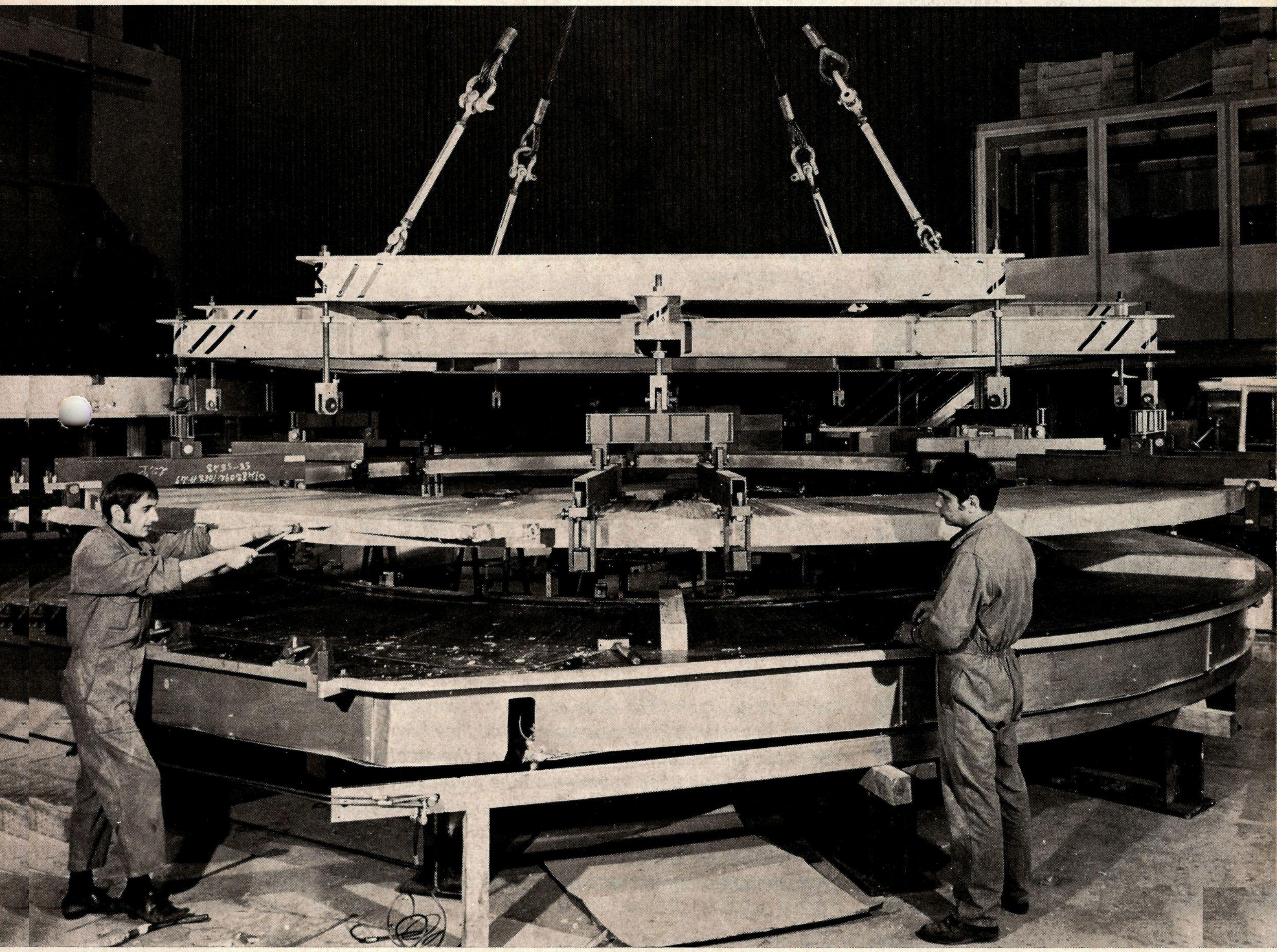
CERN COURIER

No. 11 Vol. 11
November 1971

European Organization for Nuclear Research



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

CERN Laboratory I has existed since 1954. Its experimental programme is based on the use of two proton accelerators — a 600 MeV synchro-cyclotron (SC) and a 28 GeV synchrotron (PS). Large intersecting storage rings (ISR), are fed with protons from the PS for experiments with colliding beams. Scientists from many European Universities as well as from CERN itself take part in the experiments and it is estimated that some 1200 physicists draw research material from CERN.

The CERN Laboratory I site covers about 80 hectares almost equally divided on either side of the frontier between France and Switzerland. The staff totals about 3000 people and, in addition, there are about 650 Fellows and Visiting Scientists. Twelve European countries contribute, in proportion to their net national income, to the CERN Laboratory I budget, which totals 353.4 million Swiss francs in 1971.

The CERN Laboratory II was authorized by ten European countries in February 1971 ; it will house a proton synchrotron capable of a peak energy of hundreds of GeV. CERN Laboratory II also spans the Franco-Swiss frontier with 412 hectares in France and 68 hectares in Switzerland. Its budget for 1971 is 29.3 million Swiss francs.

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

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Printed by: Ed. Cherix et Filanosa S.A.
1260 Nyon, Switzerland

Contents

CERN News

Around the Laboratories

Cover photograph : The winding of the new magnet coils for the 600 MeV synchro-cyclotron is now complete and they have now been epoxy resin coated in preparation for installation on the machine. They will replace the coils which have been in action on the accelerator for over fourteen years and which are showing signs of deterioration. The new coils will be installed during the shutdown of the synchro-cyclotron, scheduled for Spring next year, when there will also be other major modifications as part of the improvement programme to up grade the performance of machine. (CERN 349.9.71)

Research at Serpukhov

L. D. Soloviev

Operation of the Accelerator

The 76 GeV proton synchrotron at the Institute for High Energy Physics, Serpukhov, is now feeding an extensive programme of experiments. During the first seven months of this year 2900 hours were devoted to physics (80 %) and accelerator experiments.

The average intensity is now 1.4×10^{12} protons per pulse, the peak intensity being 2×10^{12}. Work on increasing the intensity further is continuing. The duration of the flat top at 70 GeV has been extended to 2 s, and the beam can be guided onto two targets simultaneously. In addition an intermediate flat top of 0.5 s duration can be introduced at any energy. As a result, three or four experiments are performed simultaneously receiving a good beam spill.

New versions of negative particle beams have been constructed and screening of the accelerator magnetic field has made it possible to extract a positive beam from an internal target. Its energy range is wide enough — from 25 up to 70 GeV at an intensity of 5×10^4 to 3×10^5 (from an accelerated beam of 70 GeV, intensity 10^{12} protons per pulse, and energy resolution ± 2 %). It has also been shown that electron and muon beams with a high enough intensity are possible. Very soon fast ejection of the proton beam will be in action using the equipment constructed by CERN.

To achieve higher accelerated beam intensities a booster project is being worked out. It could provide an increase of internal beam intensity up to 5×10^{13} protons per pulse (i.e. fifty times the original design intensity). This was mentioned in the report of the Accelerator Conference in the last issue of CERN COURIER.

Experiments on Strong Interactions

Total cross-sections and diffraction cone slope

The most interesting results from the Serpukhov accelerator were obtained in the experiments measuring total cross-sections. Four experiments were performed — two of them by a joint IHEP-CERN group (measuring the total cross-sections for negative particles in hydrogen and deuterium with gas targets and for positive particles in liquid hydrogen and deuterium); two of them by an IHEP group (measuring the cross-sections for negative particles in liquid hydrogen and deuterium). These experiments have given very precise data (shown in the first Figure) on the total cross-section for $\pi^{\pm}$, $K^{\pm}$, proton and antiproton interactions with protons and deuterons in the energy range from 20 to 60 GeV (the ranges for the various cross-sections are slightly different).

The most exciting result from these experiments is the increase of the total cross-section for K^+p interaction. This cross-section remained constant (within the error limits) in a wide range from 6 to up to 20 GeV and it was assumed that it would be constant at higher energies as well. But quite unexpectedly when going from 25 to 55 GeV, this cross-section smoothly increased by 0.8 mb. Though this increase makes up only 4 % of the cross-section, it is eight times bigger than the error limits.

The other cross-sections all decrease, at the lower energies from 6 to 20 GeV. It turns out that at the higher energies 35 to 60 GeV all the cross-sections (except $\bar{p}p$) stop decreasing and remain practically constant. Among the six cross-sections measured in hydrogen, only the $\bar{p}p$ cross-section does not change its behaviour compared with what we knew from lower energies.

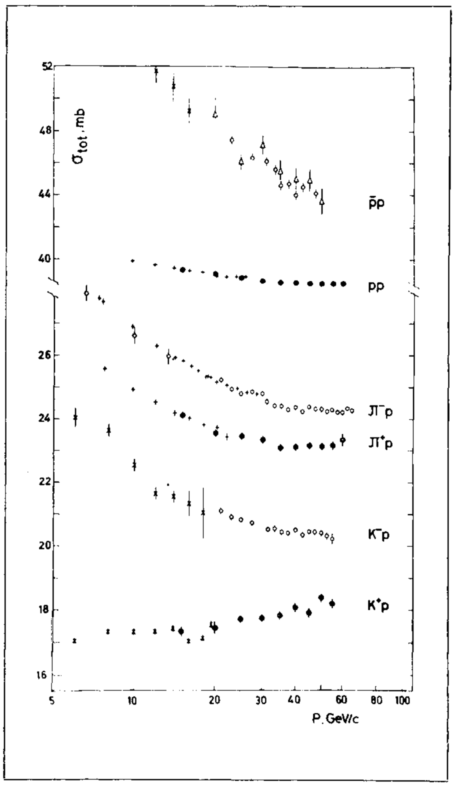
The cross-sections on deuterium, and consequently on the neutron, behave like those on the proton, but the experimental errors are larger and the data contain the theoretical uncertainties of the Glauber model. In order to check this model, IHEP physicists have measured the total cross-sections for negative particles in liquid deuterium (the data are now being processed), and an ITEP (Moscow) group is now measuring the total np cross-section with a neutral beam. The results are expected in the first half of 1972.

The importance of these results for theory can be clearly seen from their comparison with the predictions of the Regge pole model. To a certain extent this model was a summary of investigations at the accelerators below 30 GeV. Being very simple, it gave rise to new notions, e.g. duality, and allowed us to correlate rather successfully a large amount of data obtained at moderately high energies. It predicted for all the cross-sections above 6 GeV a very simple behaviour of the form

$$\sigma = \alpha + \beta E^{-1/2}$$

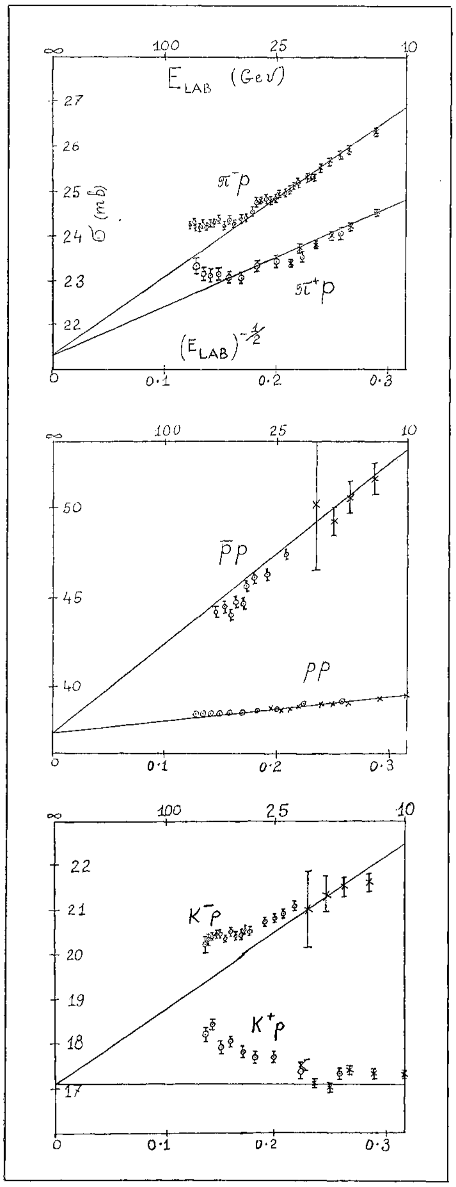
If we plot cross-sections against $E^{-1/2}$, then all the cross-sections should be described by straight lines. The second figure shows how much the experimental data above 30 GeV differ from these predictions.

What does the increase of the total cross-section for the K^+p interaction mean? Will the other cross-sections, which have stopped decreasing at Serpukhov energies, increase at higher energies? A possible interpretation of the increase, together with the shrinkage of the diffraction peak in the corresponding elastic scattering, may be in terms of a potential character of elastic scattering at high energies. Indeed, if the high energy scattering can be described with a potential (or quasi-potential) equation of the Schroedinger type, then at high



1.

1. The behaviour of total cross-sections when measured at the higher energies available at Serpukhov. The antiproton-proton cross-section is still falling as at lower energies but all the others have become virtually constant with the mysterious exception of the positive kaon-proton cross-section which has started rising. Theoretical models of the particle interactions are having a hard time explaining these seemingly contradictory new results from the Serpukhov accelerator.



2.

2. The straight lines drawn across the graphs indicate how Regge pole theory expects cross-sections to behave as energy is increased — the cross-section (vertical axis) is expected to increase linearly as $E^{-1/2}$. However the results at Serpukhov energies deviate considerably in several cases from this simple behaviour which had looked so good at lower energies.

energies the potential coincides with the diffraction scattering amplitude. Solving the quasi-potential equation with such a potential, we come to the following conclusions :

1) If the diffraction peak shrinks when the energy increases then the total cross-section should rise to its asymptotic value ;

2) If the width of the diffraction peak does not change with the energy increase, then the total cross-section should remain constant.

Of course, this simple correlation has only qualitative character. Nevertheless, it is very general, and to check the potential character of high energy scattering is of great interest. This correlation can also be formulated in terms of the complex angular momentum model, but the potential language seems more general.

Measurement of the width of the pp diffraction scattering cone was one of the first experiments at Serpukhov. It was performed by a IHEP - JINR Dubna group with a film target. Later on this parameter was measured in pd scattering with a deuterium supersonic gas jet target. The results show that the diffraction peaks shrink when the energy increases. In the potential approach, this shrinkage corresponds to the observed behaviour of the total pp and pd cross-sections at Serpukhov energies. It is of great interest to test this correlation at higher energies.

It is also interesting to obtain data on the diffraction cones of other interactions. The results obtained at energies below 30 GeV, i.e. shrinking of the peak in K^+p and $\pi^\pm p$ scattering and no shrinking in $\bar{p}p$ and K^-p scattering, if they persist at higher energies, would also be in accord with the data on the total cross-sections from the point of view of the potential.

At present an IHEP group is measuring the diffraction peak in π^-p scattering at energies up to 60 GeV and later plans to measure the diffraction peak in K^-p scattering as well.

