CERN COURIER

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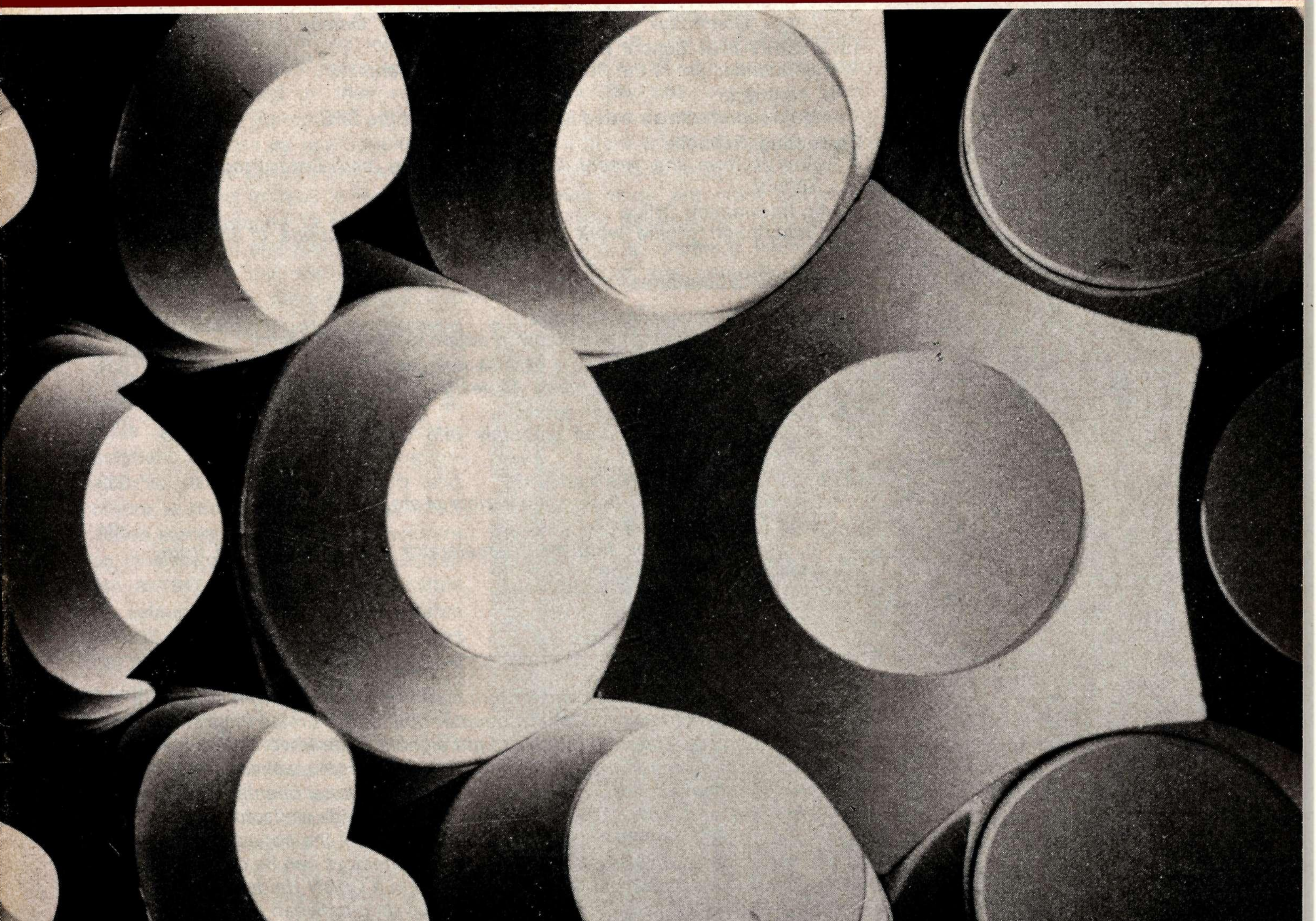
European Organization for Nuclear Research



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 850 Fellows and Visiting Scientists. Twelve European countries contribute, in proportion to their net national income, to the CERN Laboratory I budget, which totals 371.4 million Swiss francs in 1972.

CERN Laboratory II came into being in 1971. It is supported by eleven countries. A 'super proton synchrotron' (SPS), capable of a peak energy of hundreds of GeV, is being constructed. CERN Laboratory II also spans the Franco-Swiss frontier with 412 hectares in France and 68 hectares in Switzerland. Its budget for 1972 is 95 million Swiss francs and the staff will total about 300 people by the end of the year.

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Contents

Cover photograph : The intriguing pattern made by a plane of light collectors in a special threshold gas Cherenkov counter built at the Erstes Physikalisches Institut, Heidelberg. The counter gives light signals when traversed by electrons above a certain momentum and the light is reflected from a spherical mirror towards 22 photomultipliers. Light collectors, of hexagonal opening (so that they slot together to cover a full plane) and conical inside walls, focus the light onto the photomultipliers. The photograph distorts the appearance of the plane. The hexagonal shape of one of the light collectors can be distinguished on the right. The counter was successfully used in a CERN-Heidelberg experiment to measure the very small branching ratio between K_{e2} decay and $K_{\mu 2}$ decay. Over 800 K_{e2} events were collected — much higher statistics then ever before. Preliminary results were reported at the Chicago Conference.

XVI International Conference on High Energy Physics

Some topics of interest from the Conference which was held at Chicago from 6-13 September.

The sixteenth Conference in the Rochester series was held at the University of Chicago and at the nearby National Accelerator Laboratory, Batavia. The parallel sessions of the first three days took place at the University and the plenary sessions of the last three days at NAL. About 800 high energy physicists attended the Conference.

As usual a multitude of results were presented and it was noticeable that the contributions from Europe, and particularly CERN, were dominant. The Laboratories in the USA have been held back, mainly by budgetary restrictions, in recent years and this has had its impact on their results. Meanwhile the European physicists have had access to new facilities at Serpukhov, the ISR, ADONE and Gargamelle. Some redress is well on its way — the Argonne 12 foot chamber is in full action and NAL, SPEAR, the improved AGS and the CEA Bypass should begin to feed new life into the high energy physics programme in the USA.

On the theoretical front most excitement centred on the attempts to unite the interpretation of electromagnetic interactions and weak interactions. In 1967, S. Weinberg and others worked to build a weak interaction theory which is gauge invariant as is electrodynamics. R.P. Feynman etc. in 1947 showed that it is possible to calculate electromagnetic effects without worrying about infinities and the problem was to achieve the same situation with weak effects. The work of Weinberg, A. Salam etc. disappeared into the shadows until 1971 when T'Hooft showed that weak interaction theory is renormalizable in the same way as the electromagnetic.

Several variants of gauge theory are now on the table and what is gratifying about many of them is that they make fairly clean predictions which are accessible, or are becoming accessible, to experiment. The theories predict the existence of either heavy leptons or of weak neutral currents. Neither have been seen yet but the experiments in Gargamelle are on the brink of showing whether the neutral currents are there at a level predicted by the simpler versions of the gauge theory such as that of Weinberg. The neutral currents would give the interaction

$$\nu + e \rightarrow e + \nu$$

The data gathered in Gargamelle so far should have revealed between 1 and 9 events of this type but none have shown up. The further neutrino experiments which are now starting with the bubble chamber should take the number of events between 5 and 45 and if there is still no sign of them the simpler gauge theories will fall.

However there are more complex variants (for example by T.D. Lee, J. Prentki and B. Zumino) which are impervious to this neutrino experiment but at the cost of heavy leptons appearing some time. One dissatisfying aspect of the theories is that there seems no way of further extending them to take in the strong interactions so the dream of pulling all the interactions together is still nowhere near reality.

Weak interaction physics was also to the fore on the experimental front. There were several experiments which tidied up confusing situations coming from earlier results. Perhaps the most important was an experiment at Brookhaven (Columbia, Brookhaven, CERN group) which has observed six decays of the long-lived neutral kaon into two muons. The 'unitarity-limit' links such decays with the observed

During the Chicago Conference about 800 physicists were introduced to the Illinois prairie via a gigantic picnic. Activity centred in a large striped tent where roasted buffalo, steak, etc. were served. In the photograph M. Vivargent (left) and A. Zichichi chat with the Director of NAL, R.R. Wilson, who is wearing prairie regalia.

The plenary Sessions on the last three days of the Conference were held at the National Accelerator Laboratory, Batavia, in the Auditorium alongside the high rise building. The auditorium structure was completed just in time and improvisation was the order of the day. Inside the bare concrete shell the participants were accommodated on camping chairs. The photograph is of coffee break on the second floor of the high-rise building, with novel lighting effects.

decays into two gammas in such a way that it is possible to calculate that the electromagnetically induced decays into two muons should exceed 6×10^{-9} of all the kaon decays. A Berkeley result two years ago saw no two muon events at a much lower limit (they expected to see about 15 events) and sent theorists wheeling off in various directions. The Brookhaven result has brought them wheeling back.

Another odd result was the Utah measurement of how the distribution of high energy muons from cosmic rays varies with zenith angle (see vol. 8, page 12). Their result did not follow the expected distribution and suggested that the muon production processes needed fresh interpretation. This result has now been withdrawn and a Berkeley, SLAC group have presented new results from a cosmic ray experiment at SLAC which is in line with the accepted interpretation.

A completely unexpected tidying up exercise in weak interaction physics came from a CERN bubble chamber experiment and the CERN, Heidelberg experiment using huge multiwire proportional chambers. The experiments have remeasured the lifetime of the short-lived neutral kaon and found a 4 % difference compared with accepted value. More dramatic was the CERN, Heidelberg measurement of the CP violating parameter η_{+-} (which compares the rate of decay of the long-lived kaon into two pions to that of the short-lived kaon into two pions). It indicates that the accepted value should be raised by about 40 %. All the CP violating parameters need adjusting after these results. They do not uproot anything fundamental but it is startling to find such large adjustments coming after eight years of intensive study of these phenomena.

To complete the tidying up exercises we move to the strong interaction and record that the split A2 (see vol. 10, page 272) now seems to have been definitively swept under the carpet. Re-examination of the original CERN data gives the splitting as a 3 standard deviation effect rather than a 5 standard deviation effect and at that level the suggested splitting would not have taken hold so hard. The R,S,U mesons have not been corroborated either.

Continuing with the strong interaction, the first significant results from NAL were presented by the team working with the 30 inch bubble chamber transferred to Batavia from Argonne. They had excellent data on charged particle multiplicities and their distribution at energies up to 200 GeV. This is an obvious experiment to do when a new energy range is opened up and it is important because all the theoretical models of what is happening in the very high energy interactions must at least be able to interpret the multiplicity pattern correctly. A first theoretical look at the NAL data suggests that it is leaning towards the multiperipheral type models rather than the fireball models though the simple multiperipheral model may in fact be too simple.

The experiments at the CERN intersecting storage rings fed a great deal of information into the Conference. A lot of data on elastic scattering over a very wide range in momentum transfer (out to about 4 GeV^2) has been collected and something completely new was presented by the Aachen, CERN, Genoa, Harvard, Turin group. Their measurements of how the elastic differential cross-section varies with momentum transfer with the new centre of mass energies available at the ISR show the usual exponential fall off but then a dip and a secondary maximum which has never been seen before.

As usual at Conferences in the Rochester series, many of the big names in high energy physics were present. The photographs are of :

1. Left to right — M. Gell-Mann (1968 Nobel laureate), W. Metz (of 'Science' magazine), E.L. Goldwasser and R. Sachs (Co-chairmen of the Conference) and V.F. Weisskopf (from MIT, former Director General of CERN).

2. T.D. Lee (left), the 1957 Nobel laureate, talks with W. Panofsky, the Director of the Stanford Linear Accelerator Centre.

(Photos NAL)

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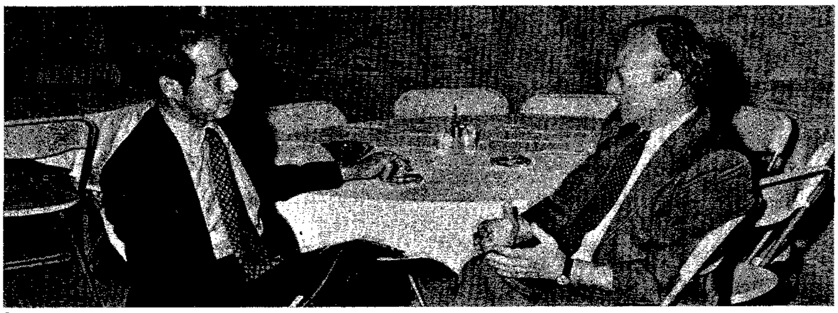

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Data has also piled up on inclusive reactions and the situation with regard to the scaling laws can be summed up as applying very well for pions, reasonably well for protons, less well for kaons (particularly negative kaons) and very badly for antiprotons. The antiproton production is much higher than expected at ISR energies. At the highest energies it looks as if the ratio of antiparticle to particle production is approaching one.

The scaling equations can also be expressed in terms of a parameter known as the 'rapidity' and when results are plotted in terms of this variable three distinct regions appear (this was particularly clear in the data of the Pisa, Stony Brook group). The regions can be interpreted as, 1) fragmentation of the 'target' particle (the detector seeing debris from desintegration of the target particle), 2) pionization region where the detector sees the produce (mainly pions) from the cloud when target and projectile particles are intermingled and 3) fragmentation of the projectile particle.

