UHV pumps, e.g. ion getter, sorption and cryo pumps.



TPU 200 on heavy ions accelerator of the Gesellschaft für Schwerionenforschung (GSI) (Society for Heavy Ions Research), Darmstadt.

PFEIFFER TURBO available for pumping speeds between 100 and 6500 l/s.

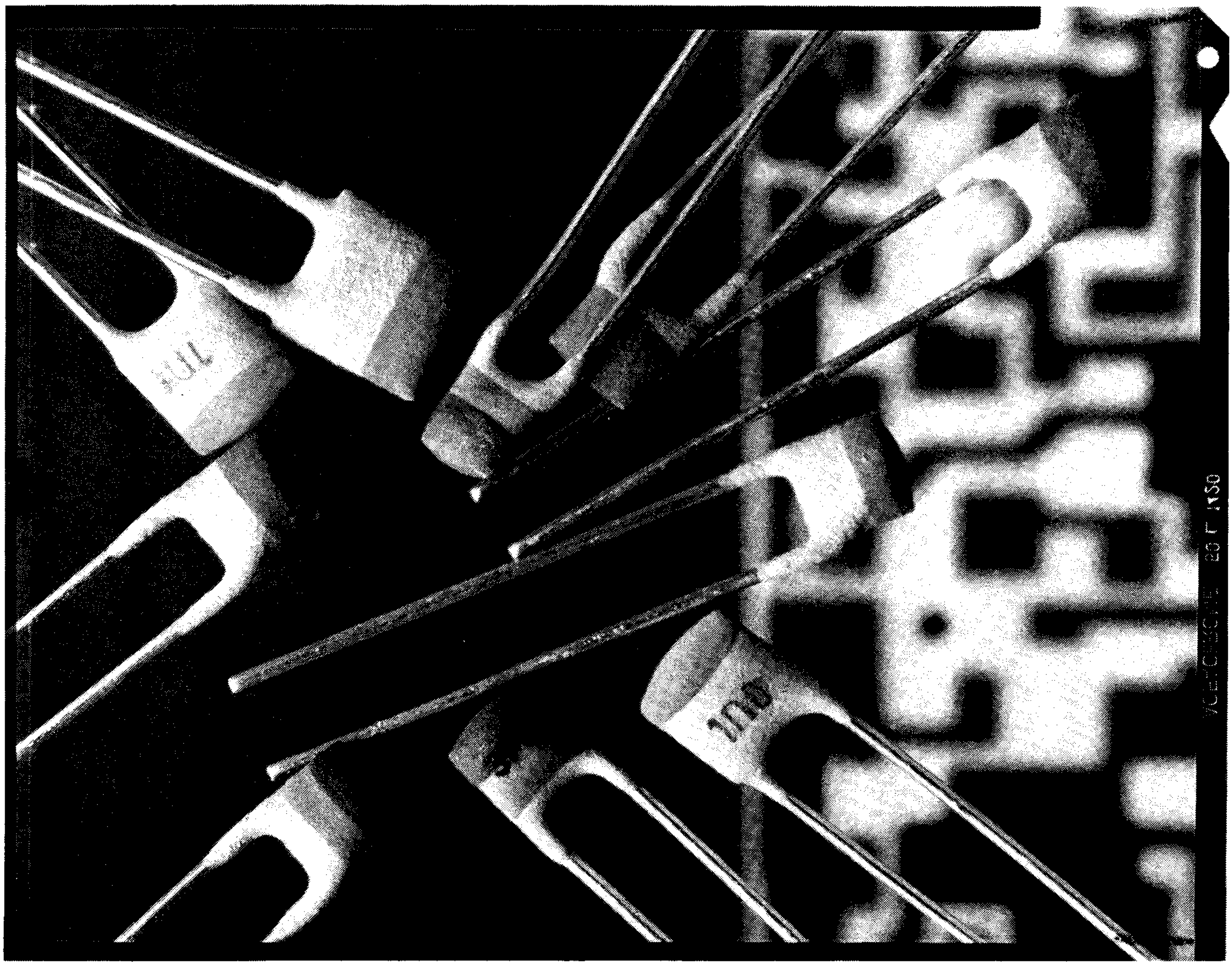
BALZERS

BALZERS HOCHVAKUUM AG
Stampfenbachstrasse 48
Postfach 186
CH-8035 Zürich
Tel. (01) 60 32 66 Telex 52 278

PFEIFFER TURBO: advanced vacuum technology

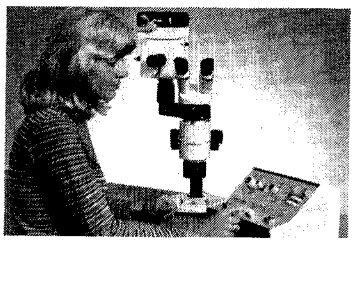
PM 800 020 PE DIN 7020

"WANTED" notice.



Photographed with Wild instruments.

Casting, machining, finishing and assembly all leave marks, even on small things. But this tell-tale evidence escapes the scrutiny of the unaided eye. This is where the Wild stereomicroscope comes in – to pinpoint and record faults with confidence. For Wild Heerbrugg not only manufacture the world's leading range of stereomicroscopes, but produce them via the building-block system, with numerous additional sets of accessories. Particular attention is paid to faithful imaging. Attachable cameras and refined devices for automatic exposure turn each photo into a piece of micro-evidence. With such a system, faults can be recorded, properties characterised and problems discussed. Wouldn't this help you? Find out – by getting hold of a copy of leaflet M 1 183.



WILD
HEERBRUGG

Wild Heerbrugg Ltd.
CH-9435 Heerbrugg/Switzerland

Free colour brochure

Send this coupon to Wild Heerbrugg Ltd., 9435 Heerbrugg / Switzerland

Name ______________________

Address ______________________

____

CC 1/77