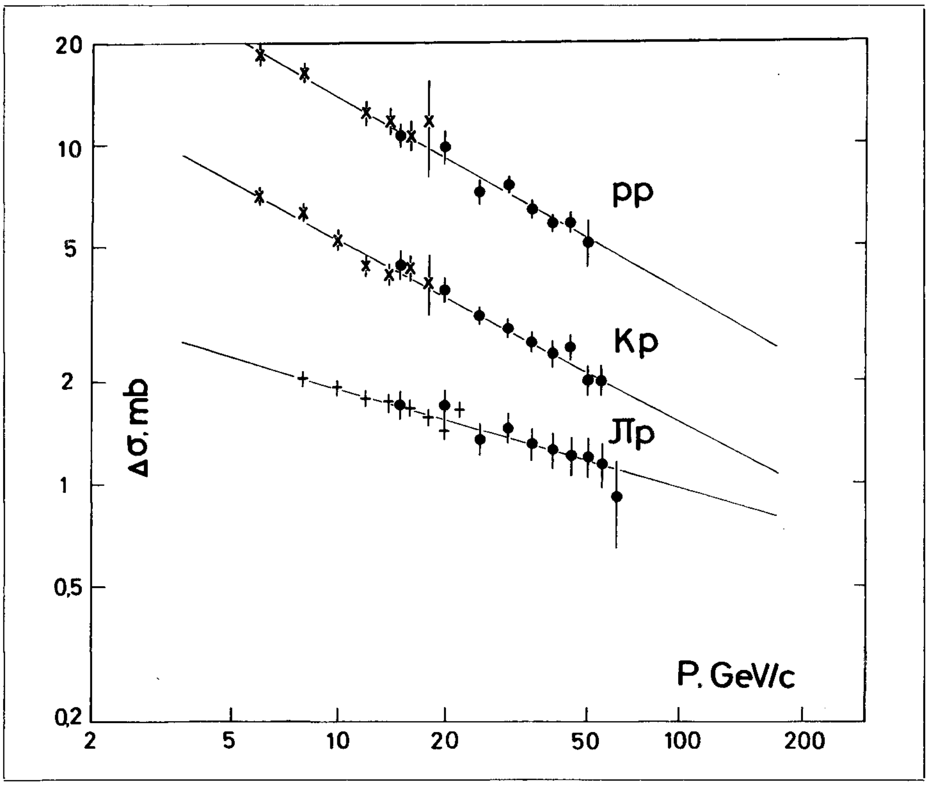
Finally, in concluding the discussion of these problems, there is the experiment on the total γp cross-section at energies above 20 GeV. It is known that below 20 GeV this cross-section decreases. Will there be any change in its behaviour at higher energies ? The answer will be given by a Moscow - Yerevan - Serpukhov group that will carry out this experiment using a tagged photon method. The measurements will start before the end of the year.

Differences of total cross-sections and the charge-exchange processes

When treating total cross-sections at high energies, say the $\pi^\pm p$ cross-sections, we should actually discuss the sum $\sigma(\pi^-p) + \sigma(\pi^+p)$ and the difference $\Delta\sigma = \sigma(\pi^-p) - \sigma(\pi^+p)$ of the total cross-sections for particles and antiparticles, as they have different kinematical and dynamical properties. From the theoretical point of view, the Regge pole model is more likely to describe correctly the difference of the total cross-sections than their sum. However, the direct determination of the difference from experiment is hard, because it is obviously much smaller than the cross-sections themselves and the errors are large.

Experiments have shown that $\Delta\sigma$ decreases slowly as the energy increases (as shown in Fig. 3). As the errors in $\Delta\sigma$ are large, it is important to get additional information, before discussing its behaviour and such information may be obtained from measurements of the charge-exchange $\pi^-p \rightarrow \pi^0 n$ differential cross-section at 0°, where the real part of the charge exchange amplitude is related to $\Delta\sigma$ by means of the dispersion relation. A charge-exchange experiment is being carried out by an IHEP group.

3. The differences in the cross-sections for particle and antiparticle are particularly sensitive to the Regge pole model. The experimental results indicate that $\Delta\sigma$ decreases considerably slower than predicted by the Regge model, at high energy.



3.

Up to now only the total charge-exchange cross-section has been measured ; later the differential cross-section and then the cross-section at 0° will be measured.

To relate $\Delta\sigma$ to the total charge-exchange cross-section, we can assume that the angular distribution of this process does not change with increasing energy. Under this assumption the slow decrease gives $\sigma(\pi^- p \to \pi^0 n) = 8$ mb at 50 GeV, which is in accord with the experimental value. However, the final conclusion may be drawn only when the data at 0° are available. For the time being, both experiments — on the total cross-sections and on the charge exchange — rule out the constancy of $\Delta\sigma$ above 30 GeV and are in line with the Pomeranchuk theorem. At the same time $\Delta\sigma$ decreases considerably slower than in the Regge model, which might be explained by an electromagnetic contribution. At any rate, this result on $\Delta\sigma$, as well as the data on the cross-sections themselves supply theoreticians with plenty of food for thought.

The cross-section differences for $K^-p - K^+p$ and $\bar{p}p - pp$ interactions are in agreement with the Regge model. For K^-n and K^+n interactions the difference is obtained from experiments on the total cross-sections on hydrogen and deuterium. Also, there is an independent measurement in the $K_L P \to K_S p$ regeneration at 0°. At high energies this is an experiment on measuring interference between $K_L \to \pi^+\pi^-$ and $K_S \to \pi^+\pi^-$ decays which in principle measures the modulus as well as the phase of the regeneration amplitude, i.e. obtains the difference $\Delta\sigma(K^\pm n)$ while avoiding dispersion relations. However in practice it is not easy to determine the modulus and phase separately because of their strong correlation.

The experiment on regeneration is being carried out by a Dubna group. Measurements have been completed on hydrogen with 8 to 10 thousand events (3000 events processed). To weaken the correlation between modulus and phase, the experimenters have assumed, that the phase is independent of energy. Under this assumption (which is in accord with the Regge model) they obtain the phase and the modulus of the regeneration amplitude and consequently the total cross-section difference. Within the experimental errors it agrees with the direct measurement of the total cross-section and does not contradict the Regge model.

Further details of high energy scattering

A further step in studying high energy scattering is the investigation of its subtle details such as the real part of the forward elastic scattering amplitude and polarization effects.

The real part of elastic pp scattering amplitude has been measured by a Dubna group with a gas jet hydrogen target. The result has been compared with the dispersion relations and is very sensitive to delicate details of the interaction which makes it possible to discriminate between various phenomenological models. At present the real part of $\pi^- p$ scattering amplitude is being measured by Serpukhov and Dubna, USA, Serpukhov groups in the experiments on elastic scattering in the Coulomb interference region.

Experiments on polarization have always been the most severe test of phenomenological models and measurements on polarization in elastic $\pi^- p$ scattering will start in the next few months by a Serpukhov, Saclay, Moscow, Dubna group.

Finally, an investigation of $\pi^- p$ and $\pi^- d$ backward scattering is being continued by a Moscow group. Preliminary results, which clarify the baryon Regge pole model, were reported at the Kiev Conference.

Inelastic processes

There are three types of experiments on inelastic multiparticle reactions — inclusive reactions (when one final particle is detected), exclusive reactions (when all final particles are detected), and studies of multiplicity.

The reactions of the first type dominate at high energies and are of interest in connection with attempts to construct phenomenological models as well as comparing them with deep inelastic lepton-hadron scattering. Measurements of yields of negative and positive particles in nucleon-nucleon collisions at 70 GeV, performed by CERN-Serpukhov groups were of this type.

An exclusive reaction $\pi^- p \rightarrow \pi^- p$ KK at 30 to 60 GeV is being studied by an ITEP group using a 6 m magnetic spark chamber spectrometer. They have obtained 50,000 triggers and are building up statistics. It will also be possible to study such reactions with the Dubna spark chamber spectrometer, which is now under construction.

Finally, multiplicity has been studied by two Dubna groups with emulsions and the propane bubble chamber. They have obtained a power increase of multiplicity with energy which is not the logarithmic one usually assumed from cosmic ray data. Investigations on multiplicity will be continued in the hydrogen bubble chambers Mirabelle and Ludmilla, which will be mentioned later.

Search for new particles

a) Antiparticles. At present, the Serpukhov accelerator is the most powerful source of antimatter on earth. It can produce up to 10^5 antiprotons per pulse, and up to 3×10^4 antideuterons per day (with energy 10 to 13 GeV). As a result it is possible to perform experiments with antideuterons, for example to study their scattering.

An experiment on antideuteron scattering on nuclei was carried out by the Serpukhov-CERN group. Then a Serpukhov group measured the total cross-section for $\bar{d}p$ scattering ; its comparison with the $\bar{d}p$ cross-section checks CPT invariance. Moreover, antinuclei of helium 3 were identified for the first time at Serpukhov. Five antinuclei were detected in 2×10^{11} particles that pass through the system of counters. This is a further confirmation of CPT invariance.

b) Resonances. A Serpukhov, CERN, Geneva, Munich group is studying the production of boson resonances using a missing-mass spectrometer. They are looking for resonances with masses from 0 to 4.5 GeV, produced in $\pi^- p$, $K^- p$ and $\bar{p}p$ collisions at 25 and 40 GeV. They have obtained 5×10^6 triggers in $\pi^- p$ collisions and 4×10^4 triggers in both $K^- p$ and $\bar{p}p$ collisions.

The first results can be formulated as follows : in $\pi^- p$ collisions at high energies only one heavy resonance with the mass of the A_2 meson is produced. The probability of its production depends only weakly on the energy of the colliding particles over a wide energy range (up to 40 GeV). The cross-sections for production of heavier resonances are smaller than 5 mb/(GeV/c)^2 at 25 and 40 GeV ; for example, the cross-section for the U meson (2382 MeV) production decreases by more than an order of magnitude when passing to Serpukhov energies from the lower energies at which this meson was found. This result is illustrated in Fig. 4 where the boson spectra are shown. The results obtained are being carefully analysed.

c) Exotic particles. A quark search by a Serpukhov group, showed that if they exist, their mass is larger than 5 GeV (for smaller masses the cross-section for their production is less than 10^{-36} to 10^{-39} cm^2). In the experiment searching for particles with integer charge (new heavy particles with negative charge) using a time-of-flight technique a Dubna, Serpukhov group obtained an upper limit of 10^{-10} for the ratio of production probability compared to the probability of pion production.

The search for Dirac monopoles at Serpukhov has occupied two groups — an IAE (Moscow) group tried to accumulate monopoles in ferromagnetic material and then to extract them using pulsed magnetic fields. Monopoles were not found to an upper limit of 1.5×10^{-14} cm^2 as the cross-section for their production. A Dubna group is trying to detect them via the intensity and polarization of their Cherenkhov radiation.

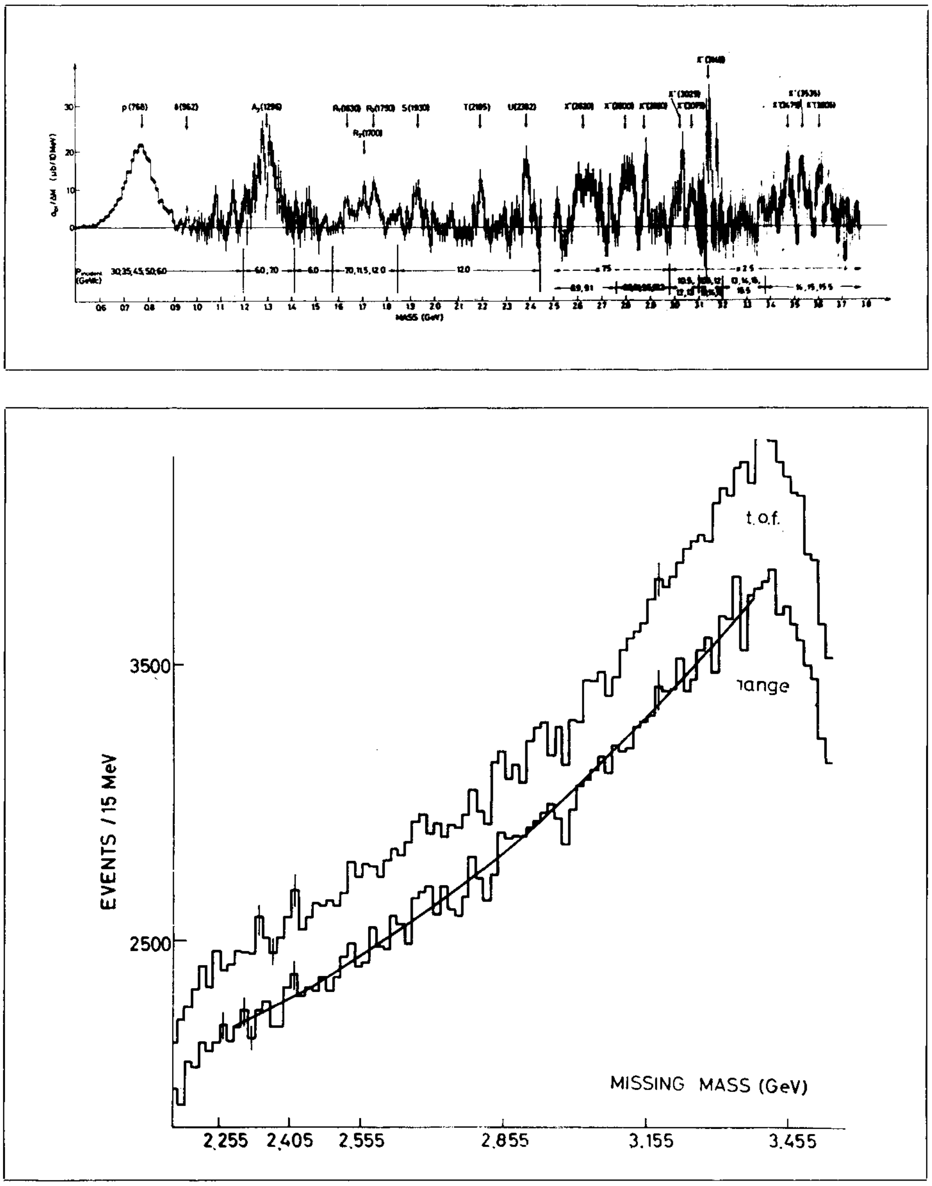
A search for the intermediate vector boson is being carried out by a MIFI (Moscow), Serpukhov group. At present the goal of this experiment is to find optimum conditions for the detection of muons produced in the internal target of the accelerator. For this purpose a special muon channel was constructed. Later, it is planned to measure muon polarization to distinguish muons produced by pions, kaons and photons from those that can originate from the intermediate boson decay. It is hoped to reach a production cross-section of 5×10^{-38} cm^2 / ster. (GeV/c). nucleon.

Investigations of the electromagnetic interactions of hadrons

It has been shown that at the Serpukhov accelerator a pure electron beam with energy up to 35 GeV and intensity 10^5 electrons per pulse can be produced. Thus, experiments with electrons are possible and, as mentioned above, the first experiment of this type on the total cross-section for photon-proton interaction is already scheduled.

It is also possible to construct a muon beam and a Serpukhov group is preparing an experiment on deep inelastic μp scattering at 30 to 40 GeV. A number of very interesting regularities of the proton electromagnetic structure was discovered in the experiments on electron-proton deep inelastic scattering at the Stanford electron accelerator. However, to clarify these regularities, it is necessary to repeat the experiments at higher energies. The Serpukhov experiment will expand the range of the measurement by about a factor of two. The experiment is planned to start by the end of 1972. Experiments on muon interactions will also be performed with the SKAT bubble chamber which is now under construction.