An astonishing result came from the CERN, Columbia, Rockefeller group. One general observation concerning the high energy interactions in the ISR is that particles with high transverse momenta are rare. Yet in the course of an experiment designed to look amongst other things for the intermediate boson they detected many neutral pions coming off at large angles to the beam directions. The number of neutral pions is a hundred times greater than expected and the transverse momenta are as high as 8 GeV/c for a single particle. This is something like Rutherford seeing his alpha particle bounce back from the supposedly transparent gold foil when he discovered the nucleus at the centre of the atom. The existence of partons within the proton is an obvious proposal to explain the origin of the phenomenon.

Partons get a further pat on the back from the beautiful neutrino results using the Gargamelle bubble chamber. For the first time healthy statistics have been gathered on total cross-sections for both antineutrino and neutrino interactions. The ratio between the two is about 1/3. Simple quark models and parton theories, where the partons have half-integer spin value, predict just this ratio. Comparing the cross-section results for neutrinos and antineutrinos in Gargamelle with the electro-production results from SLAC also reinforces the parton hypothesis.

Somehow, a feeling of excitement and anticipation emerged from the Chicago Conference which was not present after Vienna in 1968 or Kiev in 1970. It is probably a combination of examining previously inaccessible phenomena with the new experimental facilities (NAL, ISR, SPEAR, Gargamelle...) and a realization that, on a number of fronts and particularly with regard to the weak interactions, the investigations are being pushed so hard that something has to give. Whether this feeling of excitement is justified and whether something very important does come up, we should know before the next Rochester Conference in two years' time.

Tirrenia II

News from the 'Second ECFA Study Week on the 300 GeV CERN Accelerator' held at Tirrenia from 20-29 September.

Some of the European physicists returning from Chicago had hardly time to unpack their bags before they were off again to talk physics at Tirrenia near Pisa in Italy. About 150 gathered for a Study Week organized by the Working Party (under the Chairmanship of P. Falk-Vairant) which was set up two years ago by the European Committee for Future Accelerators to organize discussion on the experimental facilities and features of the experimental programme for the SPS. It is part of ECFA's function to act as a forum in European high energy physics where scientists from the Universities, the national research centres and CERN all have a voice. The Working Party initiated discussion on the experimental utilization of the SPS so that the whole high energy physics community could put forward their opinions and ideas (and knock other peoples ideas down) before the time for decision on the installation of beam-lines and experimental equipment.

Nine working parties were set up to tackle specific topics — Technical possibilities of the large European bubble chamber BEBC (contactmen I. Butterworth, R.T. Van de Walle), Technical possibilities of the heavy liquid bubble chamber Gargamelle (F. Jacquet, H. Wachsmuth), New facilities in visual devices (R.T. Van de Walle, I. Butterworth), Neutrino facilities (H. Wachsmuth, R. Turlay), Charged lepton and photon beams (J. Drees, G. Barbiellini), Hadronic beams (D. Treille, M. Steuer), Spectrometers and the use of Omega (D.E. Fries, W. Beusch), Particle identification (P.G. Murphy, J.P. Stroot) and Experimental areas and shielding (G. Brianti, J.J. Thresher). To complete the roll-call of names, there were further members of an Executive Committee of the Working Group who have given considerable time to its activities during the past eighteen months — J.V. Allaby, G. Giacomelli, E. Lillethun, I. Mannelli (who also carried very well on his shoulders the organization of the Tirrenia meeting), C. Michael, C. Rubbia, P. Söding and E.J.N. Wilson.

At a first Tirrenia meeting a year ago there was detailed presentation of the fixed and the flexible characteristics of the machine which will be available to feed experiments a few years from now. The same meeting also brought into the open the first 'off the top' ideas about experimental utilization. Since then the Working Groups have had their heads down and have produced a fat status report (CERN / ECFA / 72 / 4, Vol. I) where the problems, the possible solutions, the options, etc. are spelled out.

To pick some topics so as to indicate the sorts of things the report covers —

The availability of BEBC and Omega is one of the attractions of bringing the SPS alongside the exisiting CERN Laboratory. However, these detectors are designed for lower energy physics and, unaided, are not adequate for most experiments above about 40 GeV. For example, to cope with the production of neutral particles, either the neutrals must be made to 'materialize' or the other charged particles must be measured to sufficiently high accuracy not to miss the neutral pion mass in analysing an event. Proposed solutions for hadronic experiments in BEBC include the addition of further large magnetic analysers downstream and the insertion of a track sensitive target (see vol. 11, page 356) in the bubble chamber plus a large neutral detector in the forward direction. (Incidentally, H. Leutz reported at the meeting that the first experiment with a track sensitive target at Rutherford was completed on 16 September with 830 000 photographs under its belt and that a second experiment with a 2 GeV/c antiproton beam is now under way aiming for 200 000 pictures for Tata Institute, Bombay.) For Omega, a sequence of huge Cherenkov counters downstream is proposed. Other discussions on detectors cover the possibility and advantages of moving Gargamelle to sit behind BEBC, and the use of vertex detectors (rapid cycling bubble chambers, see vol. 11, page 91) and of streamer chambers (vol. 7, page 219).

High precision is also needed in measurements on the incoming beams and particle identification at these high energies requires devices such as refined DISC counters (July issue page 234) or possibly transition radiation detectors (September issue page 284).

Layouts for the West and North experimental areas have been considered with emphasis on the West where physics at the SPS will probably start. For the West Hall the scheme involves a radio-frequency separated beam feeding BEBC and a slow ejected proton beam rising from the machine tunnel level to the surface in the same tunnel. The proton beam could then yield five secondary beams including one to Omega and an electron beam. (This is a reflection of the very keen interest at present in weak interaction physics mentioned in the report on the Chicago Conference. It is also intended to provide a muon beam of high energy in the North area.) BEBC will also have a neutrino beam pointed at it and of the two possible schemes (target underground so as to use the intervening earth as shielding or target on the surface so as to improve flux) the underground solution has, paradoxically, came out on top.

For the North area a more tentative scheme has been put forward with a long muon/neutrino beam and a split proton beam supplying perhaps five secondary beams (electron, neutral and three charged beams for example) in a general purpose ex-

As an indication of the scale and complexity of the experimental equipment which will be needed to cope with beams from the SPS, these are three of the many schemes studied by the ECFA working parties and described in their recently published Status Report :

1. The large European bubble chamber, BEBC, used in a 'compound system' with electronic detectors, particularly for gamma detection downstream to reveal neutral particles from the interactions. The chamber itself is fitted with a track sensitive target.

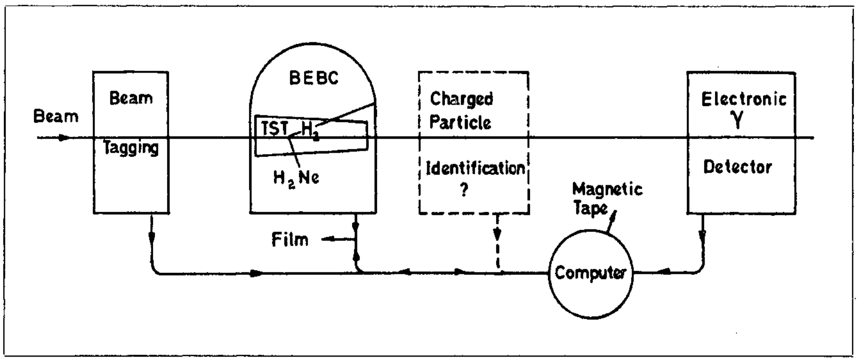
2. The Omega spectrometer adapted for higher energies with a sequence of huge threshold Cherenkov counters, C_1 C_2 C_3, and gamma detectors. Omega has multiwire proportional chambers installed rather than the present Plumbicon system.

3. The possibility of charged lepton and photon beams of very high energy has attracted a lot of attention. This scheme shows a system using a tagged photon beam with a streamer chamber.

perimental zone. The master plan for the North area will be fixed in about a year.

The content of the status report from the Working Groups was the meat of the Tirrenia meeting. We are not however going to continue on these topics here since they have either found their way into CERN COURIER before (as indicated by the references in the previous paragraphs) or will do so in coming months as the topics 'mature'. Instead we turn to the presentation by the Director General of Laboratory II, J.B. Adams, of recent studies of the different machine construction programmes mentioned in the original document defining the 300 GeV Programme. Though the decision times are not yet reached (and the options will be kept open until they are) the reaction at Tirrenia made it clear that the construction schedule known as Schedule C is the one most favoured by the experimentalists.

One possible development, which was discussed at the time when the project was authorized, is the use of superconducting magnets. To hold the door open for this possibility, only a half-set of iron-cored bending magnets has been ordered so far. Using the 'missing magnet' principle this half a ring's worth of conventional magnets can be arranged around the circumference, leaving spaces to slot in superconducting magnets or further iron-cored magnets later. Three European Laboratories (Karlsruhe, Saclay and Rutherford) in the GESSS collaboration are attacking the problems of pulsed superconducting magnets and are making healthy progress (as was reported at Tirrenia by W. Heinz and as is indicated later in this issue in the report from Rutherford). In order to synchronize with the construction schedules they will have to have all the necessary answers by the end of 1973 when the decision on



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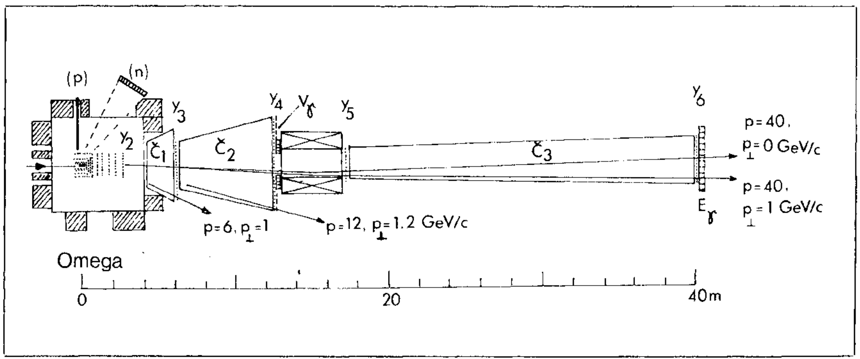

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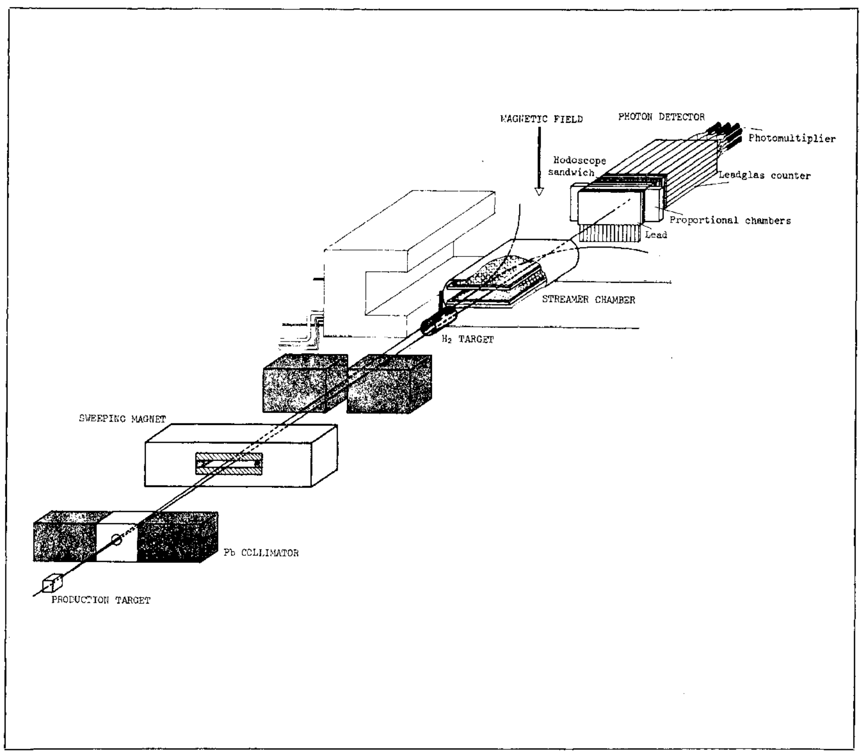
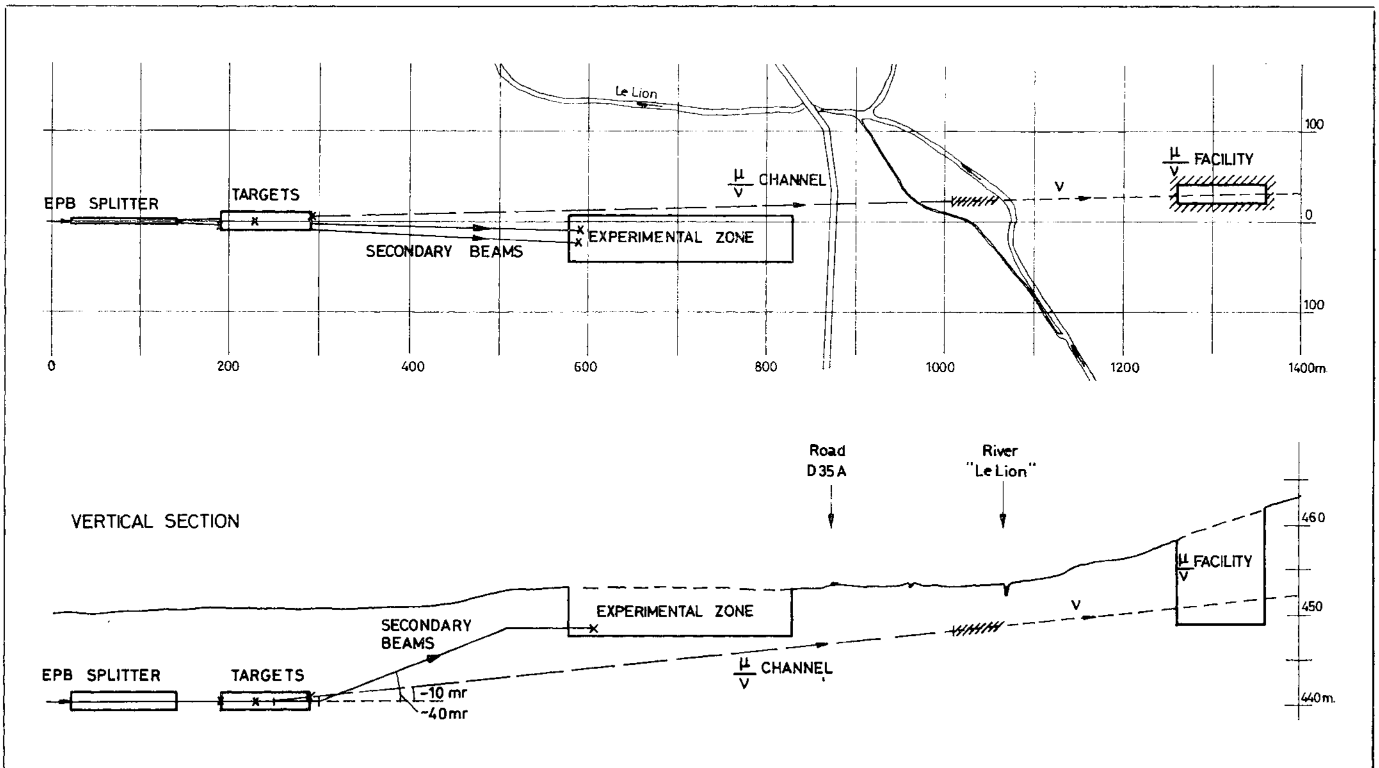