The last experiment under this topic is on elastic $\pi^- e$ scattering at energies below 50 GeV. A Dubna, USA group has recently completed measurements and the data are being processed. It is hoped for the first time to obtain the pion electromagnetic radius to the same accuracy with which theoreticians obtain this radius with the help of analyticity from the data on rho meson production in electron-positron colliding beams.



4.

4. The lower graph is the negative boson mass spectrum obtained from the CERN, Geneva, Munich, Serpukhov missing mass experiment. For comparison, the results obtained at CERN at lower energies are shown above. The lower energy work revealed a multitude of particles but the production cross-section for these particles has dropped dramatically at Serpukhov energies and, with the notable exception of the A2 meson (around 1.3 GeV and thus not shown on the lower graph), no production of negative bosons stands out.

Progress with bubble chambers

a) At present, experiments with the JINR 2 m^3 propane bubble chamber are in progress and over 100 000 pictures have been obtained.

b) The French 6 m^3 hydrogen bubble chamber 'Mirabelle' is beginning its first experiments using the r.f. separator constructed at CERN to provide separated beams. It will provide separated protons up to 70 GeV ; π^- up to 60 GeV ; π^+ and $\bar{p}$ up to 40 GeV and $K^\pm$ up to 36 GeV.

c) The JINR 0.8 m^3 hydrogen bubble chamber 'Ludmilla' has been assembled and construction of a universal beam channel with r.f. separation for this chamber is almost complete. It will provide protons and π^- up to 35 GeV, π^+ and $\bar{p}$ up to 30 GeV, and $K^\pm$ up to 22 GeV. The chamber is scheduled to be launched before the end of this year.

d) The IHEP 5 m^3 heavy liquid bubble chamber 'SKAT' is under construction. It will operate with the same beam as 'Mirabelle'.

Thus, about twenty experiments have been going on or are in course of preparation at Serpukhov this year.

CERN News

Electrostatic septum tests

The PS slow ejection system, which feeds beam into the East area, has used a magnetic septum magnet as its first component. It is a C-shaped magnet, with a thin current-carrying barrier (the septum) which restricts the deflecting field to the aperture of the magnet. The ejection efficiency is determined by the thickness of this septum since, to a first approximation, the proton losses, as they are persuaded to jump into the magnet aperture, are proportional to this thickness.

The reason for replacing the magnetic septum by an electrostatic type is to use a much thinner barrier, which becomes possible since the septum does not have to withstand the heating effect of a current. At the PS, it has already been possible to reduce the septum thickness by a factor of seven and it is hoped that the losses can be reduced by a factor of about three while using half the jump.

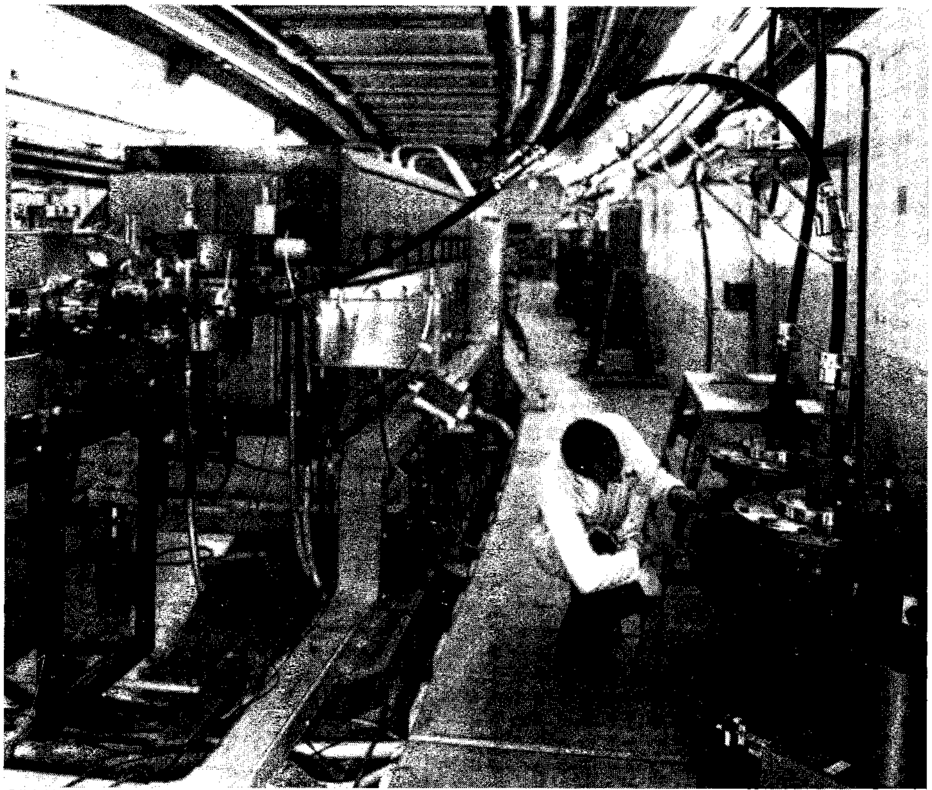
Development work on an electrostatic septum, to be accommodated in a PS straight section about one metre long, began two years ago. Tests have been carried out during 'machine development' periods, when problems which arose in the presence of a proton beam (which does not help produce good voltage holding characteristics) were solved. Good results were obtained for the ejection efficiency with losses two to three times lower than with the magnetic septum.

The first test during a physics run was carried out in October without any major troubles. The use of the electrostatic septum in the normal slow ejection, which was designed for the magnetic septum, does not allow the ejected beam optics to be optimized (missing the focusing of the magnetic septum). This fact was reflected in a widening of the beam and was a disadvantage for some of the physicists using the beam, but others could accept the new method of operation. Following the test, we can look forward confidently to the perfection of the new slow ejection system to feed the West area, which will be installed in 1972 with an electrostatic septum as its first component.

It is also intended to carry out slow ejection using an electrostatic septum at other laboratories — Batavia and Brookhaven. The recent tests at CERN are a dress rehearsal for the technique. Even though there remain no major difficulties to be overcome, there are still problems facing the section led by C. Germain in the MPS-SR group. The sparking rate, for example, averaged one per 37 cycles, which was acceptable in a first test, but will have to be considerably reduced.

An investigation with this in view is on hand, involving an analysis of the effect of many PS and slow ejection system parameters on the behaviour of the electrostatic septum. This work will be made easier when enough data has been made available for checking by computer. The PS computer control system should eventually make it possible to analyse any problems which may arise in the operation of the electrostatic septum.

The technological features of the septum are not yet finalized. They are at present based on methods developed for electrostatic separators, and give satisfactory results for the useful field, allowing the septum to be operated at a field of about 150 kV/cm, but they apply to a septum with an equivalent thickness of 0.15 mm. The characteristics need to be optimised to reduce this thickness. This will be even more important for the SPS, which will need a field



The position in the 28 GeV proton synchrotron ring where the electrostatic septum was installed, in a 1 m straight section, for tests as the first element of the slow ejection system feeding protons into the East Hall. On the right can be seen the voltage generator whose form is familiar from use in electrostatic separators.

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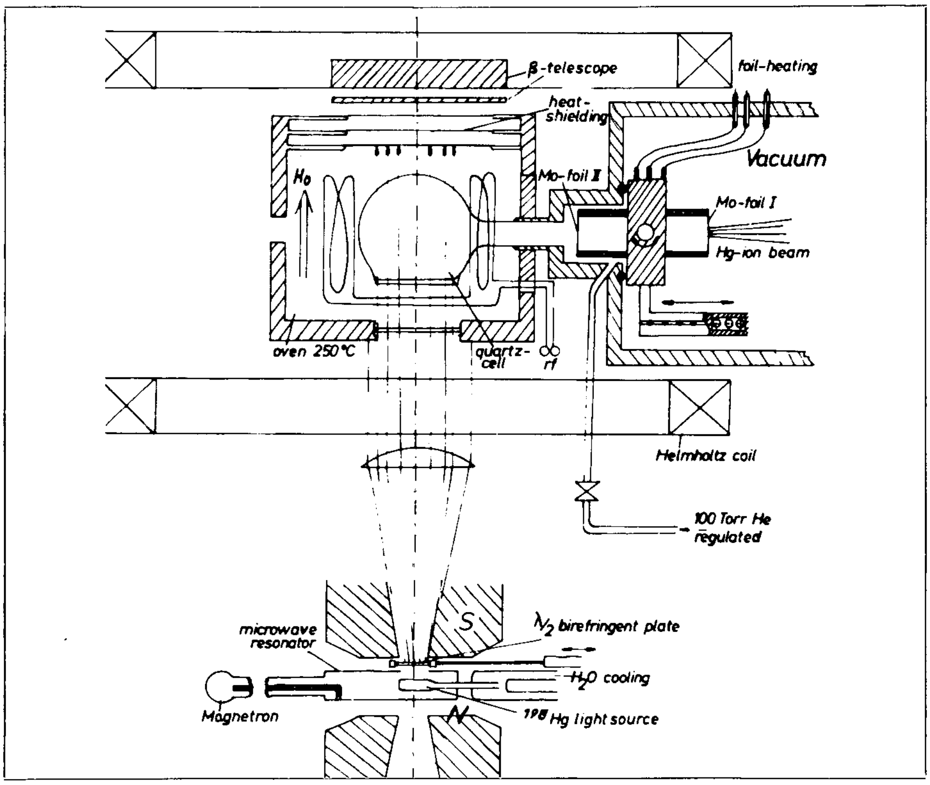


Diagram of the layout of the apparatus for the optical pumping experiment of the visiting team from Heidelberg. Mercury ions come in from ISOLDE and are collected on a molybdenum foil which can be swivelled round to feed the ions in the bulb (top centre of diagram). The bulb is surrounded by a magnetic field and an r.f. coil. Circularly polarized light from a mercury lamp is illustrated as coming in from the bottom in the diagram. The beta telescope which observes the decay of the ions is indicated on top.

length some ten times greater. Finally, the reliability may decide between the use of a plane of parallel wires or of foil for the septum. CERN preferred foil for the first tests. Batavia and Brookhaven are trying wires, thus both approaches will be tested.

Optical pumping

One of the most intricate experiments ever carried out at CERN is under way at the isotope separator on-line, ISOLDE, fed by the 600 MeV synchro-cyclotron. It is concerned with nuclear structure studies — measuring nuclear spins, nuclear moments and nuclear shapes. When such measurements are carried out with nuclei far from the stability line (nuclei which have neutrons or protons over and above what is normally a stable configuration), such as can be produced and examined at ISOLDE, new knowledge can be gathered about how the nuclei are built up. Work at ISOLDE can be compared to work on superheavy elements in the sense that we are testing whether our existing knowledge of nuclear matter can be extended to unexplored regions.

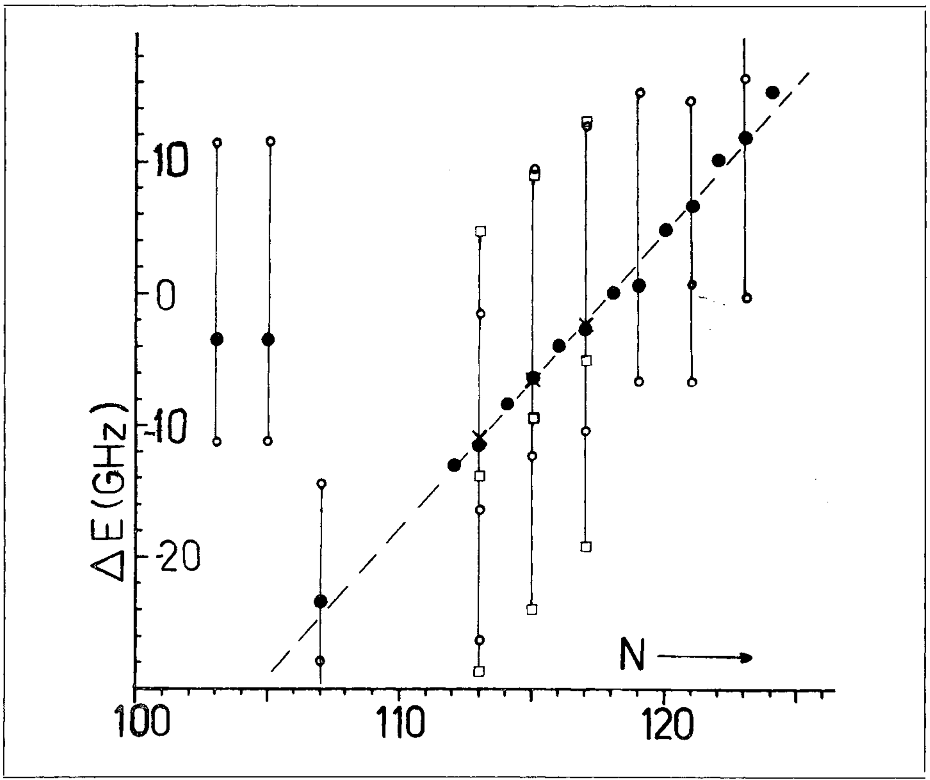
These studies are often difficult because so few nuclei of isotopes far from the stability line can be isolated for examination that only extremely sensitive methods can hope to study their properties. A visiting team from Heidelberg (J. Bonn, G. Huber, H. J. Kluge, U. Köpf, L. Kugler and E. W. Otten) working at ISOLDE have employed techniques (including ' optical pumping ' which has become particularly associated with their experiment) which run through a great deal of our knowledge of atomic and nuclear physics en route to unearthing new information about the nucleus. Indeed, when their experiment was first proposed, Professor Preiswerk remarked that it contained so much beautiful physics that it was worth doing even if it failed.

They have studied a series of short-lived mercury isotopes obtained from ISOLDE. An isotope is collected on a molybdenum foil which can be swivelled round (after a collection time of about 1 half-life) to point into a bulb containing an inert gas (helium). The foil is heated and the mercury atoms evaporate off ; the gas helps to preserve them as ' free ' atoms (keeping them away from the walls where they might interact) which is necessary for the subsequent spectroscopy stage of the experiment. While this stage is under way another foil, at the opposite end of the swivelled unit, is collecting more mercury atoms.

Only something like a million of the short-lived mercury atoms are likely to be in the bulb for investigation at any one time and this is far from adequate for normal optical spectroscopy. Hence the series of manœuvres which we will now attempt to describe in simplified form.

Optical pumping is a technique discovered by A. Kastler (earning him the 1966 Nobel Prize for Physics) which enables us to have many atoms existing in an identical energy state with their spins lined up in one direction. The technique is an essential part of the operation of the laser.

If we consider a mercury atom, it consists of a nucleus (whose properties we wish to study) with eighty electrons swirling around it. This configuration can exist in many energy states depending on the orbital angular momenta of the electrons, and on the spins of the electrons and of the nucleus. Specific amounts of energy can be absorbed or emitted by the atom as it hops between energy states. Like most of us, atoms, after being excited, will fall back to their lowest energy state. Optical



Energy level differences for a chain of mercury isotopes (the x-axis counts the number of neutrons in the nucleus ; the y-axis counts the energy difference by comparison with the ¹⁹⁸ Hg isotope). The difference as we move down the isotopic chain follows the straight line predicted by calculation until the isotopes with 105 and 103 neutrons when the difference changes abruptly. This indicates that the nuclear shape has changed radically for these two isotopes compared with the others.

pumping is used to manoeuvre the atoms into a particular energy state where their nuclei are polarized.