3.

A schematic layout, in horizontal and vertical views, for the North Experimental Area. This layout has been developed in some detail but there is still time for it to be modified before construction needs to begin. The distance indications are from the end of the ejected proton beam-line (i.e. about 600 m from the ejection point in the accelerator ring). Two zones for experiments are foreseen — one a general purpose zone with secondary beams, the other specializing in muon and neutrino physics.



whether to continue manufacturing conventional magnets to fill the ring or to use superconducting magnets has to be made. Present indications are that the costs and timescale involved in going superconducting may be beyond the 'programme definition' which is the mandate for the project authorized by the CERN Council. If this turns out to be the case it would be necessary to go back to Council for further authorization to use superconducting magnets — a very daunting prospect indeed.

Thus the superconducting option has its problems though the door is still open. However this is no reason to slacken off the effort in the GESSS collaboration. To master superconducting pulsed magnets able to meet the stringent demands of an accelerator environment is bound to bear fruit. In CERN and the other high energy physics Laboratories they could be called upon for beam-line construction but, more importantly, they are the only conceivable way at present of extending accelerator and storage ring energies. Outside the Laboratories, the technology which is being developed could have wide application and in terms of feedback to the Member States will probably be among our most important achievements.

If we then look at a fully 'conventional' machine, one of the possible construction schedules is known as Schedule A. Its major features, for the purposes of explaining the other possibilities, are : Magnets will start arriving at CERN mid-1973 and enough to fill half the circumference will be assembled and installed by mid-1975. All other major equipment to reach the 200 GeV level will be in place by the end of 1975 and commissioning for 200 GeV will begin early 1976. The accelerator will be ready to feed an experimental programme by about September 1976 (testing of experimental equipment beginning from March of that year).

These dates are extremely sensitive to progress on the boring of the machine tunnel. This is scheduled to be completed early in 1975. However, if that date slips, all subsequent dates necessarily slip with it. (Since there is just one boring machine working round the clock, no doubling up of effort or increasing working hours could rescue the situation if major problems develop — though none are anticipated — in the course of boring the tunnel.)

From the start of the experimental programme in 1976, progressive installation of further conventional magnets so as to take the energy higher will proceed, probably at the rate of two months of physics followed by one month of installation through to near the end of 1977. This would give about 14 months of physics at the

200 GeV level prior to another long shutdown to align the additional magnets and to recommission the machine at the higher energy.

An important announcement at Tirrenia is that this higher energy could be 400 GeV rather than 300 GeV (which has to be reached to meet the commitment in the 'programme definition'). The major contracts which have been placed, or are being negotiated, have in general been within the estimated cost and this should make it possible to afford the extra magnets to reach 400 GeV within the 'authorized' total cost of the project.

An alternative to the programme for the last years of Schedule A is to have a clear run for physics once the 200 GeV level is reached, without the progressive installation of magnets throughout 1977. This is known as Schedule B and would obviously require a very long shutdown for the installation of magnets and for recommissioning to give 400 GeV by the end of the eight year programme (19 February 1979).

To save the double commissioning involved in A or B and also to open up more possibilities for experimentation, Schedule C has been worked out. It involves stepping up the production rate for the magnets and intalling a full ring's worth before the machine is brought into operation. The last magnet would then be put in place around September 1975. Other equipment installation would be completed in the following months and commissioning could start about the middle of 1976. At the end of that year experiments should be possible in the West Hall and could continue with much less interruption than in Schedule A. (It might also be possible to fire 400 GeV, rather than 200 GeV, beams at the neutrino target feeding BEBC experiments.) Since most components would be in place for 400 GeV the ejection system to feed the North Hall with beams of up to this energy could be commissioned by early 1978 — a year ahead of the time foreseen in Schedule A.

The advantages and disadvantages of Schedule C are probably obvious. From the experimenters' point of view, the West Hall would come into action 4 months later, though yielding 21 months worth of physics before the end of the programme rather than the 14 months of Schedule A. (Incidentally such a delay could give a little more time for 28 GeV physics in the West Hall prior to its being shut to prepare for higher energies.) On the other hand, peak energy physics in the North Hall would start a year earlier.

The main problem is finance — not total finance, since the machine will be built within the total authorized budget no matter which schedule is followed, but annual budgets. Schedule C requires more expenditure in 1974-75 than is provided by the agreed budgets for those years. It could involve a move of up to 85 million Swiss francs from the last three years of the programme if all the attractive features of Schedule C were taken up. It seems likely therefore that some selection will have to be made so that the bump in the expenditure profile can be made tolerable. Decisions do not need to be taken before the second half of 1973 and there is time for thinking and for shuffing the various cards in the pack, so that the best hand can be played when the time comes.

Following this second Tirrenia meeting the task of the ECFA Working Party is close to its end. It will be succeeded, moving a stage nearer to decision-taking, by a new committee which was announced by W. Jentschke, Director General of CERN Laboratory I. The Committee will be known as the 300 GeV Preparatory Experiments Committee (though the '300 GeV' may look a little dépassé). It will be set up in a similar way to the other experimental committees and, like them, will be advisory to the Nuclear Physics Research Committee. However, its mandate will be much broader — it will be concerned with all types of experiment at the SPS and will also make recommendations on such things as beams, major detectors, etc. The committee, will be set up as soon as possible so that it can start work from the beginning of next year and it is expected to be in action through to the time when the SPS comes into operation. Its functions could then divide between the already existing committees or it could stay as a distinct committee depending on what seems to be the best approach at that time.

One of its first tasks will be to start things moving concerning proposals for experiments at the SPS. Given the long time required to build up experiments for the new high energy range, much of the initial experimental programme will need to be fixed well in advance of the machine commissioning date. The Committee is likely to call for 'letters of intent' by the middle of next year and actual proposals not very long afterwards.

EPS at Wiesbaden

The European Physical Society Conference on 'Trends in Physics' held at Wiesbaden from 3-6 October.

Compared to the meditative pace of the Tirrenia Study, the Second General Conference of the European Physical Society, held in the lovely German town of Wiesbaden, was a furore of activity with four days packed with lectures and meetings morning, noon and night. It was held in the huge Rhein-Main-Halle which easily absorbed the 1300 physicists attracted to the Conference.

'Trends in Physics' is obviously a very broad subject for a Conference and we can only touch a few of the topics in a short article. Astrophysics and cosmology which held pride of place at the EPS Conference in Florence in 1969 (see vol. 9, page 106) appear to have lost none of their excitement. One of the highlights at Wiesbaden was a fascinating talk by W. Kundt on 'The Origins of the Universe'. Measurements on the background radiation (2.7 K), radioactive decay and galaxy recessional velocities are strong evidence for a singular event (some version of the big bang) about 10^{10} years ago. When physics is fed back into the probable state of matter as the 'bang' developed distinct eras of time can be distinguished — quantum physics and special relativity holding sway up to 10^{-23} s ; hadronic era extending up to 10^{-4} s when embryonic galaxies possibly originated from thermal fluctuations in the hadron soup ; radiation era through to about 10^{5} years when electromagnetic interactions dominated ; matter era through to the present day when galaxies and stars are acting out their life cycles. The various models of these processes each explain some features but none holds the whole evolutionary chain of the Universe together. In particular, more information on particle behaviour from the high energy physics Laboratories could feed some precision into the more speculative areas.

Another talk on 'origins' was given by Nobel laureate M. Eigen and was from the field of molecular biology where many science disciplines, including physics, are intermeshed. The title of his brilliant lecture was 'The Origin of Biological Information' and his aim was to spell out a theory of how life as we know it could have emerged. A plausible sequence has been deduced to show how the protein/nuclei acid systems that we know could have been 'selected' from the myriad combinations of molecules and then sustained.

High energy physics emerged better from Wiesbaden than from Florence (where the main speakers on h.e.p. stepped in at short notice and, in hastily prepared talks, did not convey much interest to their audience). There were four lectures in a Divisional Session — H. Lehmann on 'Axiomatic field theory and particle physics', A. Zichichi on 'Physics with electron-positron colliding beams', A. Wetherell on 'Physics with colliding hadron beams' and N. Cabibbo on 'New developments in the theory of weak interactions'. In the Plenary Session L. Van Hove gave a fine talk on 'Recent developments in high energy physics'.

He selected five topics which appealed to him as major advances from recent years in our knowledge and understanding of particles :

The first was the progress in renormalization theory (covered earlier in this issue in the report on the Chicago Conference).

The second was the violation of time reversal invariance. The high precision measurements on the decays of the neutral kaon over the past few years have shown that the weak interaction violates invariance for reversal of the direction of time. This violation of the symmetry between past and future is a completely new finding about Nature.

The third topic was the evidence for granular structure in the nucleon. This topic was launched experimentally with the famous deep inelastic scattering experiments of high energy electrons on protons at Stanford and theoretically has yielded the 'parton' models. The experimental results indicate that the electric charge in the proton is distributed in point-like grains (or partons). In addition to this evidence for granularity with regard to the electromagnetic interaction, there is also evidence for similar effects with regard to the weak interaction (neutrino total cross-section experiments) and possibly even with regard to the strong interaction (recent ISR results on large momentum transfer).

The fourth topic was the systematics of high energy collisions between hadrons. Simple two-body collisions have been the subject of a multitude of experiments and, though their detailed behaviour can be complicated, qualitatively the same underlying mechanism — the exchange mechanism — seems to apply in all cases. In recent years the study has been extended to collisions resulting in many particles being produced. Again it looks as if similar exchange mechanisms underly the observations.

The fifth topic was the recent surprising result from a CERN, ETH Zurich experiment which revealed that a many-pion system can find its way as rapidly through nuclear matter as can a single pion. This is in complete contradiction to naive calculations and may be a consequence of the pions being mostly in virtual states as they propagate through matter. This finding could have repercussions on the interpretation of the behaviour of matter in condensed, high energy states.