The polarization of nuclei, so that their spins line up in one direction, is quite common in the field of high energy physics. In polarized targets it is achieved by the use of high magnetic fields and low temperatures. With optical pumping it is achieved by directing circularly polarized light, where the photon spins are all aligned in one direction onto the atoms. The polarization can be transferred to the atoms by the absorption of the light quanta — conservation of angular momentum then requires that the spins of the atoms are polarized after absorption. Coupling between the electron spins and the nuclear spins completes the desired polarization of the nuclei.

Absorption can only take place when the incoming light quantum matches the difference between two energy levels in the atom. This condition can be covered by ajusting a magnetic field applied around a mercury lamp (Zeeman effect) shining on the bulb containing the radioactive mercury atoms. The light quanta can be varied over a range of values which are known when the field at the lamp is known. But without being clever we would never know that we had hit the particular values at which absorption, and thus atomic and nuclear polarization, takes place since there are too few atoms in the bulb to give us discernable light signals. However, the values can be identified when the nucleus decays sending out an electron (beta decay).

Beta decay is a weak interaction and does not conserve parity — as found in the famous experiment of C. S. Wu, the direction at which the electron emerges depends upon the direction in which the nucleus is spinning. There will be an asymmetry in the distribution of the electrons emerging from our bulb when we hit the right values because they then come from polarized nuclei.

When we can see that we have produced polarized nuclei we can measure the nuclear magnetic moment using the usual r.f. resonance technique. R.f. energy is fed to the atoms, via loops wrapped around the bulb, and, as the r.f. frequency is varied, the polarization (the asymmetry in emitted electron direction) will disappear when the r.f. frequency reaches the value corresponding to the energy needed to swing the nuclear spin round from one direction (relative to the magnetic field) to the other. The magnetic moment can be calculated knowing this r.f. frequency.

Another way of estimating the nuclear magnetic moment comes from the way in which energy levels split into several levels when in a magnetic field due to the ' hyperfine ' coupling between the magnetic moments of the electrons and of the nuclei. As described above, we sweep over a range of frequencies with the ingoing light. This will produce polarization at several values (because there are more energy levels between which the atoms can hop), the number of which yields the nuclear spin and the separation of which is a measure of the nuclear magnetic moment.

The most surprising results have come from a third item of information which is drawn from knowing the frequency of the light needed to achieve the optical pumping. The energy level difference to which this corresponds is related to the nuclear shape (to be more precise — the mean squared radius of the nucleus). This is because the electrons passing close to the nuclear surface act as a probe of the nuclear charge distribution. The work with mesic atoms (see, for example, vol. 10, page 251) is based on the same principle.

The way the nuclear shape changes as we go along a very long chain of isotopes has never been studied so extensively before. ISOLDE makes over twenty mercury isotopes available for investigation.

The difference between levels by comparison with that of the stable isotope ¹⁹⁸ Hg (118 neutrons, 80 protons) follows the straight line anticipated by calculation as the number of neutrons varies from 125 to 107 (²⁰⁵ Hg to ¹⁸⁷ Hg). Then with 105 and 103 neutrons the difference departs radically from the predicted value — in other words the nuclear shape changes abruptly (probably from a spherical to a deformed shape).

Why this sudden deformation of the nucleus takes place is unknown. It is certainly not expected to take place for an element like mercury which has an almost closed shell of protons. This very intricate experiment has succeeded not only in carrying out the difficult measurements it set out to do but also in revealing some very unexpected features of nuclear structure.

DISC counters

When a fast-moving charged particle passes through a transparent medium such as air, water or glass, it can emit light by the Cherenkov effect. The mechanism of this effect is often compared to that of an aeroplane travelling through air. When the plane travels through the air faster than the speed of sound, a supersonic bang is produced ; when a particle travels through a transparent medium at a speed faster than that of light in the medium, Cherenkhov light is produced. The light wave is conical, like the shock wave of a supersonic plane, and the angle of the cone depends on the relationship between the speed of the particle and that of light in the medium — this is the basis for the measurement of the speed of charged particles in Cherenkov counters.

A special optical system picks up the light produced and focuses it into a ring. The speed of the particle is determined from the diameter of the ring of light. If particles of different mass such as pions, kaons and antiprotons are sorted magnetically in a beam-line so that they all have the same momentum, their velocity will depend on their mass (the heaviest being the slowest). A Cherenkov counter will record for each type of particle a ring of different diameter which can be distinguished by means of a combination of screens and photomultipliers. The measurement of the particle velocities can then be calculated knowing the refractive index of the medium

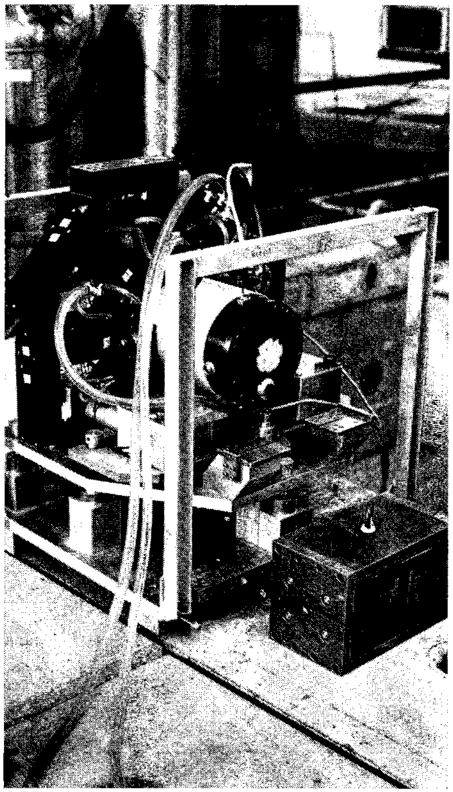
$$\frac{v}{c} = \frac{1}{n \cos \Theta}$$

The first counters of this type were in use long before physicists had access to accelerators of even 1 GeV. Their performance was limited by the quality of the photomultipliers then available and by their relatively simple optics. From 1959 studies were undertaken at CERN to perfect an optical system. The main difficulty in the optics is that there is a chromatic dispersion of the Cherenkov light which limits the ultimate velocity resolution of the instrument. A counter was finally developed in which chromatism was corrected, using a doublet of axicons. The resolution was greatly improved.

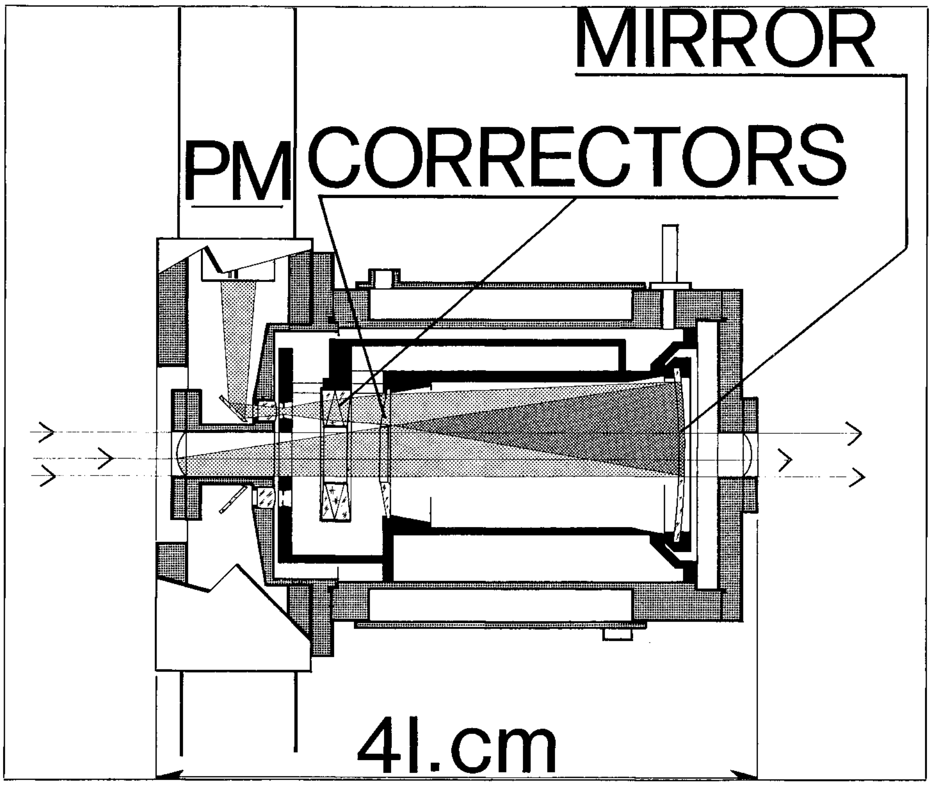
The first models of this type of counter, known as Differential Isochronous Self Collimating (DISC) counters, which were liquid-filled, were used on the 600 MeV synchrocyclotron for a variety of experiments with pions and were then tested without modification on the 28 GeV

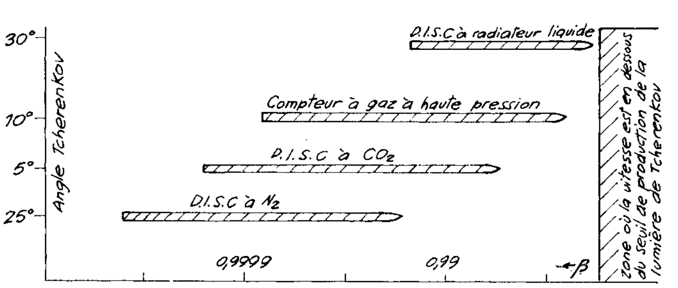
A DISC counter specially designed to identify charged hyperons. The optics are housed in the cylindrical sections. The photomultipliers with their magnetic shielding are shaded black.

Alongside is a diagram of the same instrument.



CERN 21.5.71





The velocity ranges (the x-axis gives the velocity of the particle compared with the velocity of light) over which different types of DISC counters can be used. This particular graph refers to the identification of a kaon.

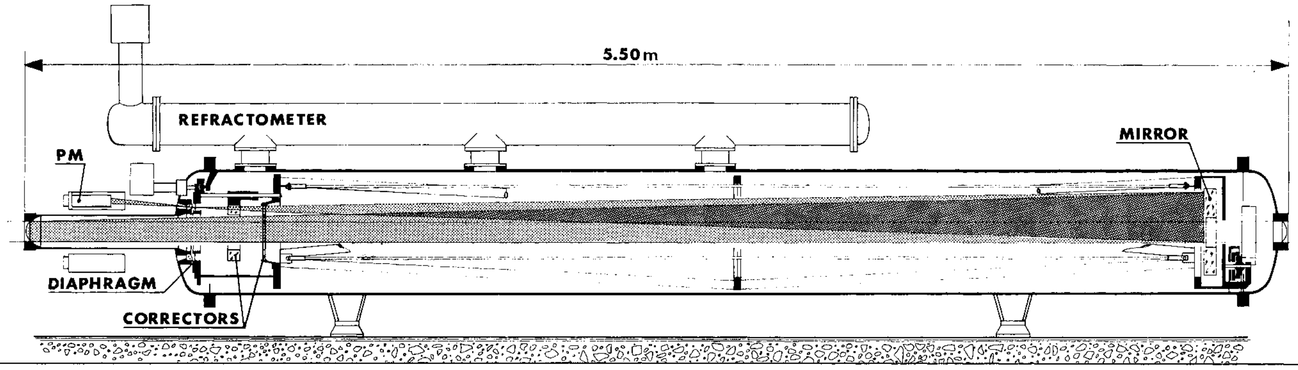


Diagram of the DISC counter built at CERN by a CERN-NAL collaboration, to be used in an experiment at Batavia.

proton synchrotron when it came into service in 1960.

Their adaptability and development potential were clear: the ability to identifiy π^+, π^-, K^+, K^-, p, $\bar{p}$, d, He^3 and He^4 with the same instrument provided the impetus to continue this line of development systematically and to extend the range of application of the early models from energies of a few GeV to cover the entire energy spectrum available from the PS. To this end the liquid was replaced by a gas and the old optics, consisting of lens and aspherical mirrors made out of a plastic material, were replaced by a new unit of fused silica and sodium chloride.

In this way the counters were transformed into high resolution DISC counters. With these counters the accuracy of the measurement of the velocity of the particle depends upon the accuracy with which the speed of light in the gaseous medium can be determined for a given wave-length and Cherenkov angle characteristic of the counter. The latest method consists of employing long wavelength digital interferometers, specially produced at CERN for this purpose, which, coupled with the use of a gas laser, make it possible to achieve absolute accuracy of the order of 3×10^{-8}.

The liquid counters built around 1963 are still used in CERN and various other laboratories. The high resolution counter built in 1964 has not exhausted its full possibilities. After it had been used in many different experiments, including the first tests of the slow ejected beam at the PS, it was realized that the counter's capabilities exceeded what was necessary at the PS and that it could even be used at the maximum energy of the Serpukhov 76 GeV accelerator. Hence it was used in the first experiment of the CERN-Serpukhov collaboration where, in conjunction with a similar counter built at Serpukhov, it was used with beams of pions, kaons, antiprotons and antideuterons.

Thinking about the future use of these instruments in high energy physics has underlined their great flexibility particularly for very high energy work where, in various forms, they are still a basic method for distinguishing particles at energies beyond the reach of almost all other techniques. Over the years a better understanding of the ways in which they may be used has made it possible to optimize their construction. New optical units have been perfected which are both more efficient and easier to make.

A new use is in the first beam-line for Σ^- and for Ξ^- hyperons, which came into operation at the PS at the beginning of 1971 (see vol. 11, page 191). Two miniature DISC counters are incorporated in this beam-line.

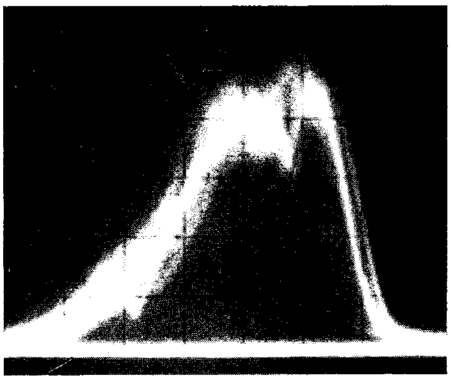
There is no lack of future plans. Investigations are being carried out as to what kind of DISC will be needed for the SPS. In the meanwhile, efforts are concentrating on the Batavia 200/500 GeV machine where a group from CERN will take part in an experiment using DISC counters built specially at CERN to deal with this new energy range. The cost will be shared by the two Laboratories.

There is no reason to believe that the limits of application for detectors using the Cherenkov effect have been reached. Developments in optical techniques used in astronomy in association with the remarkable properties of Cherenkov light are being brought into the study of new types of detectors capable of measuring the particles produced in interactions at several hundred GeV.

Sodium jet beam detector

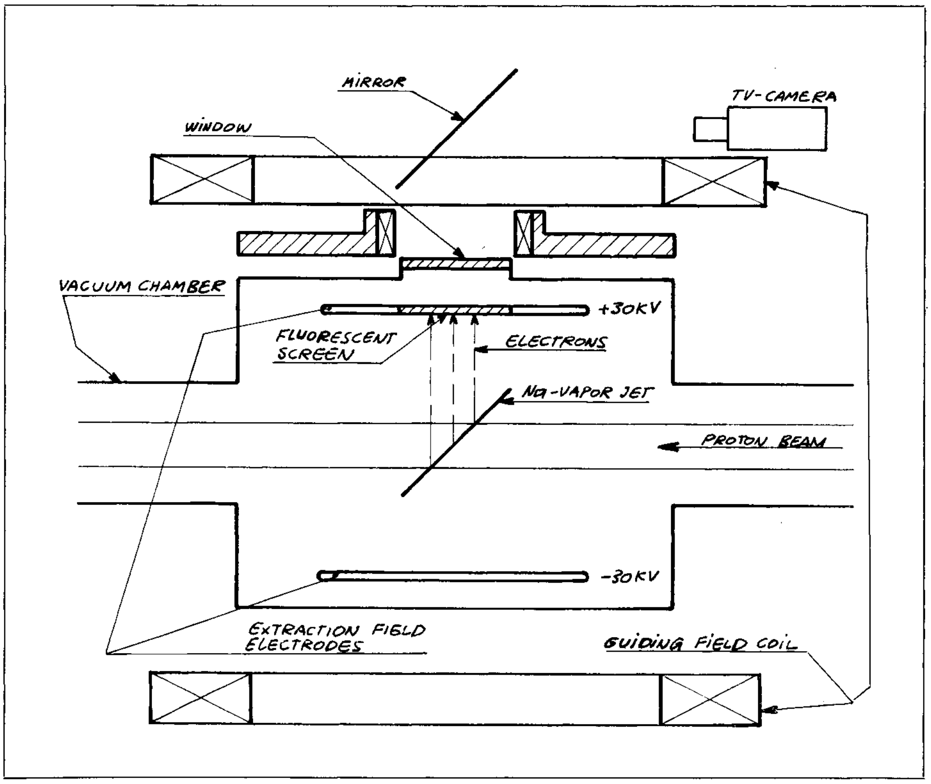
The range of beam detectors at the ISR has just been increased by the installation of a novel type of instrument — a beam profile detector which observes the ionization caused in a sodium curtain through which the beam passes.

This detector is a distant relative of the familiar luminous screen placed in the beam which lights up in the path of the beam. The high intensity of the beam in the ISR, and the cata-



Below is a simplified drawing of the ISR beam profile detector, using a sodium gas jet, which is scheduled to be in action (one in each ring) next Spring. The detector collects the electrons from the ionization of the sodium atoms by the beam particles and, with electric and magnetic fields, directs them to a fluorescent screen where they represent the beam profile.

A detector of this type installed in Ring I is already in use collecting the electrons from ionization of the residual gas. The oscilloscope photograph on the right shows a signal from the detector proportional to the radial density of the beam.



strophic effects which such a screen would have on a beam intended to circulate for hours, rule out the insertion of a fixed solid screen. One way of solving the problem (albeit while raising others) was put forward by the ISR Vacuum Group (Beam Profile Section). It involves the use of a screen, or curtain, of gas — sodium was chosen for reasons which will not be explained here.

Because of the low density in a gas curtain, the light emitted is too weak for photographic purposes or observation with a television camera. If, however, an electric field (4 kV/cm) is set up perpendicular to the beam, the electrons, coming from collisions between the beam particles and atoms in the gas, are accelerated perpendicularly to the beam so as to strike a fluorescent screen and produce an image of the beam. Light output is thus increased about 10 000 times. A magnetic field (0.03 T) is combined with the electric field to ' wind ' the electrons around the lines of force of the electric field.

The gas curtain consists of a flat jet of sodium issuing from a slit inclined at 45° to the beam and projected at supersonic speed towards another slit on the opposite side of the vacuum chamber through which it emerges. The curtain is only 1 mm thick, so that good definition is obtained. After passing through the chamber, the sodium jet is recondensed and pumped back to a supply tank. (Sodium is highly corrosive at the high temperatures which are needed to have a supersonic jet of sodium gas ; all the components which might come into contact with the sodium had to be made of a special stainless steel.)

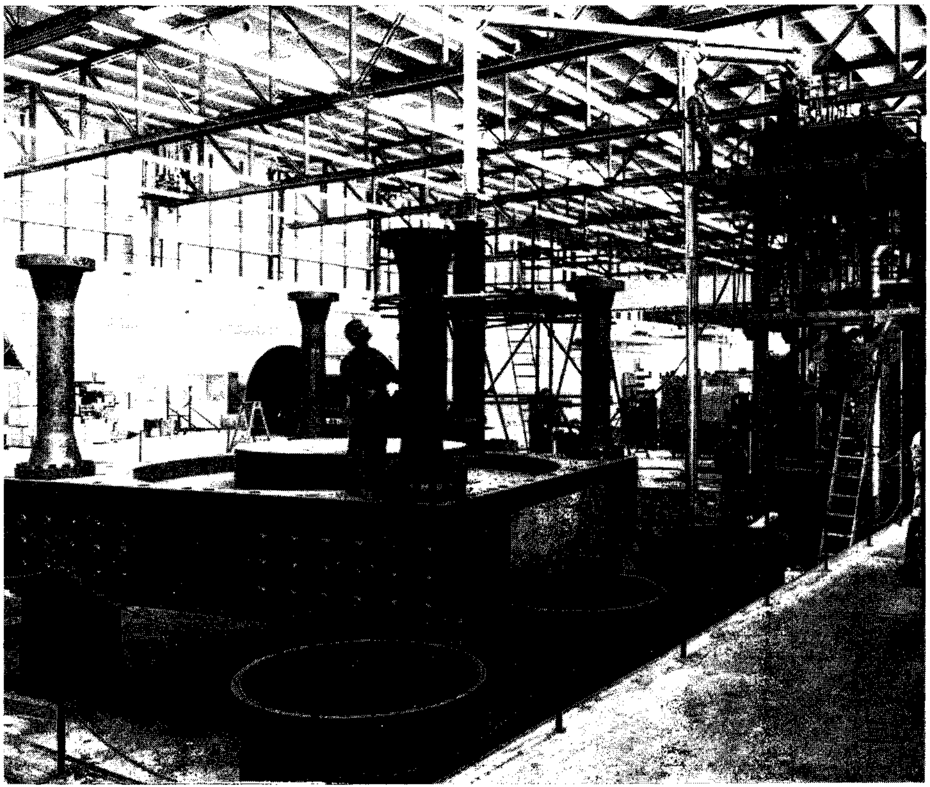
The detector was fitted in Ring I in October while waiting for delivery of the gas jet generation system. After the optical system had been connected up, what became visible on the screen was not the image of the beam cross-section (produced with the sodium curtain) but an image one would see looking from above the beam, due to electrons coming from ionization of the residual gas. Despite the very low residual pressure (less than 10^{-10} torr), the extreme sensitivity of the television cameras and the acceleration of about 60 kV given to the electrons yield a visible signal from the fluorescent screen. The electrons produce streaks of a thickness proportional to the radial density of the beam.

Using this signal, it was possible to produce the shape shown in the Figure, where the beam intensity is proportional to the height. Even with the detector in this state it is possible to follow the process of formation of the beam and its radial movements during stacking. Thus even before the sodium curtain is installed (scheduled for the Spring of next year), we have available a beam profile detector which is already providing a great deal of useful information.

Midi-console

A new item of control equipment, known as the ' midi-console ' has been installed this month in the control room of the PS. It is a unit connected to the computer which concerns itself with the operational aspects of the booster (injection, transfer systems, etc.). The controls of the booster (which is now in its final stages of construction) are entirely piloted by the PS control computer, an IBM 1800, to which has been connected a satellite computer to generate all the time-varying functions.

Using a computer in the operation of an accelerator may be implemented in various ways by having :



CERN 3.11.71

The lower section of the magnet core of the Omega spectrometer was installed in the West Experimental Hall in October. The four columns will support the upper section which is due early next year. The first coil of the superconducting magnet will then also be installed.

1) separate units independent of the computer, for giving commands ;
2) a console fully integrated with the computer, capable of being used as a centralized control station for all processes ;
3) several midi-consoles each handling some processes.

The booster midi-console was developed by the PS Control Group, the appropriate programs having been assigned to the booster. Its most obvious advantages are its simplicity, flexibility and speed. A very wide range of possibilities is offered by the computer which guides the operator by means of visual messages.

The console takes the form of a panel 60 cm wide and 1 m high. From top to bottom, it carries an alphanumeric display system, a control section with actuating push-buttons, and a selector section with as many keys as there are parameters to be controlled. When a command has to be given to a component (a change in magnet current for example) the appropriate key is operated (the magnet code and the minimum variation which may be given to the current would then appear on the screen).

The control section comprises two sets of graduated push-buttons : + 1000, + 100, + 10 and + 1 ; and — 1000, — 100, — 10 and — 1. It is also possible to switch components on and off and to reverse polarities. Each button is located opposite the figures on the display unit and controls the appropriate instruments. If the limits are exceeded, or if the component does not respond, or if the command is impossible to execute, a clear indication appears on the screen. Advantage is taken of the computer's memory to allow the operator to return to a previous condition if he is in any doubt. Keys ' save and back ' and ' restore preserved ' are fitted for this purpose.

The midi-console permits simultaneous control to two different parameters, which may be currents or voltages to be regulated by the use of analog converters, or step-by-step motors, or preselection counters. Certain parameters may be controlled in a coupled manner by linearly correlated values. 256 parameters may be handled by one midi-console. The electronics system is of the 'modular' type, and a very legible luminous spot read-out is used.

The midi-console management program has a high-priority level in the central memory of the IBM 1800, and is designed to allow widely differing parameters (currents, positions, voltages, angles, frequencies, times, etc.) to be handled. Programs for specific functions are loaded into lower-priority levels of the central memory when requested by the management programme.

One unit of the midi-console is at present in use on an experimental basis to control the back leg windings of the PS. It will be used from December to control the booster injection beam-line. Two further units will be fitted at the beginning of next year.

CERN School

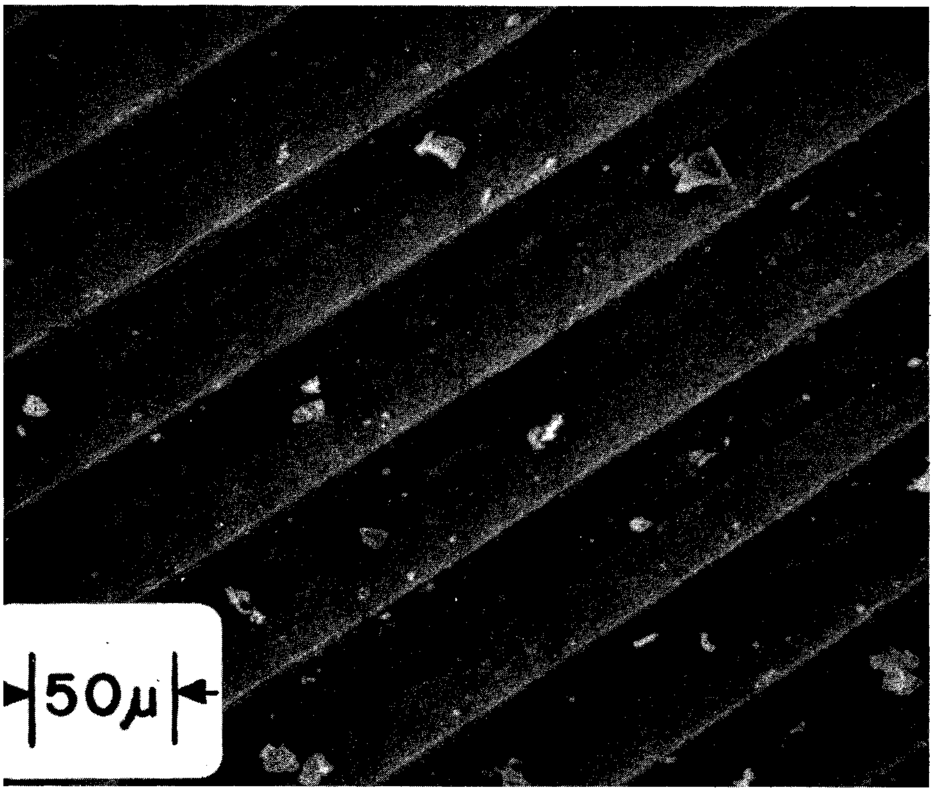
The 1972 CERN School of Physics will be held at Grado in Italy from 15 to 31 May. It will be organized in collaboration with the International Centre for Theoretical Physics (ICTP), Trieste. The School will concentrate on various aspects of high energy physics, especially theoretical physics, and is directed particularly to young physicists from the CERN Member States (but also from other countries).

Six main topics will take up the bulk of the programme — Inclusive reactions (H. M. Chan) ; Longitudinal phase-space analysis (E. W. Kittel) ; Lepton deep inelastic scattering (M. Gourdin) ; High-energy two-body phenomenology (A. Donnachie) ; Neutrino, gamma and hadron interactions in nuclear matter (K. Gottfried) ; Electron-positron interactions (G. Kramer).

Among the speakers giving special lectures will be M. Gell-Mann (Nobel laureate), A. Salam (Director of ICTP), W. Jentschke (Director General of CERN Laboratory I) and probably A.M. Baldin (Director of the High Energy Laboratory at Dubna).

Students in CERN Member States can request further information or application forms from: Dr. W.O. Lock, Personnel Division, CERN 1211 Geneva 23, Switzerland. Students from other countries may contact JINR Dubna or CERN.

Around the Laboratories



A highly magnified photograph from Berkeley of strips of gold deposited using a technique similar to that used for cutting gramophone records. This could be one way of laying down gold 'wires' with extremely close spacing for use in a liquid filled proportional chamber to give excellent spatial resolution.

(Photo LBL)

BERKELEY
Liquid chambers

At the time of the Dubna Instrumentation Conference last year (see vol. 10, page 274), the exploratory work at Berkeley, Dubna and Novosibirsk on the possibilities of liquid chamber detectors, was one of the most interesting topics. We report here some subsequent work at the Lawrence Berkeley Laboratory.

The reason for pursuing liquid filled proportional chambers as detectors is to have an electronic detector capable of very good spatial resolution. Conventional spark chambers and multiwire proportional chambers have difficulty in indicating the position of a charged particle which has passed through them to an accuracy of much better than about ± 0.2 mm. This stems from features of the ionization produced in the gas in the chamber such as, electron diffusion and the need for the particle to traverse a reasonable thickness of the gas.

A liquid filled proportional chamber because of the high density of the medium crossed by the particle could be adequate with a very narrow gap (perhaps 100 µm) and could make spatial resolution an order of magnitude better (perhaps down to ± 10 µm). If it proves possible to perfect these chambers and to achieve such accuracy in positioning particles, it could take some of the strain off the spark chamber spectrometers of the future which will have to measure the much higher energy particles from the accelerators of several hundred GeV. Without much better spatial resolution the shear physical size and the magnetic fields involved in spectrometers for accurate measurements on very high momentum particles are a daunting prospect. There are also other applications, particularly in the medical field, which make the effort to master these chambers worthwhile. However, the mastery is not coming easily for there is a lot of basic physics of liquids to be understood before any large-scale device can be confidently attempted.