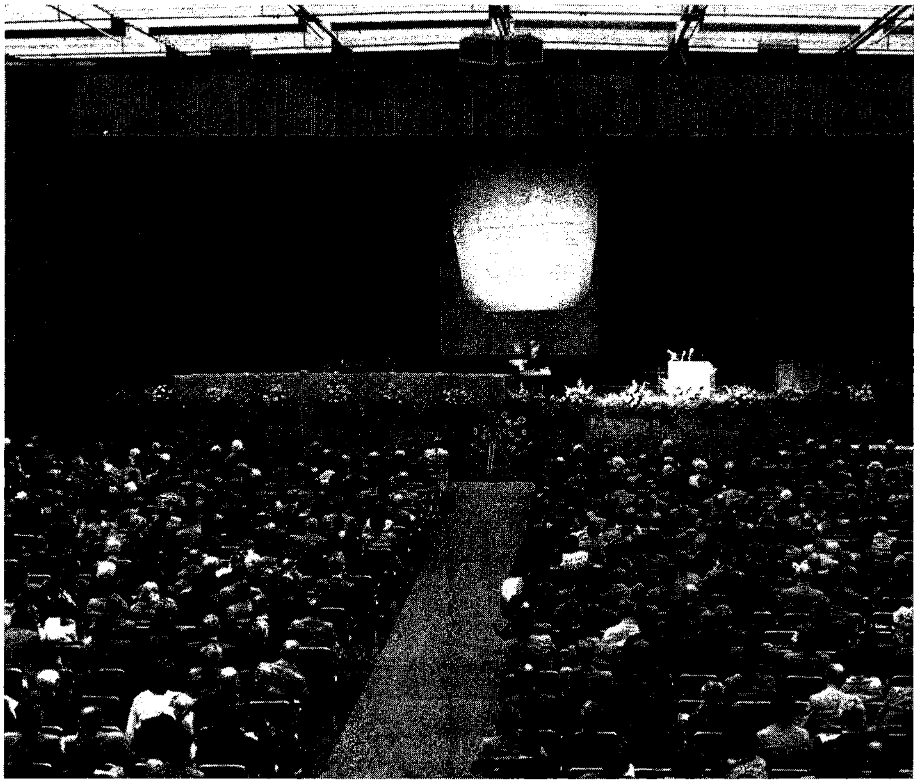
Physics and Society

Moving away from the purely physics topics and looking at the Conference

H.B.G. Casimir, President of the European Physical Society, addresses the inaugural session of the Second EPS General Conference, 'Trends in Physics', held from 3-6 October.

The Conference was held in the huge Rhein-Main-Halle at Wiesbaden, Federal Republic of Germany, and attracted about 1300 participants.

(Photos Gudrun Henrich)



as a whole, it was obvious that the dominant 'Trend in Physics' is an increasing concern about the interrelation between physics and society. In sheer weight of hours this subject overwhelmed all others. There were specific plenary lectures by J. Tinbergen (Nobel laureate for his work on econometrics) on 'Environment, scientific research and economic policy' and by H.B.G. Casimir on 'Physics and society'. The theme of applications of research came into many other lectures also in a way which was almost completely absent in Florence. Then one evening was given to a long discussion under the heading 'Physics and society — public policy and current prospects'.

The discussion evolved around the report by the EPS Advisory Committee on Physics and Society (see Europhysics News, July 1972). The report, after a tentative analysis of the present situation, made recommendations on the promotion of science as a predominant element of human culture and general progress and on increased efforts to communicate with society at large about science and its consequences. On the political front the report recommended that effective coordination systems should be set up at top corporate and government levels for planning and implementing scientific progress and that research and development organizations not tied to governments should be made aware of the vital role of science in solving public problems. Finally, the report urged more interdisciplinary activities, more concern with science policy and promotion of the work of talented individual scientists.

After a brief presentation of the report by the Chairman of the Advisory Committee, G. Diemer, the discussion fragmented into individual statements of attitudes and priorities which was probably a fair reflection of the confusion reigning on this issue. Most people acknowledge that serious problems exist concerning the future of science, the applications of growing knowledge, criteria for the well-being of society, the social responsibility of scientists, the depletion of resources in an increasingly technological world, irreversible ecological effects and so on... but few have a confident response to the problems. (We do not include the two extreme ends of the spectrum — the prophets of inevitable doom whose hysterical outbursts based on insufficient data have weakened the credibility of more balanced concern and the ostriches who believe we can safely put our heads in the sand of our research and the problems will go away.) The problems are broad and complex and in many cases the best way of attacking them is far from clear. Hence the woolly discussion at Wiesbaden.

J. Tinbergen has obviously thought

longer and deeper on these issues than most people and as an indication of points that were raised, we pick a few themes at random from his lecture — Human welfare is not necessarily optimized by economic growth; Reduction of population growth is vital ; People should be made environment conscious ; Communication between scientists and people should be improved ; Separate organizations should be set up to defend long-term interests since otherwise the short-term will always win ; World authorities are needed acting autonomously in well-defined fields (there are many issues where purely national interests are an unrealistic relic of the past) ; There is excessive expenditure of resources on military research...

H.B.G. Casimir is President of the European Physical Society but in his 'Physics and Society' lecture he was giving his personal reactions. Since they are probably typical of many physicists they are worth outlining here. Casimir began by sketching the background of the science/technology based civilization we live in and his interpretation of the science/technology spiral (that the results of scientific research, after a time-lag of some ten or fifteen years, give advances in technology which then make possible further progress in scientific research).

On the one hand, the spiral can be seen as having brought tremendous benefits to mankind. Even those who attack science can hardly envisage life without the comforts it has made possible — who would consider living without electricity ; who would change his doctor for a witchdoctor, etc. ? On the other hand, the spiral can be seen as outstripping all other human capabilities — overcoming our ability to keep it in check in our social systems, polluting our environment, eating away remorselessly at our resources, being used in ruthless human destruction for political ends.

Casimir acknowledged that his stand with regard to these two attitudes is hesitant and evasive. His love of physics and admiration of its achievements and his fascination by technology and confidence in its abilities to master problems brings him into the first camp. Yet increasing alarm at the influence of science and technology in war, in destruction of the environment and in human relations makes him speak of the 'ominous and inexorable spiral'.

In this ambiguous position he felt unable to present even tentative solutions. Instead he limited himself to a few strong recommendations :

1. A physicist should realize that being a physicist does not put him in a position beyond all responsibility, even if he is dealing with abstract academic subjects.
2. Since we are unwilling and probably unable to stop the development of science and technology and since we are quite obviously unable to design a comprehensive masterplan for science and society, our best chances for gaining some control over the ominous spiral lie in a plurality of controls, in an independence of opinion of the several participating groups, and in openness.
3. In particular, universities should maintain their independence versus industry and industry should respect this independence.
4. Relations between the military and the universities — if they exist at all — should at the very least follow similar rules as those between industry and universities.
5. It is desirable to have also a more clear cut separation between industry and the military. Physicists in industrial research laboratories might, for instance, insist on being informed about military aspects of their work.
6. In view of the alarming uses of science-based technology in warfare, no scientist in an academic position should of his own free will be active in, or advise on, military technology.

European Physical Society

The EPS held its fourth annual General Assembly during the Conference and this is an appropriate time to summarize the structure and activities of the Society.

The Society now has 2350 individual ordinary members and 27 Member Societies (via which the EPS reaches some 40 000 European physicists). The list of Member Societies covers practically all European countries — Ampere Group (Switzerland), Austrian Physical Society, Belgian Physical Society, Bulgarian Academy of Sciences, Danish Society for Physics and Chemistry of Condensed Matter, Department of General Physics and Astronomy of the USSR Academy of Sciences, Eötvös Lorand Physical Society (Hungary), Finnish Physical Society, French Physical Society, German Physical Society, The Institute of Physics (UK), Institute Rudjer Boskovic (Yugoslavia), Israel Physical Society, Italian Physical Society, The Netherlands Physical Society, Norwegian Physical Society, Physical Section Union of Czechoslovak Mathematicians and Physicists, Physical Section Union of Yugoslav Societies of Mathematicians Physicists and Astronomers, Physical Society of the German Democratic Republic, Polish Physical Society, Portuguese Physics and Chemistry Society, Rumanian National Committee for Physics, Royal Irish Academy, Spanish Royal Society of Physics and Chemistry, Swedish Physical Society, Swiss Physical Society and Turkish Physical Society.

Seven specialized Divisions have been set up to coordinate European activities in particular areas of physics — Atomic physics (Chairman H. van Regemorter), Condensed matter (A. Guinier), High energy and particle physics (A. Zichichi ad interim), Nuclear physics (L.L. Green), Physics in astronomy (E. Schatzman), Plasma physics (B. Lehnert) and Quantum electronics (S.A. Ramsden). There is also a Computational Physics Group (A. Schluter) whose interests obviously cut across the Divisional boundries.

Advisory Committees have been set up to tackle the questions of Applied physics and physics in industry (O.G. Folberth) — they have organized a survey of physicists working in these fields and the results were published in Europhysics News March 1972; Conferences (G.H. Stafford) — they have begun to feed a little order into the plethora of European Conferences, have established criteria for 'Europhysics Conferences' and have encouraged the publication of a list of meetings twice a year in Europhysics News; Physics and society (G. Diemer) — they have issued the report which was discussed at Wiesbaden; Publications (J. de Boer) — they are studying the coordination of physics publications in Europe and have established criteria for journals to carry the Europhysics Journal label; Summerschools and student exchanges (G. Bernardini) — they have not made much progress to date due to the illness of their Chairman.

The Advisory Committees report to the Executive Committee which currently consists of H.B.G. Casimir (President), C.M. Braams (Vice-President), L. Jansen (Secretary), N. Cindro (Vice-Secretary), L. Cohen (Treasurer), G.J. Béné (Vice-Treasurer), L.A. Artsimovitch, J. Friedel, K.E. Ganzhorn, T. Riste and G. Szigeti.

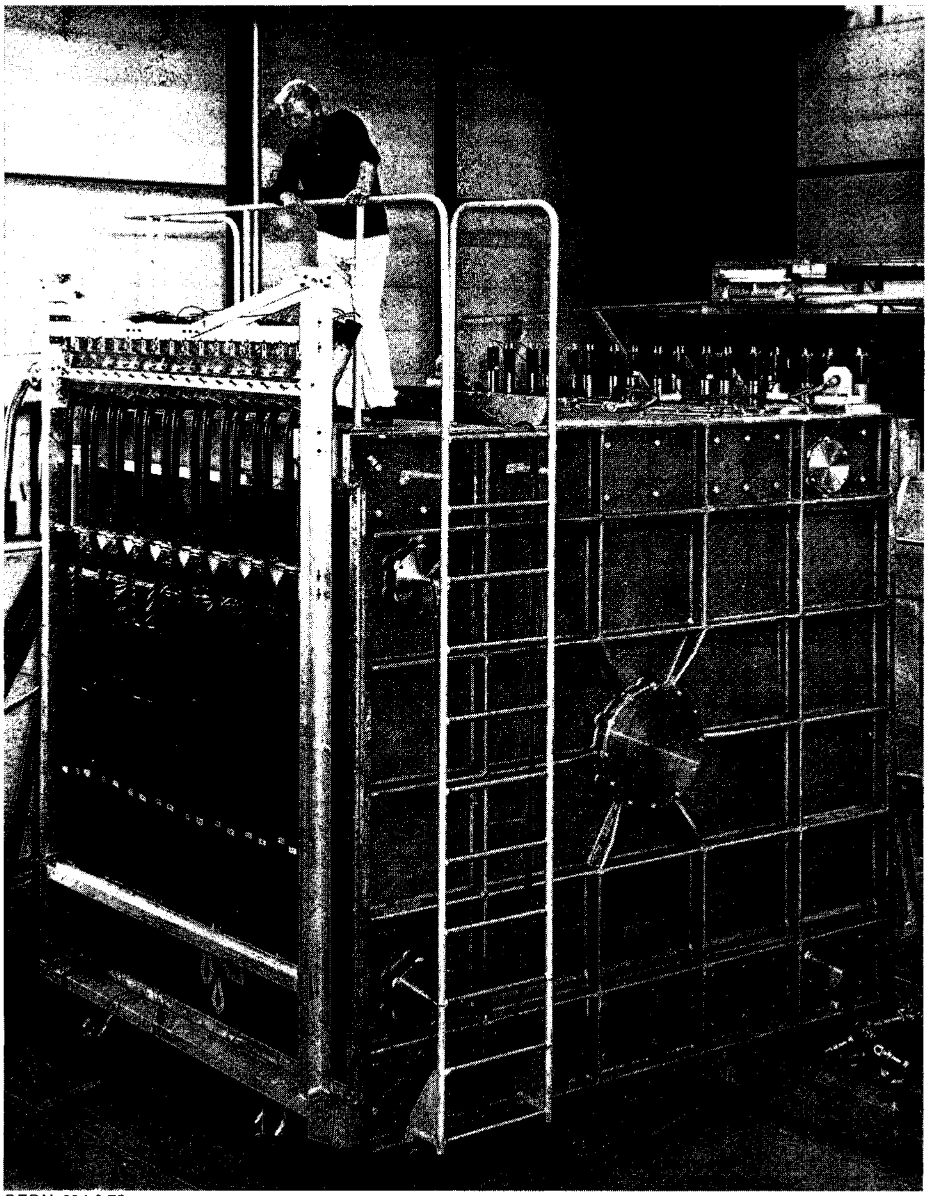
Administration is carried out from the headquarters in Geneva. Applications for membership and any other information concerning the Society may be obtained from European Physical Society, P.O. Box 39, CH-1213 Petit-Lancy 2, Switzerland.

CERN News

Giant Cherenkov

In keeping with the scale of the Omega spectrometer, a giant Cherenkov counter has been installed immediately downstream of the spectrometer magnet. It is designed to catch particles from interactions in Omega over as large a solid angle as possible and since the aperture of the magnet is very large both horizontally and vertically the size of the Cherenkov must follow suit.

The total volume of the counter is 25 m³. It is presently filled with isobutane at atmospheric pressure which has the refractive index for the Cherenkov to serve as a threshold counter for pions with momenta higher than 2.8 GeV/c and kaons with momenta higher than 10 GeV/c. About 7 m² of mirrors direct the light to two arrays of eight photomultipliers. The



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The giant Cherenkov counter (25 m³ volume) from Saclay which is now installed at the Omega spectrometer. Its size is dictated by the need to cover as much solid angle as possible from the large horizontal and vertical aperture of the spectrometer magnet. At each end there is a 'picket fence' of scintillation counters provided by the Glasgow group supported by the Daresbury Laboratory.

Group photograph from the 1972 CERN Computing and Data Processing School held at Pertisau in Austria from 10-23 September.

efficiency of the counter is very close to 100 %.

At the moment it effectively covers half the Omega horizontal aperture but can easily be moved to different angles. However it is hoped to install a twin in the future so as to completely cover the available solid angle. These counters could also serve as the first stage units in the proposal to add a sequence of huge Cherenkov counters to Omega so as to adapt it for physics with high energy beams from the SPS.

The counter has been financed and built by Saclay and brought to CERN to be added to the facilities at the Omega spectrometer for general use. Saclay is participating in the first two experiments using the counter. One is a study of baryon exchange (in collaboration with CERN, ETH, Freiburg and Karlsruhe) where a lambda is produced in the forward direction. It is the fast proton from the lambda decay which is identified by the Cherenkov.

The second experiment is a study of baryon-antibaryon production (in collaboration with Glasgow). Here the Cherenkov will see the fast antiproton which is either directly produced in the initial interactions or comes from the decays of antilambda or antisigma minus particles.

The two experiments are now testing and already have a neat mass spectrum clearly bringing out the lambda mass at the expected value. The mass width is $\pm$ 2 MeV without optimization.

1973 CERN-JINR School of Physics

The 1973 CERN School of Physics will be held at Ebeltoft near Aarhus in Denmark from 17-30 June. Like two former Schools in the series it is being organized in collaboration with the Joint Institute for Nuclear Research, Dubna USSR. The basic aim is to put across various aspects of high energy physics, particularly theoretical physics, to young experimentalists from the CERN and JINR Member States.

The programme will include lectures on Introductory material — Reggeism, duality, etc... (given by K. Kajantie, Helsinki), Deep inelastic processes at high energies (V. Matveev, Dubna), Multi-body phenomena in strong interactions (Z. Koba, Copenhagen and M. Jacob, CERN) and Many-body hadronic reactions (R. Muradyan, Dubna). There will also be lectures on special topics to be decided later and reviews of the experimental programmes of some of the major Laboratories.

Further information may be obtained from Miss D.A. Caton, Scientific Conference Secretariat, CERN, 1211 Geneva 23, Switzerland or V.S. Shvanev, Joint Institute for Nuclear Research, Head Post Office, P.O. Box 79, Moscow, USSR.

SPS contracts

After the stages of design and prototype testing, the moment of truth has arrived for many of the components of the SPS. The Finance Committee has adjudicated major contracts for the manufacture of machine components at its last two meetings. Four of these contracts have now been signed.

Three of them concern the production of the 6 m long bending magnets for the accelerator ring. As discussed many times before (see the report of the Tirrenia meeting for example), half a ring's worth is being ordered initially. The contract for the production of the magnet cores has been awarded to Morfax Ltd (UK) for a sum of about 18.35 million Swiss francs. A major part of the contract involves the purchase of an approved quality of steel and Morfax is subcontracting the supply of the steel to Cockerill (Belgium).

The magnets are of two types (known as B1 and B2) of different aperture and coil configuration. Manufacture of the coils for 186 magnets of the B2 type has been awarded to Alsthom S.A. (France) for a sum of about 8.54 MSF. Manufacture of the coils for 263 magnets of the B1 type has been awarded to Lintott Engineering Ltd (UK) for a sum of about 11.5 MSF. With all the firms involved in the magnet contracts, the possibility of continuing the production of the magnets so as to fill the ring has obviously been discussed and options for the additional magnets have been negotiated.

The other major contract to be signed recently was for the radiofrequency power amplifier plant. This plant will feed the r.f. accelerating cavities in the ring with a total power of up to 1.5 kW. Three complete amplifiers using tetrodes are to be acquired. The contract for their manufacture has been awarded to Siemens A.G. (Federal Republic of Germany) for a sum of about 7.45 MSF.

Computing School

After the success of the Varenna School in 1970 (see vol. 10, page 279), a second 'CERN Computing and Data Processing School' was organized from 10-23 September at Pertisau in the Austrian Tyrol. Pertisau is a tourist centre on the shore of the Achensee, an alpine lake at about 1000 m altitude surrounded by mountains.

The lecturers and the 67 students formed a very cosmopolitan group. The lecturers came from centres in Western Europe and from CERN. The

students were physicists and computer scientists from CERN Member States, the German Democratic Republic, Israel, Poland, USSR and Yugoslavia.

The topics of the lectures were divided between :

- pure computer science (compilation techniques and data base management systems)
- small computers and their application in physics (including case histories)
- applied mathematical techniques (function minimization and function parametrization).

A significant fact to emerge from the school was that the data handling and control requirements of high energy physics are becoming so large and demanding as to require new techniques of greatly increased complexity in the application of computers. The growing volume of complex raw data requires the application of data base management techniques, already developed for commercial purposes, with appropriate modifications to take account of the intrinsically sequential nature of the major part of the analysis of particle events.

In most cases, all the events go through the same chain of computation, including lengthy calculation of functions — for example, the momentum of particles deflected in a magnetic field. When the number of events to be analysed is in the 10^6 region, as in an average counter experiment, suitable preprocessing to parametrize those functions is resulting in a great saving of computer time.

Nowadays, experiments use sophisticated equipment fed by very expensive accelerators. It is essential to monitor the performance of the apparatus, as well as that of the accelerator, and small computers are widely used for this application. The problem is to simplify the interaction experiment-computer-physicist and standardization is playing an essential role, mainly with the use of CAMAC and CAMAC-oriented software which allows the physicist to talk to his equipment in a very simple way. A particularly good example of how these problems are handled is provided by the Omega data collection system (see March issue page 83) which was the topic of some lectures at the School.

Another important topic is that of data communication between scientists working in different Laboratories and using different data handling facilities (both hardware and software). In the near future, specialized scientific data banks will be set up. A European network of fast data links is technically feasible but difficulties arise in setting the standards to be used to exchange the information among various machines which are monitored by different operating system and which speak different dialects. The importance of establishing standards for information exchange was also emphasized during one of the informal discussions organized by the students themselves. Certainly one of the main successes of the School was to bring together young people working in scientific data processing so that they could exchange opinions and discuss problems, stimulated by experienced lecturers.

The general concensus at the end of the School was that 'a good, and professionally profitable, time was had by all'.

P. P.

Public Information Office

From its early days CERN has had a 'public information office', referred to internally as the PIO, which has served as the channel of communication to the outside world and for many internal communication tasks.

The major route to the public at large is the press. It is difficult to believe that high energy physics could enjoy the exceptional support it receives from governments without the encouragement of the press. And yet high energy physics is not the easiest subject to put across or to defend. Despite this, CERN has generally been

Reception desk at the Public Information Office. The work of PIO involves more than pointing people in the right direction when they arrive at CERN. Contact with 'the media', publications, photographic work and the visits service are described in the accompanying article.

treated very well by the press. The role of the PIO is to make information available to journalists as fully and as 'straight' as possible. This attitude seems to be appreciated because journalists continue to approach CERN through the information office rather than, as in many other organizations, preferring the back door.

In relations with the press, personal contacts are of great importance, more so than the more formal issuing of press releases, etc., and PIO staff are well known to top class journalists from almost all the Member States. There is a 'specialized press list' of some 160 names of journalists with a particular interest in CERN and the 'general press list' runs to over 1000 names. Attempting to cater for so many journalists covering a wide range of interests is a measure of the problem of press relations in an organization with 12 Member States.

The other media are not neglected. Many television teams and radio interviewers invade CERN each year and it is the job of the PIO to either cover their needs from its own resources or to guide them to the most appropriate contacts etc. within CERN. The PIO is also involved in lectures and discussion groups taking place outside CERN though these are necessarily almost all in the region of the Laboratory.

On the film front, activity has blossomed recently. The first documentary on CERN, 'Matter in Question', appeared in 1961 and is still in limited use though obviously its content is now largely outdated. A new film, 'CERN 67', was made in 1967 and projected much of the atmosphere of CERN without attempting to be a classical documentary. A little earlier a film made in collaboration with CDC became available and in recent years several collaborative film with national television networks have been made. The latest is the film on high energy

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physics (rather than on CERN itself) made in collaboration with the BBC and reported in the last issue of CERN COURIER, page 228. A film will also be made of the development of Laboratory II. In producing these films the PIO does much more than ensure that there is somewhere to plug in the camera — there is full participation in suggesting and developing the themes of the films.

The PIO produces a range of publications — from the pop to the not-so-pop — giving information on CERN and its work. A mandatory one is the Annual Report which is produced in English and in French and gives a rather solid account of the activities of CERN in the previous year. It requires a considerable effort from the Divisions, the translation service and the PIO itself.

Regular publications are the monthly CERN COURIER, to which we shall return at the end, and the Weekly Bulletin. The Bulletin averages some 12 pages and is a sort of internal notice-board for CERN staff. It announces seminars, meetings, etc. and has a section reserved for the activities of the Staff Association and its Clubs.

Standard documentation which is given particularly to visitors, includes a light-hearted booklet 'A look at CERN'. It consists of a dozen separate sections on the Laboratories, the physics, detectors, accelerators, etc. and is available in English, French and German. A more formal reference booklet is 'CERN and its Laboratories' which is also available in three languages. Moving to the more specialized — a series of Technical Booklets has been started and numbers exist on the proton synchrotron, the synchro-cyclotron, the storage rings, Gargamelle and computers. But such booklets require constant up-dating and there never seems to be enough of this type of documentation to meet the needs.

Most of these brochures and booklets are prepared by the PIO with help from the Divisions growing as the degree of specialization grows. Art work is also handled within the PIO and modern and uniform styles of presentation are thus assured. A documentation section, besides looking after the stocks of brochures above, runs a small library of reference material on CERN and a collection of general photographs and slides.

The PIO photo section takes photographs throughout CERN mainly on demand from the scientists. About 8000 photos are taken per year and around 25 000 enlargements are produced. These are available for experimenters as a visual record of the development of their projects.

Some ciné-film is also taken by the photo section — for example, a short film on the assembly of the large European bubble chamber BEBC. Important stages of other large projects have been recorded on 16 mm film for archival records.

Another major activity of the PIO is the visits service. Statistics show a gradual rise in the number of visitors over recent years and the current annual figure is about 11 000 (not including Open Days, etc.).

Over two thirds of the visitors come on Saturdays, when visits are regularly organized. They are held mostly in French, German or English but occasionally in Italian, Spanish, Greek or Scandinavian languages. About fifty CERN staff, covering many nationalities, are available as guides and lecturers. The usual Saturday programme consists of an introductory talk illustrated by slides and followed by a short film. Then comes a tour (on foot) around that part of the Laboratory I site in Switzerland which takes about 1 1/2 to 2 hours. The tour concentrates on the proton synchrotron where the visitor sees the control room, experimental halls and the Gargamelle bubble chamber (if it is accessible). To conclude there is a look at the scanning and measuring tables where bubble chamber pictures of particle tracks always prove a source of fascination. As he leaves the visitor receives general documentation about CERN.

The bulk of Saturday visitors consists of school parties, common-interest groups (engineers, farmers, nurses, etc.), youth clubs, firms' outings, etc. to which is added a steady trickle of individual visitors having a wide range of interests and educational levels.

It has been necessary to restrict the number of midweek visits, despite a considerable demand, because they tend to interfere with operations on the site and guides have to take time off their normal work. Midweek visitors are mainly university groups, industrialists from firms working for CERN, and the occasional scientists in transit. VIP's, such as Ministers, obviously receive special attention.

To reduce pressure on CERN staff in midweek it is intended to develop, as far as proves possible, the unaccompanied visit of the site by individuals or small groups. Careful sign-posting, exhibitions and audio-visual aids will be used. The tremendous growth in CERN both geographically and in terms of major equipment (with the advent of the ISR and now the SPS) introduces difficult problems in carrying out the visits service efficiently. How best to respond to these problems is now being discussed.

And now we return to CERN COURIER. There is no need to describe the journal or to indicate its aims to our regular readers. It tries to report, as topically as possible, the interesting advances in research and the major events at CERN and other high energy physics Laboratories throughout the world. In this it is helped by some twenty correspondents distributed around the other Laboratories. In general, an attempt is made to write the COURIER articles in a style which is accessible to a broad spectrum of people.

A few facts and figures may be of interest : The present print order for the journal is about 5700 in English and 4800 in French each month and it has been increasing at about 10 % per year.

The number of pages produced has doubled in recent years the increase being partly accounted for by an increase in the number of advertisements. For several years advertising revenue has covered production costs.

About 1200 English and 1600 French copies are absorbed within CERN itself. The external readership is divided approximately as follows: Western Europe – 2200 English and 2250 French ; Eastern Europe – 280 English and 50 French; Canada and USA – 880 copies ; South America – 45 copies ; Africa – 40 copies ; Asia – 150 copies. In addition over 1000 journalists receive copies (about equally divided between each language version).

The latest external readership survey indicated that the readership (not including journalists) is divided about 30 % in universities, 24 % research centres, 14 % industry. About 40 % are engaged in research, 16 % design and manufacture, 17 % education. The survey also revealed that each copy is read by an average of 3.5 readers and more than a third of them claimed to be cover-to-cover readers. There are still people of stamina left in the world.