Initial work involved the use of liquid argon, but no-one succeeded in achieving high detection efficiency (figures were usually below 20 %) without measures (such as using thick heated wires) which destroyed the potential advantages of liquid filled chambers.

Berkeley changed to the use of xenon which has proved a much more amenable liquid. They used a small single wire chamber in an arrangement like a gas-filled proportional counter to carry out the basic tests. A very fine anode wire (down to 3.5 µm diameter) helped to give high gain without spurious electrical discharges. The high voltage cathode was formed by coating the inside of the glass chamber wall with tin oxide and ^{241}Am was introduced into the chamber as a source of particles. Feeding in xenon of high purity was a problem which took a long time to solve (a few parts per million of electronegative impurities can destroy the chamber performance).

Operating in the proportional mode gains of up to 100 were achieved (this could yield 10 mV signals on 10 pF in a chamber 0.5 mm thick). The efficiency for alpha detection was close to 100 % and a time resolution of ± 0.1 µs was achieved.

These encouraging results have to be balanced by the problems to be solved. For example — spurious pulses can occur at high voltages, possibly due to the second Townshend process (increased effect of ultraviolet radiation). Quenching agents are being tried, as is the use of a resistive cathode (germanium on glass) to inhibit sparking. 'Hot spots', where electric fields exist some 30 % higher than average, are still troublesome (occurring about one per centimetre along the anode wire) but could be removed if the irregularities on the anode surface can be sorted out.

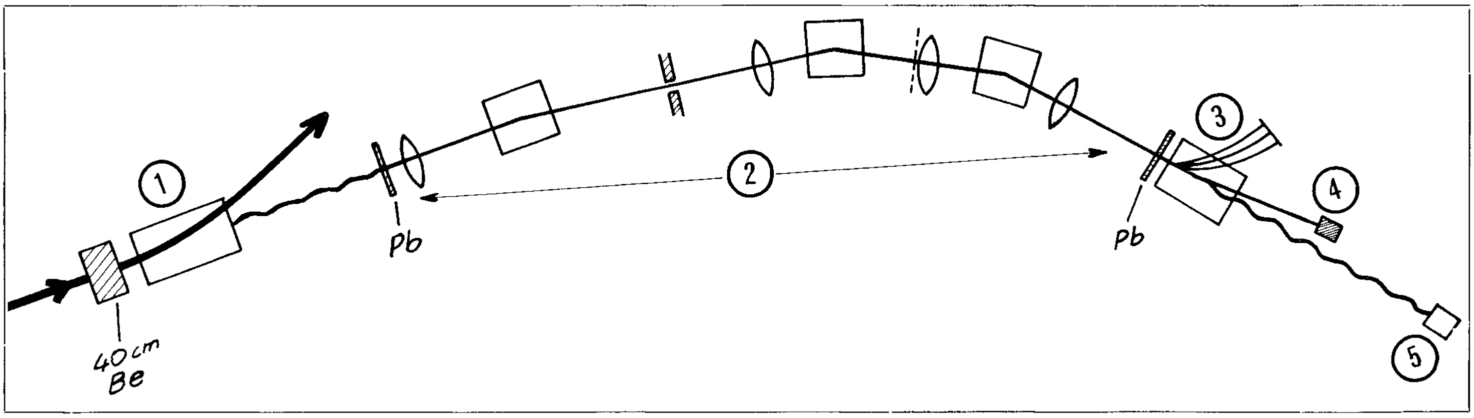
A preliminary measurement on spatial resolution in a liquid xenon chamber was made using rather thick wires (12 μm) to simplify construction. These thick wires stopped the chamber being used in the proportional mode but a spatial resolution of ± 15 μm was achieved.

Methods of laying down very fine strips of conductor closely spaced on an insulating substrate are now being tried as an essential step towards reaching the full potential of liquid proportional chambers as large scale detectors. The photograph illustrates one technique which has been used. In parallel, simple read-out schemes to deal with large chambers, involving many more 'wires' than we are used to, are being investigated.

A much fuller description of this work can be found in a Lawrence Berkeley Laboratory report (UCRL 20811) by R. A. Muller, S. E. Derenzo, G. Smadja, D. B. Smith, R. G. Smits, H. Zaklad and L. W. Alvarez.

BATAVIA
Electron-photon facility

Schematic diagram (not to scale) of a possible layout of the electron/photon facility to be built at Batavia. The proton beam entering from the left produces photons in a beryllium target; charged particles are bent off by sweeping magnets (1) leaving a neutral beam. The photons yield electrons in the 0.5 radiation length lead target which are conveyed by a 300 GeV/c transport system (2) to a second lead target (0.1 radiation length). This is followed by a tagging magnet and counters (3), a beam stop (4) and the experimental target (5).



It is intended to establish an electron beam at NAL of sufficient intensity to do electron and photon physics in the 100-200 GeV energy range which is obviously unobtainable at present electron accelerators. (The present highest energy at DESY is 7.5 GeV, at Cornell 10 GeV and at SLAC 21 GeV.) Although the intensity of the electron beam at NAL will be lower than those at the electron accelerators, it will be sufficient to carry out important and interesting experiments.

The beam could be produced in the following way: the full intensity 500 GeV ejected proton beam would be directed onto a beryllium target about 40 cm (approximately one collision length) thick. Neutral pions, produced in the interactions of the protons with beryllium, decay quickly into two photons. The charged particles are swept away by bending magnets leaving a neutral beam containing neutrons and neutral kaons as well as photons. Because the relative number of neutrons is high at this point (particularly at a production angle of 0°) it is not desirable to use the direct beam for most of the photon experiments which have been proposed.

Instead, a double conversion process could be used, producing electrons which are bent away from the neutral beam and then reconverting to photons. A layout for such a beam is shown in the figure. The electrons are produced by letting the primary photons strike a lead target (0.5 radiation length thick) placed downstream from the sweeping magnets. They are then collected by a conventional beam transport system.

A number of special requirements strongly influence the design of the beam. Firstly, the final focus must be transversely displaced by at least 8 m from the primary beam direction to ensure that the flux of muons coming from the decay of charged pions in the beryllium target will not be excessively high for the detectors in the experimental area.

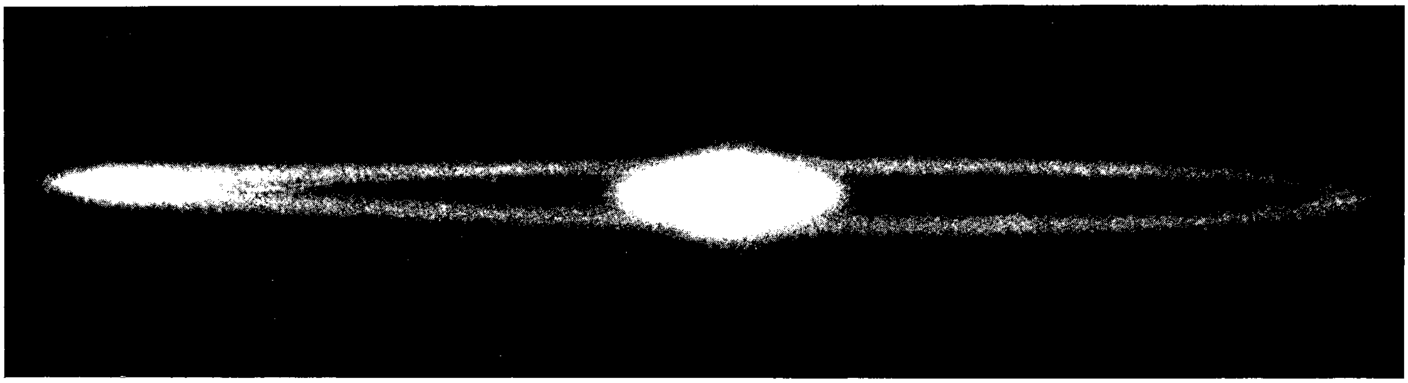
The beam could have a solid angle of up to 2 μsr and a momentum acceptance up to ± 3 %. For an incident proton flux of 10^{13} per pulse, a peak electron rate at 100 GeV of about 10^9 per pulse is expected, based on calculations using the Hagedorn-Ranft thermodynamic model.

This electron beam is reconverted to a photon beam by placing a thin 0.01 radiation length lead radiator just beyond the last magnet in the beam. The energy of the photons incident on the hydrogen target could be deter-

At the end of October, V. L. Auslander and S. G. Popov from Novosibirsk visited CERN and some accelerator physicists were able to see again the famous films of the synchrotron light emitted by beams orbiting the storage ring VEPP 2. This photograph, looking like a view of the planet Saturne, is a 'still' from one of the films recording the light from a positron beam (integrated over many turns by the photographic film).

The beam during these turns had effectively broken into two groups of particles — one group forming a central stable core and another executing large amplitude, horizontal oscillations. The oscillations are believed to have been caused by an induced voltage possibly on the clearing plates in the ring. The vertical separation of the oscillations is due to coupling of the two transverse planes. Particles could swop from one group to the other via the amplitude dependence of the Q-shift. Thus when particles reached the extreme amplitudes (which are about 1 cm in either direction) they get out of tune with the mechanism exciting the oscillations and fall back into the stable group. (The apparent asymmetry of the two peaks of the oscillations, where more particles seem to populate one peak, is believed to be simply an imperfection of the optical system between the beam and the film).

(Photo Novosibirsk)



mined by using a conventional tagging system. By extending the electron beam to include an additional dispersed focus the energy resolution can be improved to an accuracy of about ± 0.5 %. Discussions are currently underway between NAL and the interested participants to arrive at the final design of the beam and its uses.

Such a photon beam will make some new experiments possible. Clearly, they will be restricted to studying interactions where the cross-sections do not decrease rapidly with energy, such as the total gamma-proton cross-section and diffractive processes like compton scattering and vector meson (rho, omega, phi) production.

It will be interesting to see if the total cross-section (γp) continues to decrease as present theoretical extrapolations suggest. The A dependence of σ_T (γA) can be measured to check whether the effect of shadowing in the nucleus has increased from what is observed at lower energies. Photoproduction of vector mesons and compton scattering at high energies can be studied to see whether the diffraction slopes change with energy. This is possible because omega and phi production can be studied more easily at high energies because K decay corrections for $\o \rightarrow K^+ K^-$ are small and the efficiency for detecting $(\omega\ \varphi) \rightarrow \pi^+ \pi^- \pi^0$ is very high. A study of these four reactions will also provide a check of vector meson dominance (VMD) at high energies.

One can also look for new phenomena such as the existence of additional vector mesons in the 2π and 3π spectra up to masses of several GeV, which can be checked by looking at the missing mass spectrum in the reaction $\gamma + p \rightarrow p +$ anything as well as heavy leptons, which, if they exist, should be produced via the Bethe-Heitler process $\gamma + p \rightarrow p + l^-$. Studies of the inclusive reactions $\gamma + p \rightarrow \pi^\pm +$ anything can also be extended to very high energies.

The electron beam can be used to investigate scaling behaviour in deep inelastic electron scattering at higher values of q^2 and ν than are presently accessible at SLAC. This would complement the deep inelastic muon work already planned for NAL.

This new electron/photon facility should help increase our understanding of electromagnetic phenomena by opening up a new energy band. Indeed, though it is limited in the range of experiments it can feed, it is probably the easiest and most economical method of producing electrons of such high energy.

BERKELEY
Superheavies still elusive

The possibility of finding 'superheavy' elements in Nature has taken another knock following a two year search by a team from the Lawrence Berkeley Laboratory. They examined more than forty large samples of ore and rock and saw no signs of a superheavy.

Up to now it has proved possible to manufacture, artificially at particle accelerators, nuclei of elements as high as element 105 (with 105 protons and 155 neutrons in the nucleus). However, by studying the chemical periodic table and by calculating how the protons and neutrons cling together, it has been predicted that several elements around element 114 ought to be unusually stable. Estimates of their stability suggest that measurable quantities could very well still be hanging around even from the days of the formation of the earth 4000 million years ago.

The Berkeley team (S. Thompson, R. Jared, E. Cheifetz, E. Guisti, B. Price, H. R. Bowman, J. Hunter) set up their experiment some 240 m below the summit of the Berkeley hills in a tunnel about midway between Oakland and Orinda being constructed for rapid transit in the Bay Area. Their detector looked for showers of neutrons (as many as ten) which would be expected from the spontaneous fission of a superheavy nucleus. Hiding in a tunnel greatly reduced the possibility that cosmic rays could penetrate and initiate a similar neutron shower.

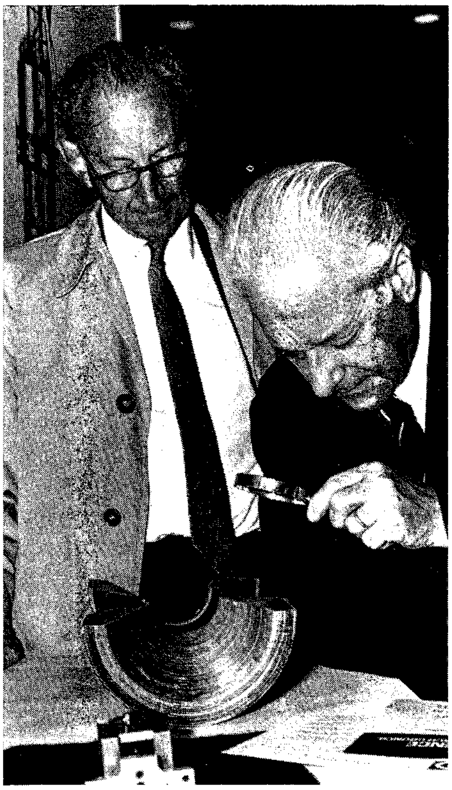
Large samples of material from many sources were carried to the

As part of the Royal Society celebrations for the centenary of the birth of Ernest Rutherford (born in New Zealand on 30 August 1871) a group of distinguished scientists visited the Rutherford Laboratory on 29 October. The photographs show :

1. E. Amaldi, President of the CERN Council, studying a copper model of a superconducting magnet used as a 'holding' magnet in a polarized target (the polarization is frozen in at 0.3 K in a 5 T field and then the target is moved to the holding magnet which has wide angular access). With him is G.H. Stafford, Director of the Rutherford Laboratory.

2. Reminiscing over a scaler built under Rutherford at the Cavendish Laboratory in 1932 are : left to right — N. M. King (Rutherford Lab.), D. M. Robinson (President, High Voltage Engineering Corporation), W. B. Lewis (Vice-President, Atomic Energy of Canada Ltd.), F. F. Heymann (University College London).

(Photos Rutherford)



detector — including moon rock, a large sample of gold nuggets, manganese from the floor of the Pacific, platinium ore, lead ore, etc. No sign of the fission of a superheavy nucleus was seen. If naturally occurring superheavies exist their abundance seems to be very low. Earlier this year a possible identification of element 112 in targets bombarded in the CERN proton synchrotron was reported from Rutherford (see the March issue, page 70). However, confidence in this identification appears to be waning and the superheavies remain elusive.