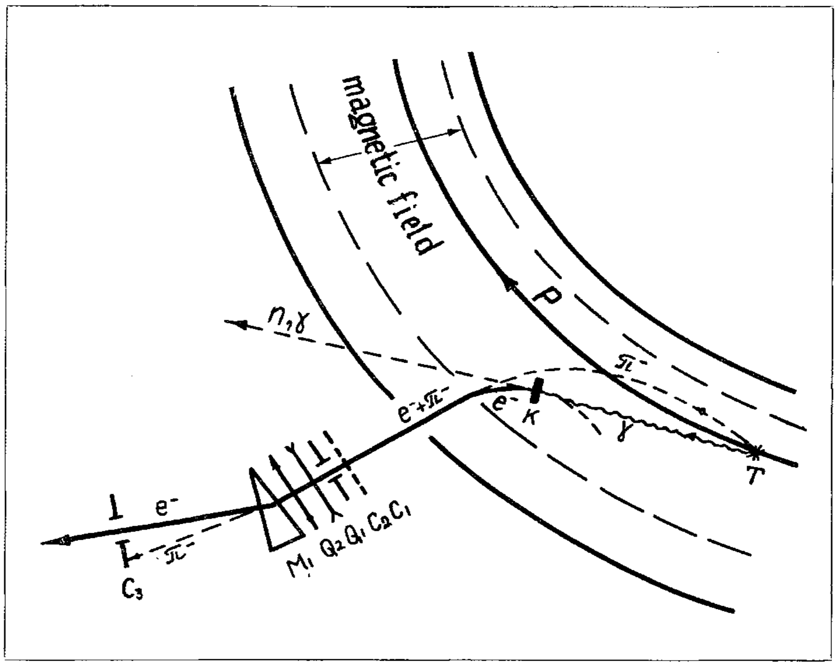
Around the Laboratories

SERPUKHOV
Electron beam

An electron beam in the energy range from 26 to 46 GeV has been developed at the Serpukhov proton synchrotron by a Serpukhov, Moscow, Yerevan collaboration. The beam intensities are between 10^4 and 10^6 electrons per pulse with an energy spread of $\pm 3\%$ from 10^{12} protons accelerated to 70 GeV.

The beam makes it possible to study electromagnetic interactions at energies not available from electron accelerators, though the intensities of the Serpukhov electron beam are considerably lower than those at the electron accelerators. However, this disadvantage is partially compensated by the long time duration of the beam (up to 2 s per pulse) with which the efficiency of the beam in experiments becomes some orders of magnitude higher than with beams from electron linear accelerators.

The main source of electrons (or positrons) at proton accelerators is the conversion of photons into electron-positron pairs. Photons are emitted in the decay of neutral pions that are produced by protons in a target. A method to get a pure electron (positron) beam was proposed at the Serpukhov accelerator making use of internal targets. The scheme is sketched in the Figure. It is based on locating the target (T) and converter (K) at some distance in the magnetic field of the accelerator. Then not only electrons from the converter but also charged hadrons from the target enter the transport system (units C_1 to C_3 on the Figure). However, generally the electrons and hadrons have unequal momenta since they have followed different paths in the magnetic field. The hadrons can be swept away from the electron beam by the analyzing magnet of the transport system when it is tuned for electrons from the converter.



Schematic diagram of the method of producing high energy electron beams at the Serpukhov accelerator. T and K are movable target and converter respectively. Q_1 and Q_2 quadrupole focusing magnets and M is a bending magnet. Electron beams in the energy range 26 to 46 GeV with 10^4 to 10^6 electrons per pulse have been produced using this method.

Using this method, only an additional target and converter is required to obtain electron beams in any transport system that is designed for hadron beams from internal targets. If it is possible to radially displace the additional target and converter the electron energy in the transport system can be changed over a wide range, keeping the proton energy onto the target constant. Note that electron beams can be drawn off into the experimental area outside the accelerator magnet ring while positron beams can be drawn off into the experimental area inside the ring because of their different curvatures in the magnetic field.

This simple and economic method was studied experimentally at Serpukhov in the summer of 1970 and results were presented at the International Conference on High Energy Physics Apparatus held at Dubna from 8-12 September of that year. At the end of 1971, an electron beam with the parameters quoted at the beginning of this article was set up in a transport system at the Serpukhov accelerator.

The indicated intensities were obtained using a beryllium target of 3 mm diameter and 40 mm long and a lead converter whose optimum thickness was 0.5 radiation lengths. Hadron and muon impurity in the beam was not greater than 1 % at electron energies less than 40 GeV reaching 3.6 % at 45.5 GeV.

At the present time, the Serpukhov, Moscow, Yerevan collaboration are using the beam to measure cross-sections for photon absorption by protons and more complex nuclei with hadron production in the final state within the energy range 12 to 40 GeV. The method of tagged photons is being used.

The pulsed superconducting magnet known as AC4 which performed as predicted during its first test. The magnet gave peak fields of 4.5 T in a 9 cm diameter aperture with a 2 s rise time.

(Photo Rutherford)

RUTHERFORD
Successful tests of AC4 magnet

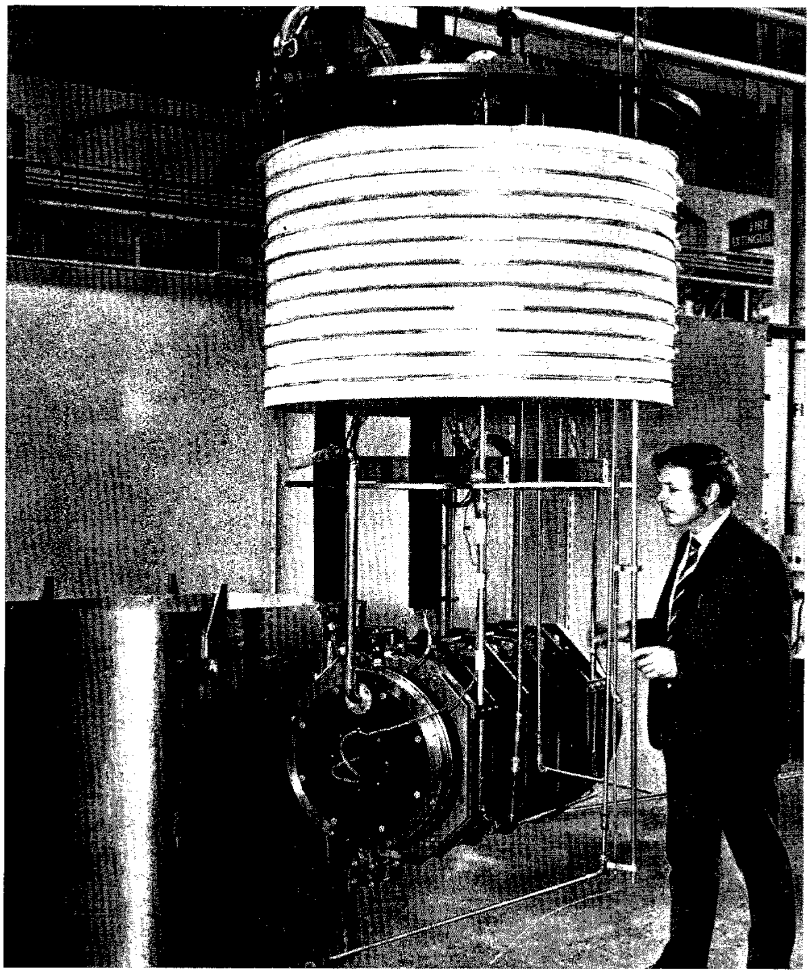
The latest in the series of pulsed superconducting magnets being built at the Rutherford Laboratory performed well up to expectation during its first tests in September. Known as AC4, the magnet is a 'pre-prototype' of the sort of magnet which will be needed for the construction of a superconducting proton synchrotron. It was designed to push the engineering mastery of these magnets a stage further. Rutherford, together with Karlsruhe and Saclay in the GESSS collaboration, is mounting a systematic attack on the problems of pulsed superconducting magnets with the initial aim of being able, by the end of 1973, to spell out with confidence their feasibility for the SPS. The AC4 project was under the direction of J.M. Coupland with P.T. Clee as project engineer.

The main parameters of AC4 are — length 70 cm, aperture 9 cm, design peak field 4.5 T with 2 s rise time. The magnet is designed to operate horizontally (previous versions were in vertical cryostats) completely immersed in helium, cooling of the superconductor being via vertical channels. A shaped iron shield is positioned close to the coil where it contributes about one third of the field strength in the magnet aperture.

Performance of the magnet during its first tests was described at the Conference on Magnet Technology held at Brookhaven from 19-22 September. AC4 pulsed to a peak field of 4.5 T with a 2 s rise time as designed and to peak fields a few per cent less with a 1 s rise time. The a.c. losses were as calculated for the type of conductor used. The conductor, supplied by IMI, consists of a cable of 25 strands each 0.85 mm in diameter and each containing 2000 filaments of the superconductor niobium-titanium, 12 μm in diameter, embedded in a copper/cupro-nickel matrix. The 4.5 T field level corresponded to 5300 A through the cable.

One concern of the AC4 tests was to gather accurate field measurements so as to see whether the field shape was right (and whether it changed during the excitation cycle) and to see whether the effect of the iron shield lined up with computer calculations. The field shape was as predicted and varied by only a few parts in 10^4 during the cycle. The effect of the iron was as calculated. The field integral through the magnet was also good which indicates that the specially designed turned-up coil ends do what they are supposed to do. Remanent field was a few gauss.

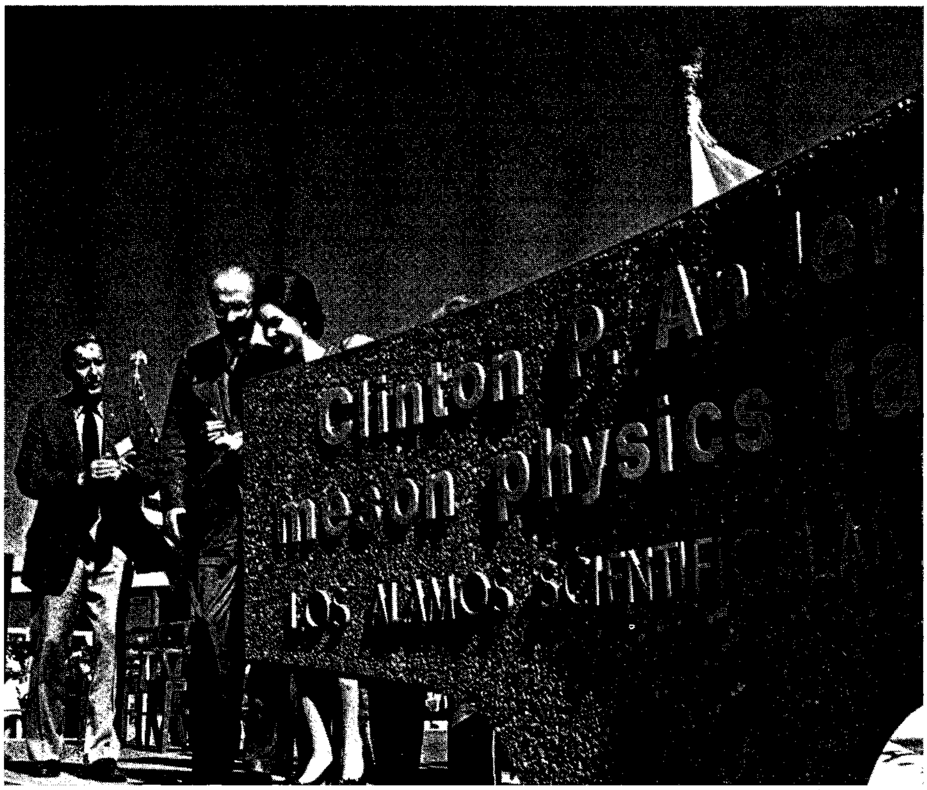
There was however a constant field asymmetry which seems to come from



On 29 September the Los Alamos Meson Physics Facility, LAMPF, was formally dedicated as the 'Clinton P. Anderson Meson Physics Facility'. Senator Anderson has represented New Mexico in the US Senate since 1948 and played a vital role in securing the meson physics facility for Los Alamos. The photograph, taken during the unveiling of the sign at the dedication ceremony is of H. Agnew (Director of the Laboratory), C.P. Anderson and Mrs. J. Nixon-Eisenhower.

(Photo Los Alamos)

an error in fabrication or assembly. Also some 'training' occurred during the first tests, fields climbing from 4.1 T to 4.5 T. This will be watched during subsequent cooldowns to see whether further training occurs or whether re-training is necessary. These aspects will be studied carefully so as to ensure that they do not recur in the next magnet of the series — AC5 which will be 1.5 m long and which is scheduled to be ready for tests in the middle of 1973.



ARGONNE
ZGS back in action

On 1 May the Zero Gradient Synchrotron (ZGS) at Argonne was shut down to replace the original epoxy-bonded stainless steel vacuum chamber with a new all-metal titanium chamber. This involved taking the accelerator ring apart almost completely. Four and a half months later, on 18 September, beam was injected into the rebuilt ring for the first time and within 24 hours acceleration to full energy (12 GeV) was achieved. A week later, the intensity of the circulating beam was taken to 2.3×10^{12} protons per pulse and it was possible to start the experimental program on 2 October as scheduled.