RUTHERFORD IBM 360/195

Instant computer commissioning has just been practised at the Rutherford Laboratory. An IBM system 360 model 195, which takes over from a 360/75 as the Laboratory's main computer, was successfully commissioned on 15 November only fifteen days after its delivery.

The contract for the new computer was placed exactly one year ago. It is six times more powerful than its predecessor and is intended to serve the University teams and the Laboratory staff involved in the high energy physics programme, processing data from experiments at the two UK national Laboratories and from experiments at CERN, and also to be used for other research work carried out by the Science Research Council. In particular, it will be accessible to be nearby Atlas Computer Laboratory which provides extensive computing services to Universities and other research Institutes.

The computer costs about £ 3 million. It has a central processor of 2 megabytes supported by a block multiplexor and a fast access fixed head file. A disk store of 800 megabytes and high speed tape units will be added early next year, and in 1973 it is intended to convert the installation to a more powerful version — a system 370 model 195.

IBM succeeded in trimming the time needed for installation down to two weeks (a month less than initially foreseen). The disruption to the Laboratory's computing services was therefore considerably reduced. The 360/75, which has been in action at the Laboratory for the past five years, continued to provide a limited service during the transition. Prior to delivery of the computer, test programs prepared at the Rutherford Laboratory had been run extremely successfully on a model 195 at Pough Keepsie. It was thus with considerable confidence that the buttons were pressed on 15 November. The confidence proved justified.

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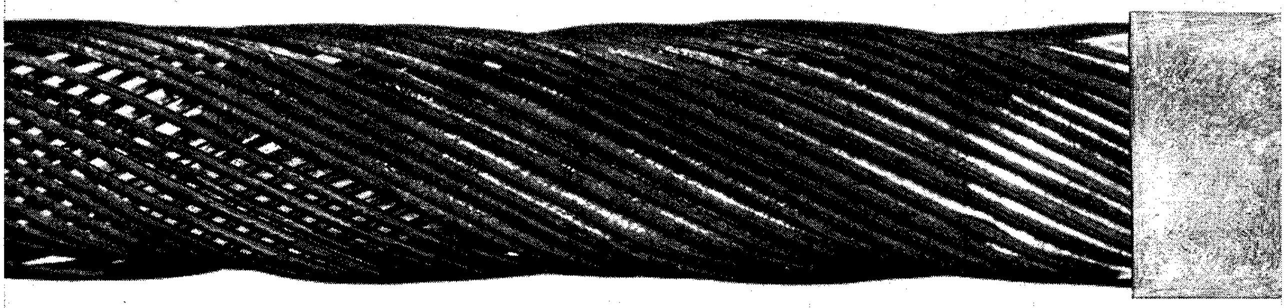
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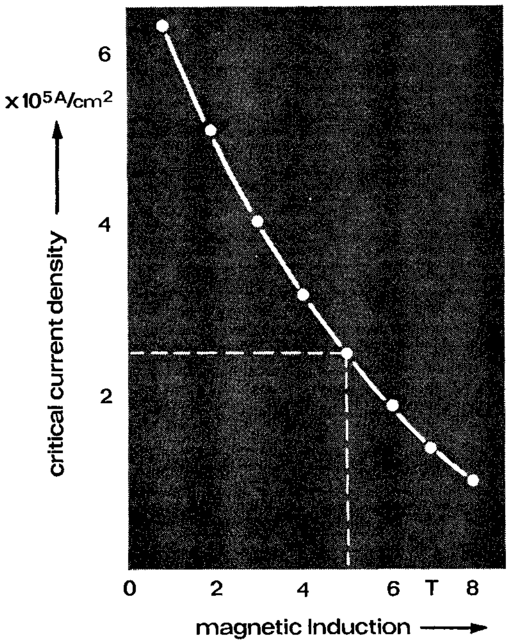

Application: Magnets both of big volume and on laboratory scale

Single core conductors for magnets of high homogeneity (critical current density about 2-2,5 x 10⁵ A/cm² at 5 T)

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Filament conductors containing 60 to about 1000 twisted superconducting strands, intrinsically stable (critical currents varying from 100 to 2000 A at 5 T)

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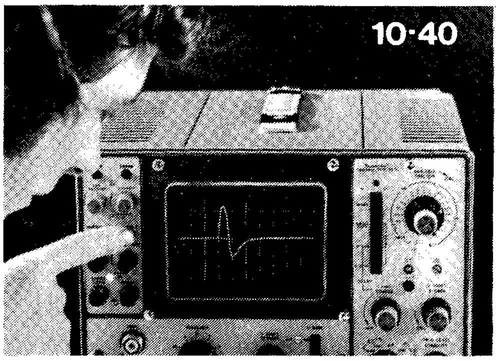
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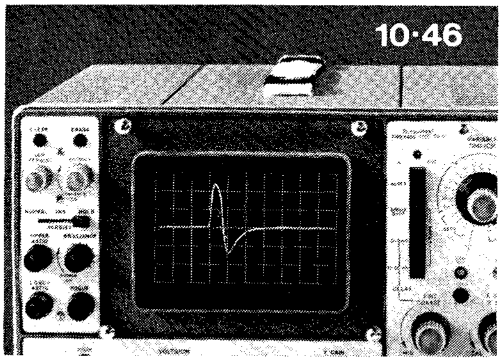
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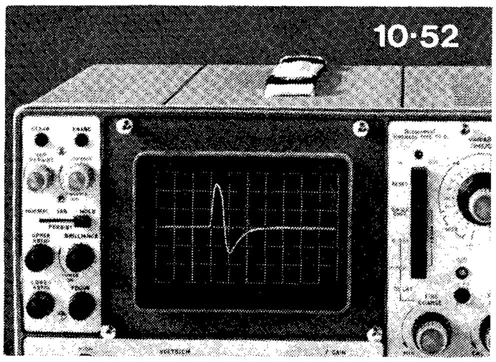
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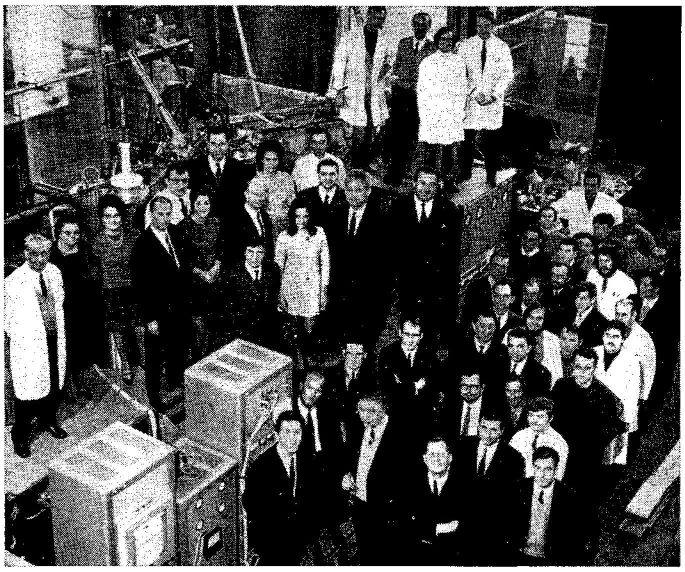
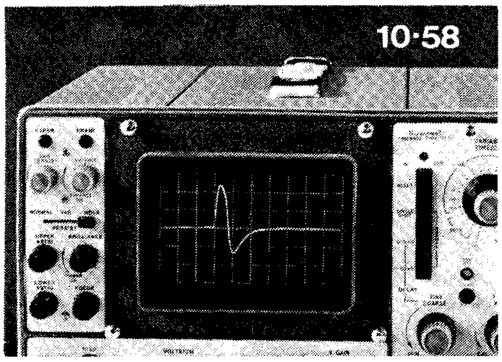


minutes with their storage tubes.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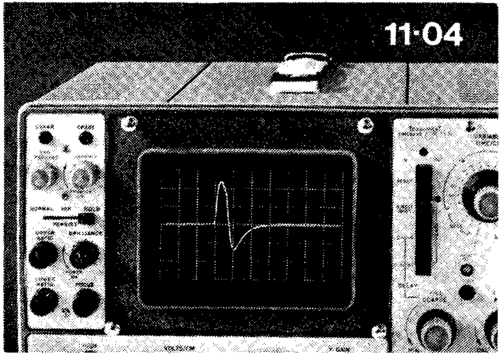
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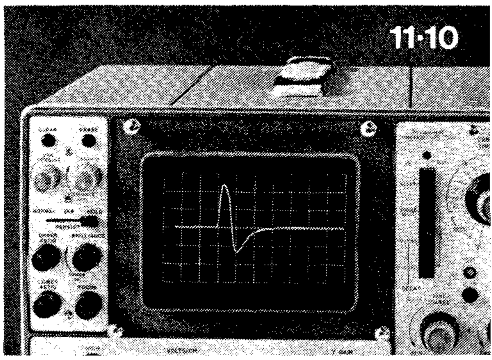
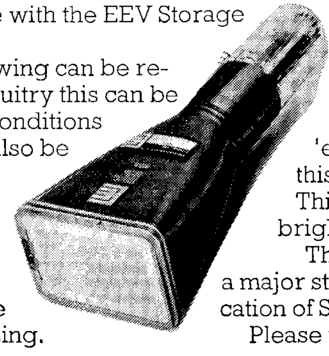

11·10

Observation of random transient waveforms—difficult, if not impossible with ordinary c.r.t. 'scopes—is made simple with the EEV Storage Tube.

A full brightness image with continuous viewing can be retained for several minutes—and with added circuitry this can be extended to ten minutes or more. Under 'hold' conditions an image may be stored for days. The tube can also be used as a conventional c.r.t. with post deflection acceleration.

No viewing hood is necessary; good, clean photography of waveforms is as easy as taking a family group. No expensive recording cameras are required and film is saved because the wave shape can be adjusted as required before exposing.



Quite an achievement isn't it? How is it done? Conventional c.r.t.'s have one electron gun. The EEV tube has two. One of them, the flood gun, is capable of illuminating the whole screen whilst the other—the writing gun—has a finely focused beam which writes information on a storage mesh, so producing an 'electronic stencil'. The flood gun's electrons flow through this stencil, lighting up the pattern on the fluorescent screen. This gives an image that is not only longer lasting, but also bright enough for full daylight viewing.

The EEV rectangular type E714 is unique, and represents a major step forward in the design, manufacture and application of Storage Tubes—the latest proof of EEV knowhow.

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EEV know how.

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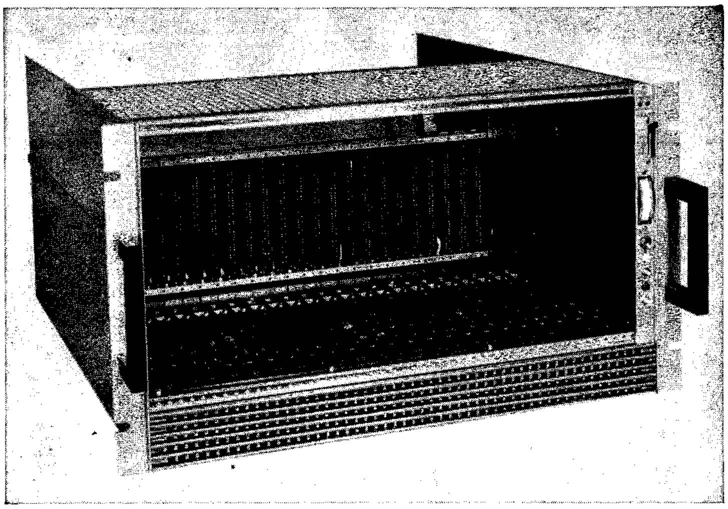

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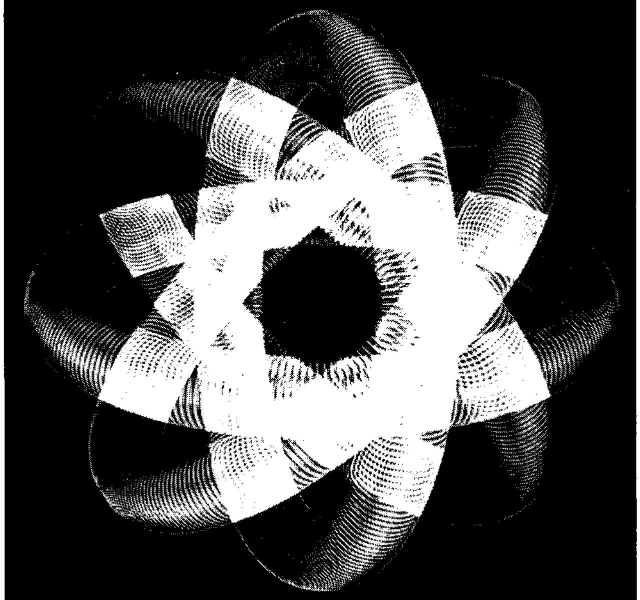