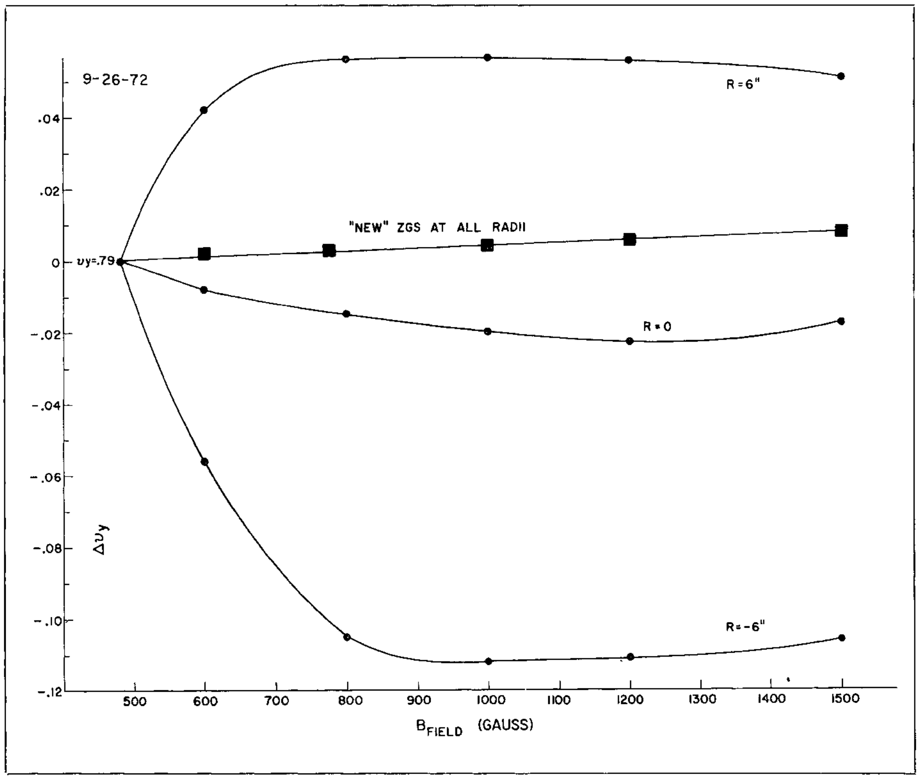
The original vacuum chamber had been in use since 1963 and evidence of radiation damage became increasingly apparent during the past two years. In addition, precise tune control which can be obtained with pole face windings (which were not installed in the old chamber) was needed to take maximum advantage of slow spill resonant extraction at the ZGS. The new titanium chamber has 42 pole face windings incorporated into it, 28 being used for passive correction of the eddy current effects resulting from the all-metal construction and 14 being available for the rapid tune shifts required for resonant extraction.

The titanium chamber consists of eight sections which were fabricated by the North American-Rockwell Corporation. At the time of their assembly they were the largest diffusion-bonded structures in existence. They were received at Argonne in 1969 and, after being thoroughly tested, were stored to await an appropriate time for installation. Pressure for operation of the ZGS for the experimental programme has beeen intense in the past two years and to find a suitable five-month shutdown period for the installation of the new chamber was very difficult. However, in the spring of 1972 a combination of financial pressure, the need to fully implement resonant extraction, and the need to obtain a flat magnetic field profile for the acceleration of polarized protons (planned for 1973) gave the go-ahead for the installation.

The accelerator came back into operation in less than two weeks, reflecting the care that went into the design and development of the new instrumentation and the thoroughness of the retuning strategy devised by the ZGS operating team. These activities were given considerable attention in the months preceeding the shutdown. A full-dress rehearsal was carried out during a machine research period in April when the ZGS was briefly retuned for 6 GeV following the proposed retuning plan. This energy was chosen because previous experience suggested that many of the machine behaved very differently at this energy compared with their familiar behaviour at the normal operating energy of 12 GeV.

Retuning during the week of September 18-24 went almost exactly to plan. After acceleration to full energy the currents in the pole face windings

Comparison of the vertical tune characteristics of the ZGS before and after replacement of the epoxy-bonded vacuum chamber with a new all-metal chamber with pole face windings. For the old ZGS the tunes varied substantially as a function of radius; the curves in the figure are for the equilibrium orbit (R=0) and for the orbits with R equal to plus and minus six inches. The pole face windings have made it possible to eliminate the drastic tune shifts that previously existed in the early phases of acceleration.



were adjusted to 'flatten' the tunes so that they closely resembled what would be expected with an ideal (theoretical) zero gradient accelerator. This was greatly aided by the high degree of sophistication attained with the real-time software for the control computer and its on-line display and with the automatic tune measuring instrumentation.

In the weeks ahead, top priority will be given to bringing the many experiments (about ten) on the experimental floor into simultaneous operation as rapidly as possible. During the shutdown extensive modifications to beam-lines and shielding were carried out and some of this work remains to be completed. High on the priority list is the tuning of a new r.f. separated beam to the 12 foot bubble chamber — initial (engineering) operation of this beam is scheduled for the middle of October.

NOVOSIBIRSK of VEPPs and VAPP

News from the complex storage ring complex at the Institute of Physics, Novosibirsk.

The 700 MeV electron-positron storage ring VEPP 2, which has been the scene of most of the colliding beam physics coming from Novosibirsk, is close to the end of an improvement programme which has added a new ring VEPP 2'. The aim is to achieve higher luminosities using a low beta section in VEPP 2'. Stored electron and positron beams will be transferred to the new ring from VEPP 2 and this has been accomplished for electrons which circulated in VEPP 2' during the summer.

The 3.5 GeV electron-positron storage ring VEPP 3 has not yet reached its design potential. Electrons were first injected in 1970 at an energy of 300 MeV. During the following year it was planned to use the ring to study the phenomenon of 'electron cooling' (see vol. 6, page 219) which is crucial to the aim of storing proton and antiproton beams. However it proved impossible to have the protons circulating in VEPP 3 and the cooling device 'Epocha' was not installed. This line of research was therefore abandoned in November 1971 and work on VEPP 3 turned back to electron-positron beams.

Electron beams of up to 100 mA in one bunch (limited by longitudinal instability) have been achieved and accelerated to 2.3 GeV. Beams have also been ejected (at 1.35 GeV) for an experiment to measure the magnetic moment of the positive sigma hyperon. The electrons produce gammas which can give hyperons in a second target positioned at the edge of a 1 MG field (produced by explosive compression of magnetic flux). Emulsions record the proton from the sigma decay and the change of sigma polarization direction can be measured giving the magnetic moment. Higher intensity ejected electron beams (in the 10^{12} region) are however needed and up to now intensities have been around 3×10^{10}.

Most of the effort on VEPP 3 this year has concentrated on achieving a good positron beam (Novosibirsk has no electron linac for the production and acceleration of positron beams which makes it more difficult to achieve good quality beams.) The injection line provides positrons of 220 MeV energy which have passed through a 6 T bending and focusing magnet. Obtaining a reliable good quality beam through the magnet has been the main difficulty. The more limited aim of reaching 10 mA stored positrons is now on the programme. This would yield a luminosity of over 10^{30} per cm^2 per s with a low beta section.

The large storage ring, intended for proton-antiproton physics, will initially be used for electron-positron physics, beginning with energies up to 5 GeV. It is now known as VEPP 4. The first magnets are being installed. All the magnet cores are machined and many are assembled ready to be put in the ring. The vacuum chamber is scheduled to be complete next spring. Beams for VEPP 4 will come from VEPP 3 and, obviously, the positron problem will be important here also.

The proton-antiproton storage ring, VAPP, has been postponed for the future. In the meantime a special ring known as NAP-M is being built specifically for the study of electron cooling. Experiments are scheduled to start in Spring 1973. The proton-antiproton scheme would then involve a version of NAP to 'cool' antiprotons of 2 GeV. The storage ring group hopes to demonstrate that they can store at least 10^6 antiprotons since this would be essential for physics experiments, corresponding to a luminosity of 10^{26} per cm^2 per s.

BATAVIA Recent news

Two items of news from the National Accelerator Laboratory : On 9 October multi-pulse injection from the 8 GeV Booster into the main ring of the accelerator was tried successfully. Up to now only one Booster pulse per accelerator cycle has been used. Six pulses were fed in per cycle and the beam intensity at 200 GeV consistently reached 10^{11} during the first tests.

On 10 October cooldown of the magnet for the 15 foot bubble chamber reached superconducting temperatures and the full design field of 3 T was achieved in the large chamber volume. Full commissioning of the chamber has been delayed by problems with the piston which are now receiving attention.

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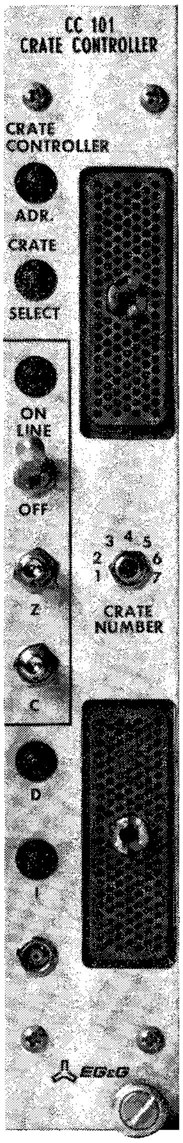

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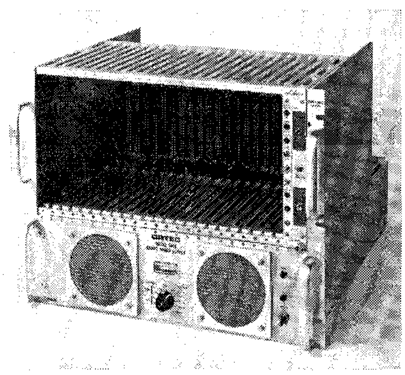

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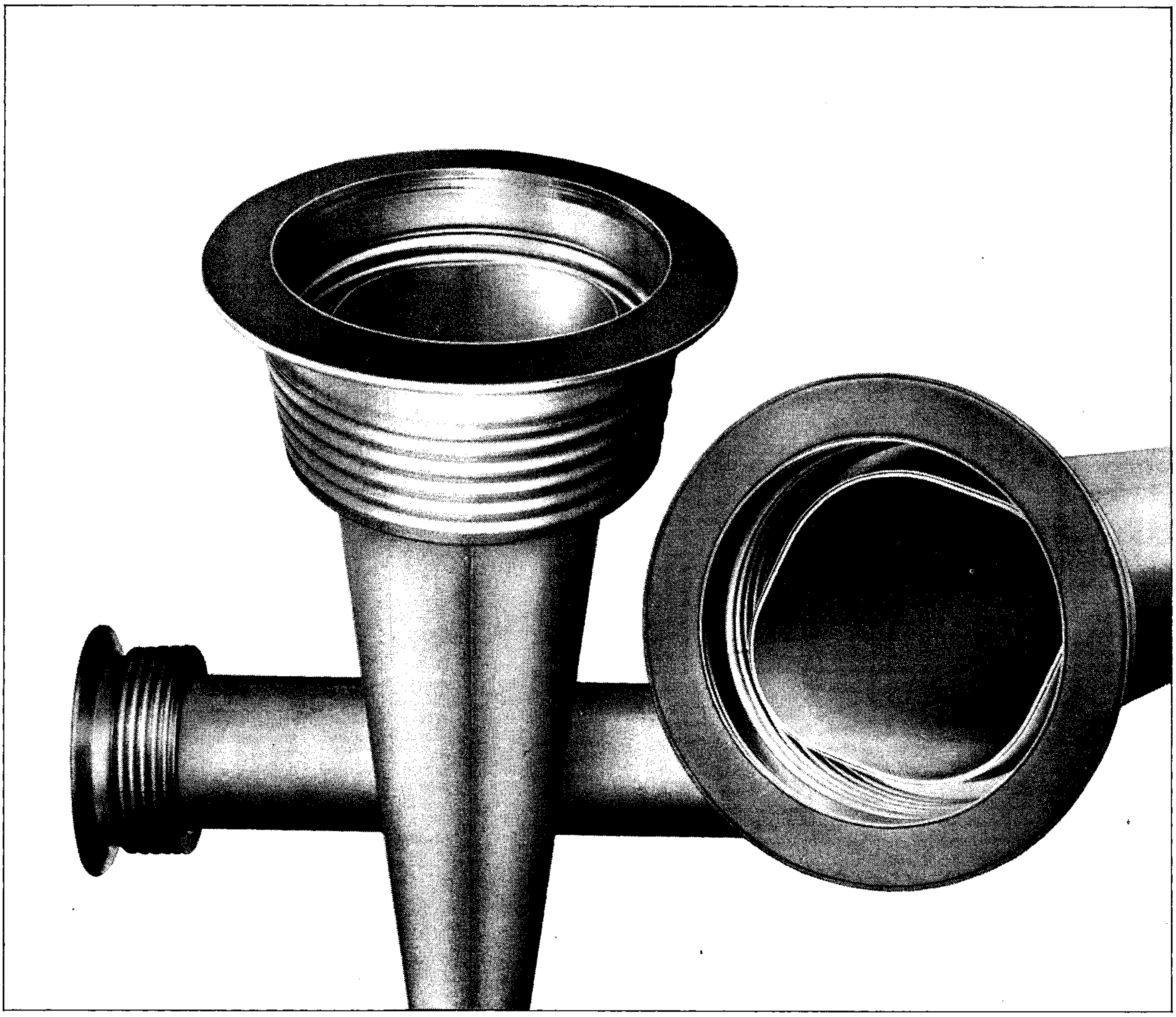