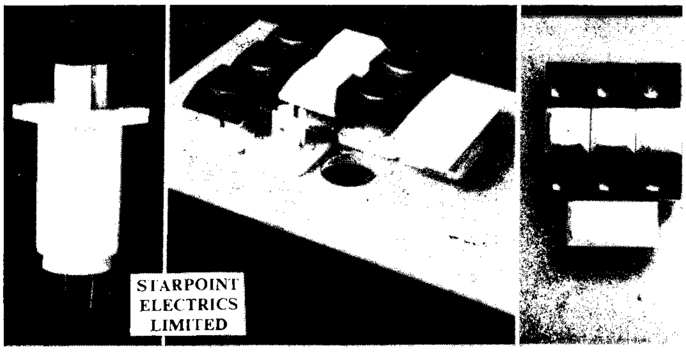
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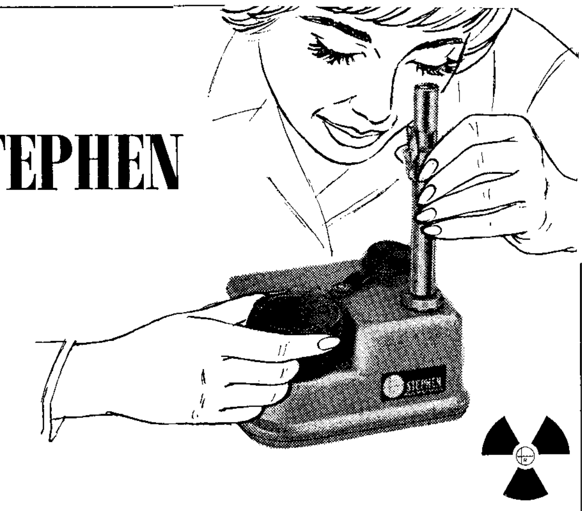
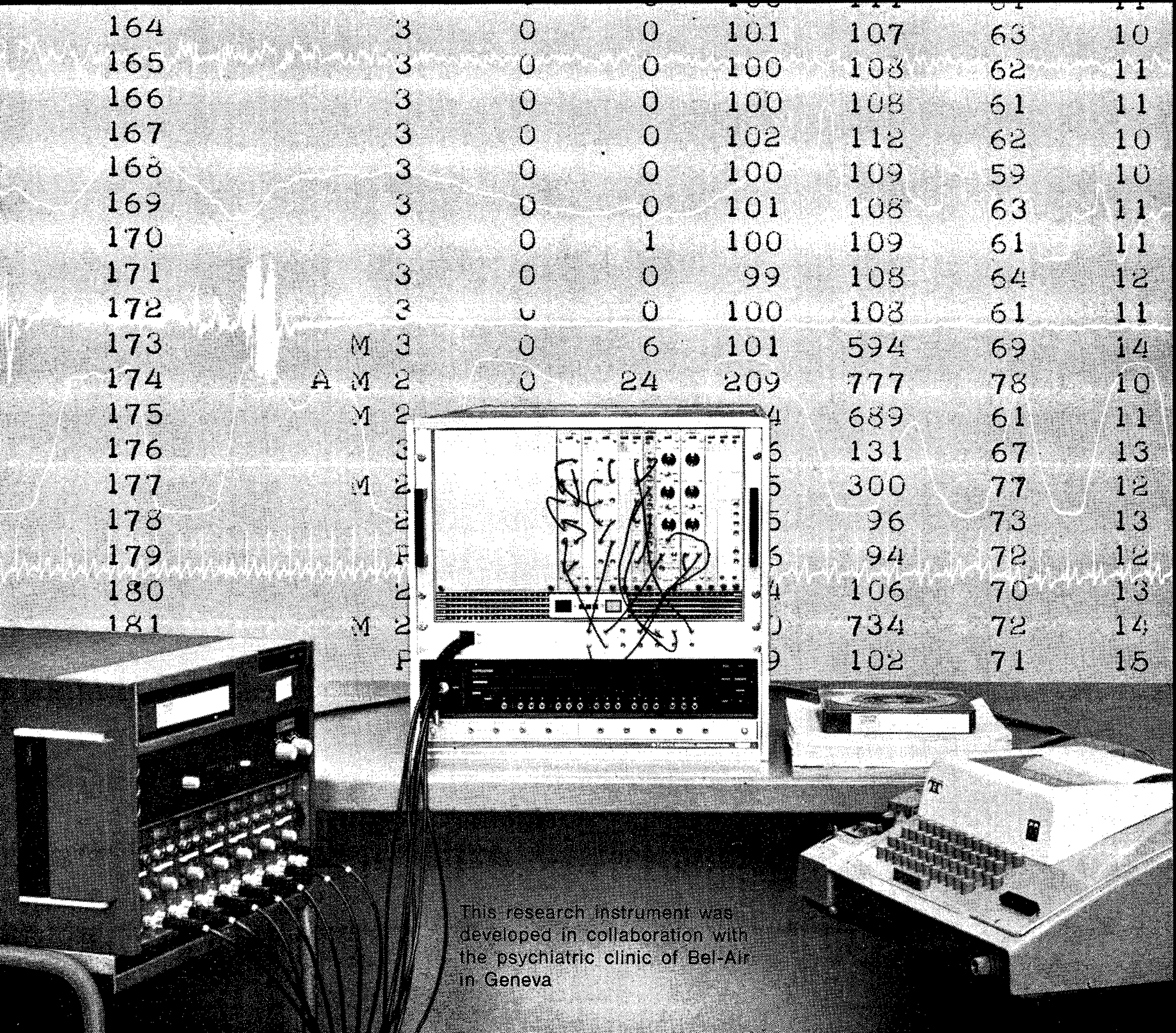
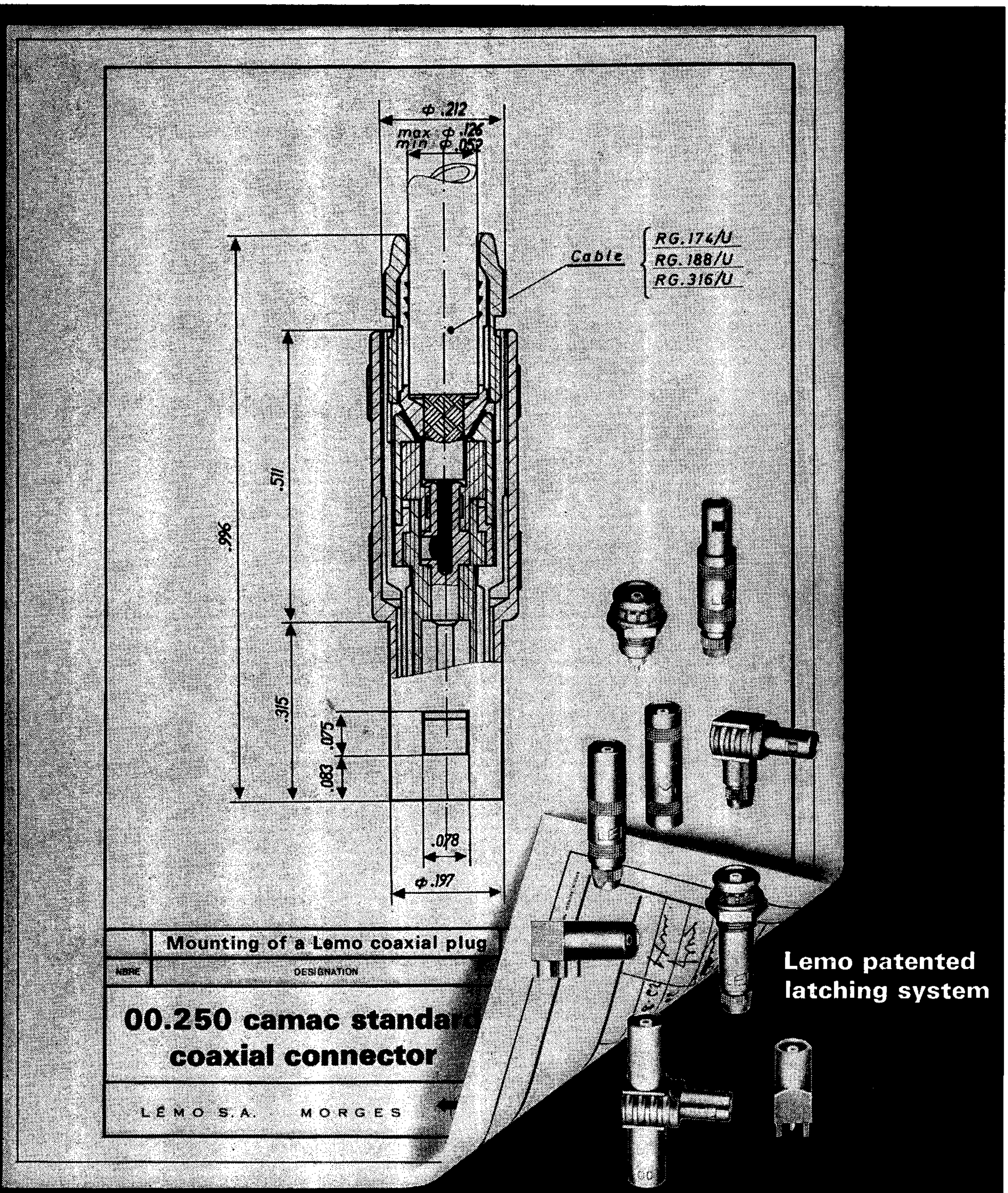

STEPHEN





General specifications

Composition
Shell : brass 59 A
Insulator : teflon PTFE
Contact : brass 59 A

Finish
Shell : nickel + chrome
RP + RPL types gold plated 3 microns
Contacts : nickel and 3 microns gold plated
Operating temperature range : –55° C +150° C

Electrical specifications

Characteristic impedance : 50 Ω ± 2 %
Frequency range : 0-10 GHz
Max VSWR 0 ÷ 10 GHz : 1 : 12
Contact resistance : < 8 m Ω
Insulator resistance : > 10^{12} Ω under 500 V. DC
Test voltage (mated F + RA) : 3 KV. DC
Operating voltage (mated F + RA) : 1 KV. DC

Normal maximum cable diameter : · 126
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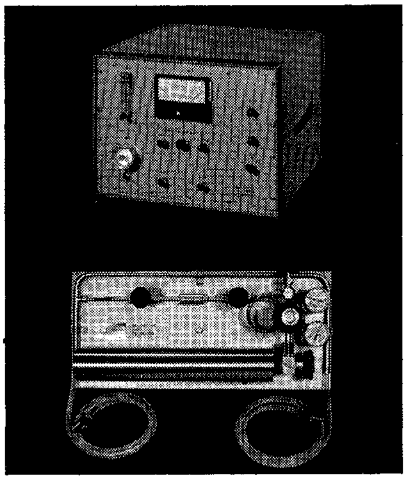

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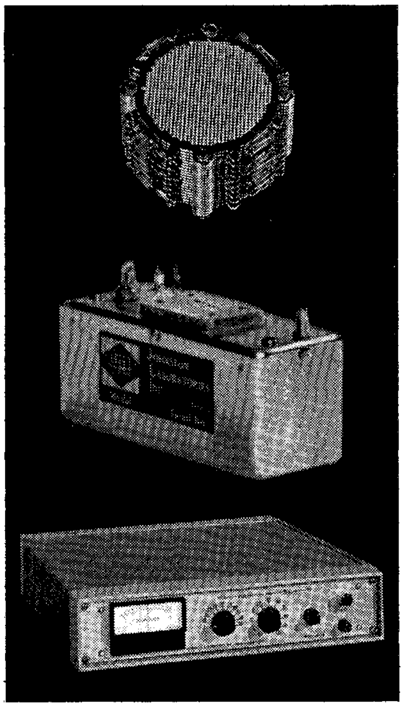

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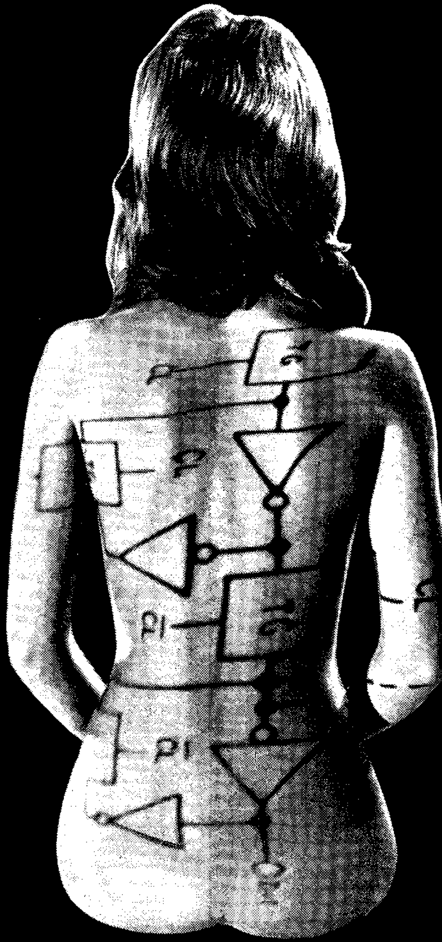

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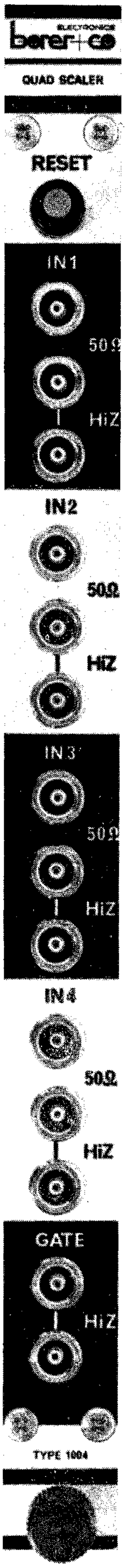

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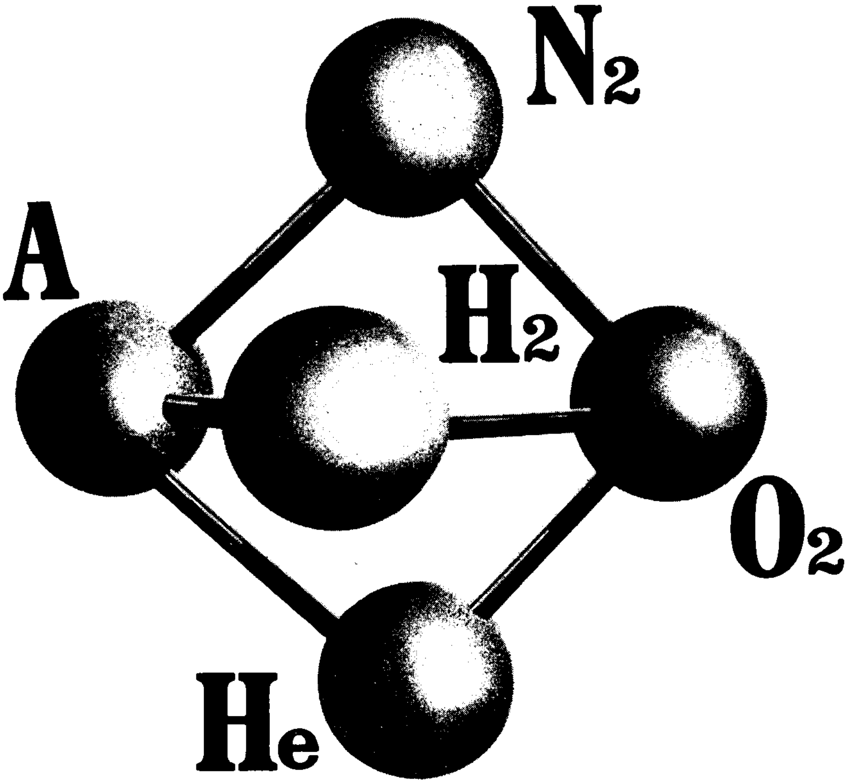
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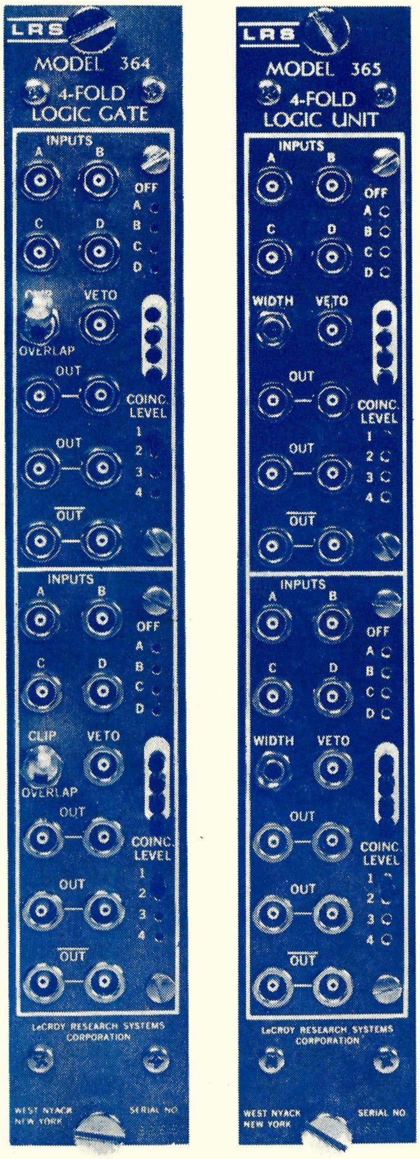

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