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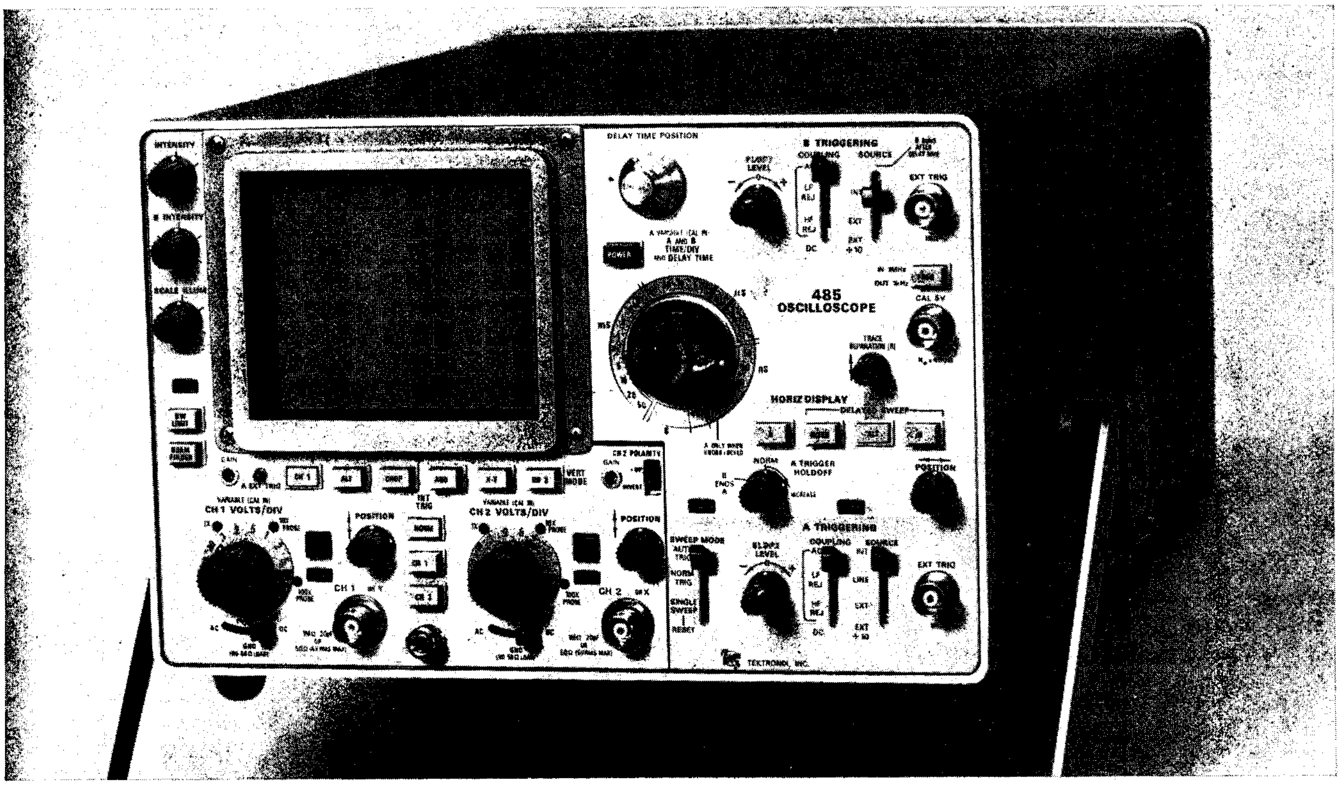

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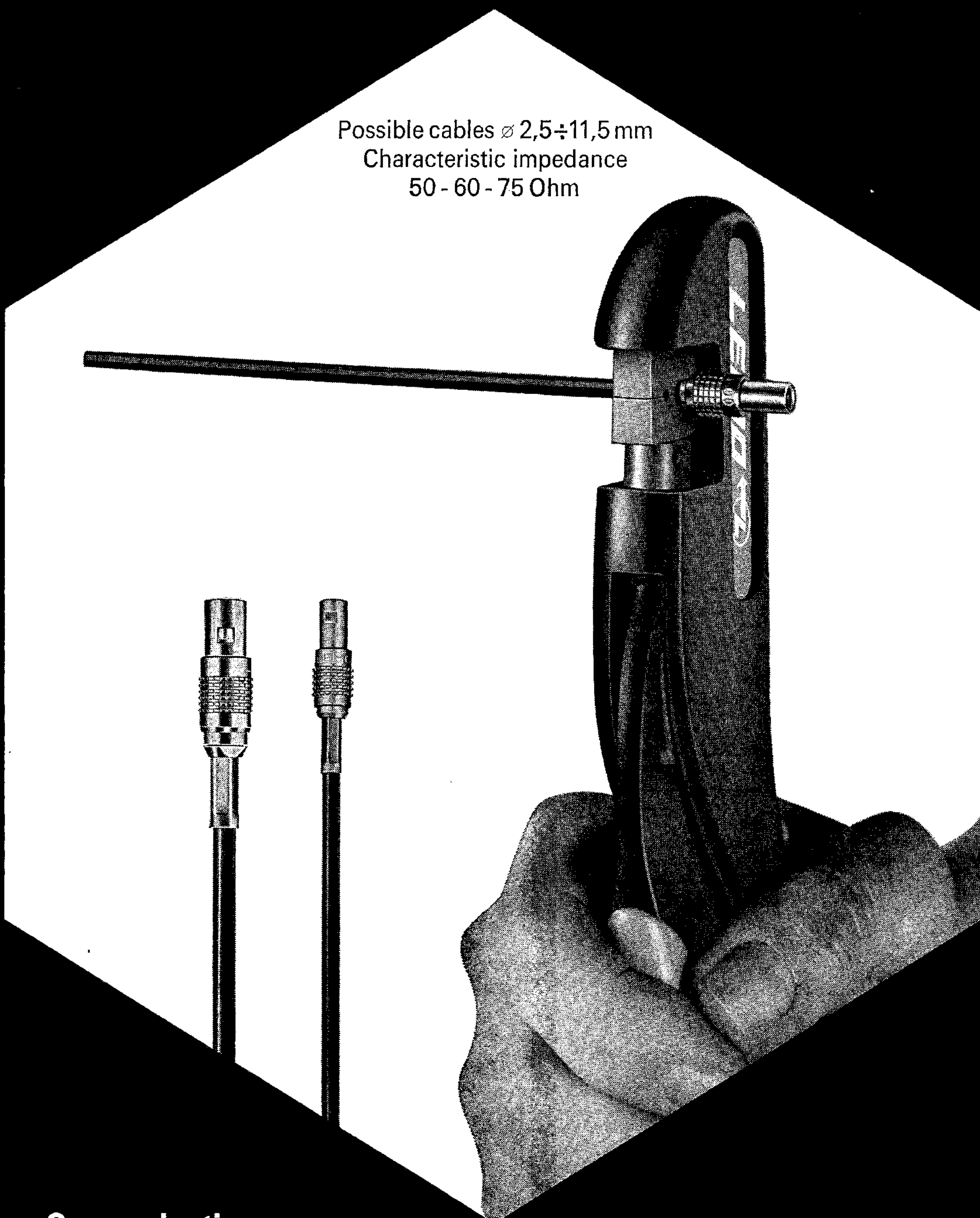

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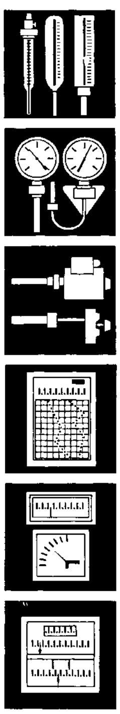

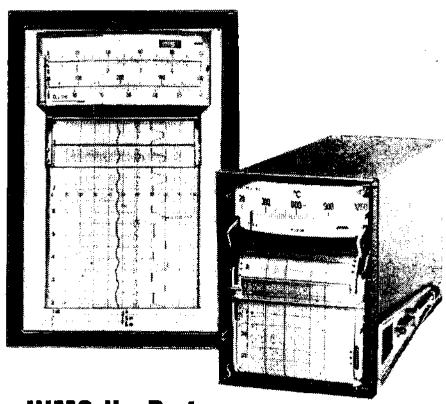

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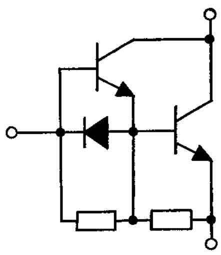

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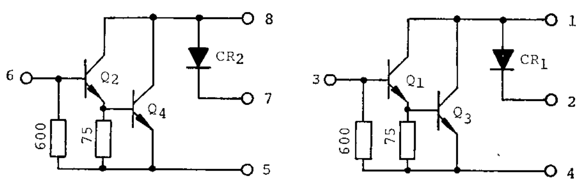

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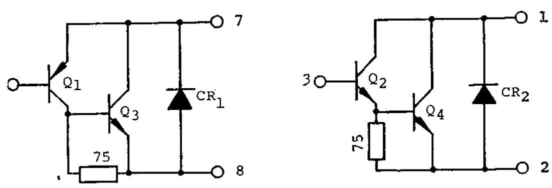

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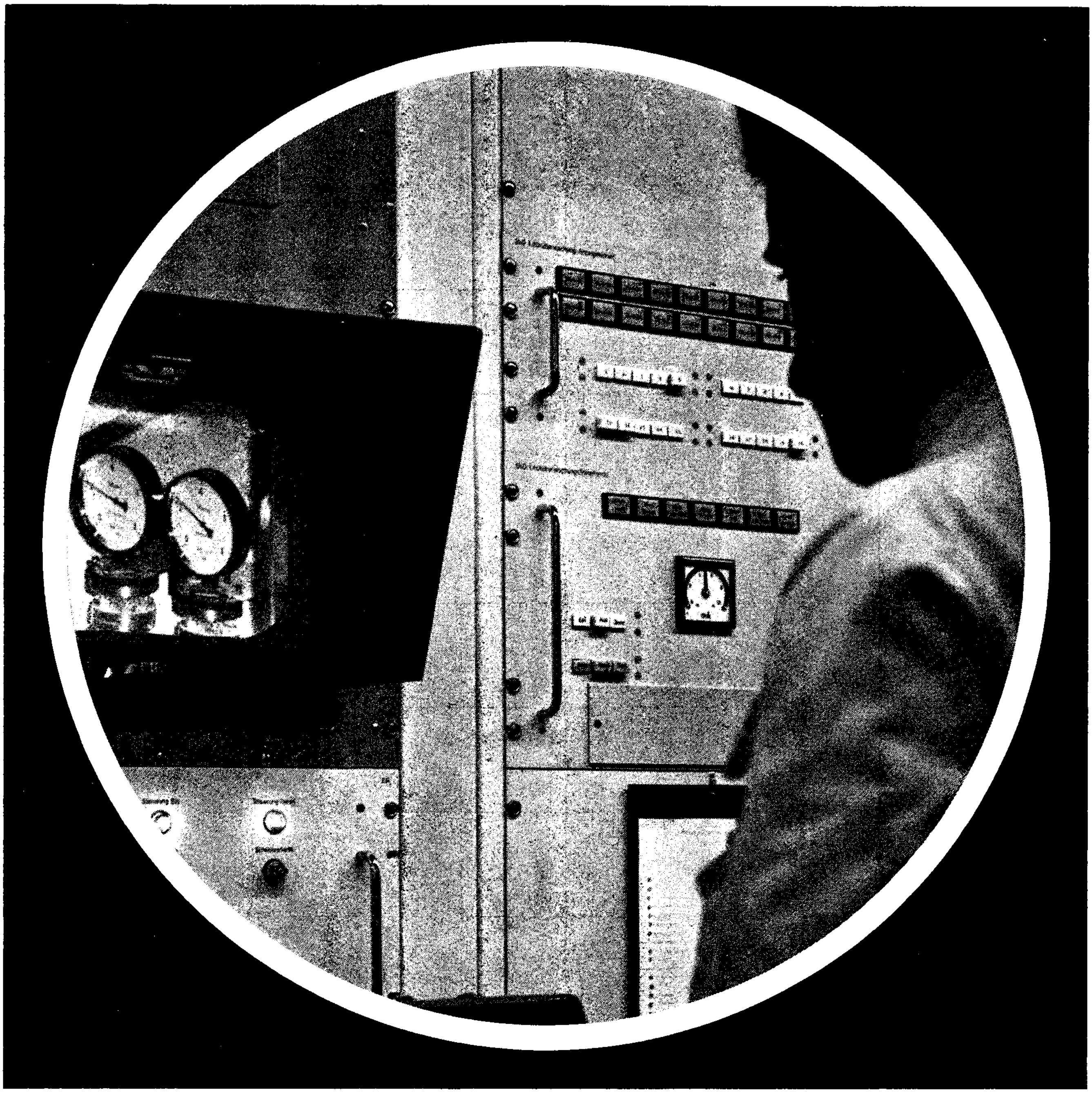

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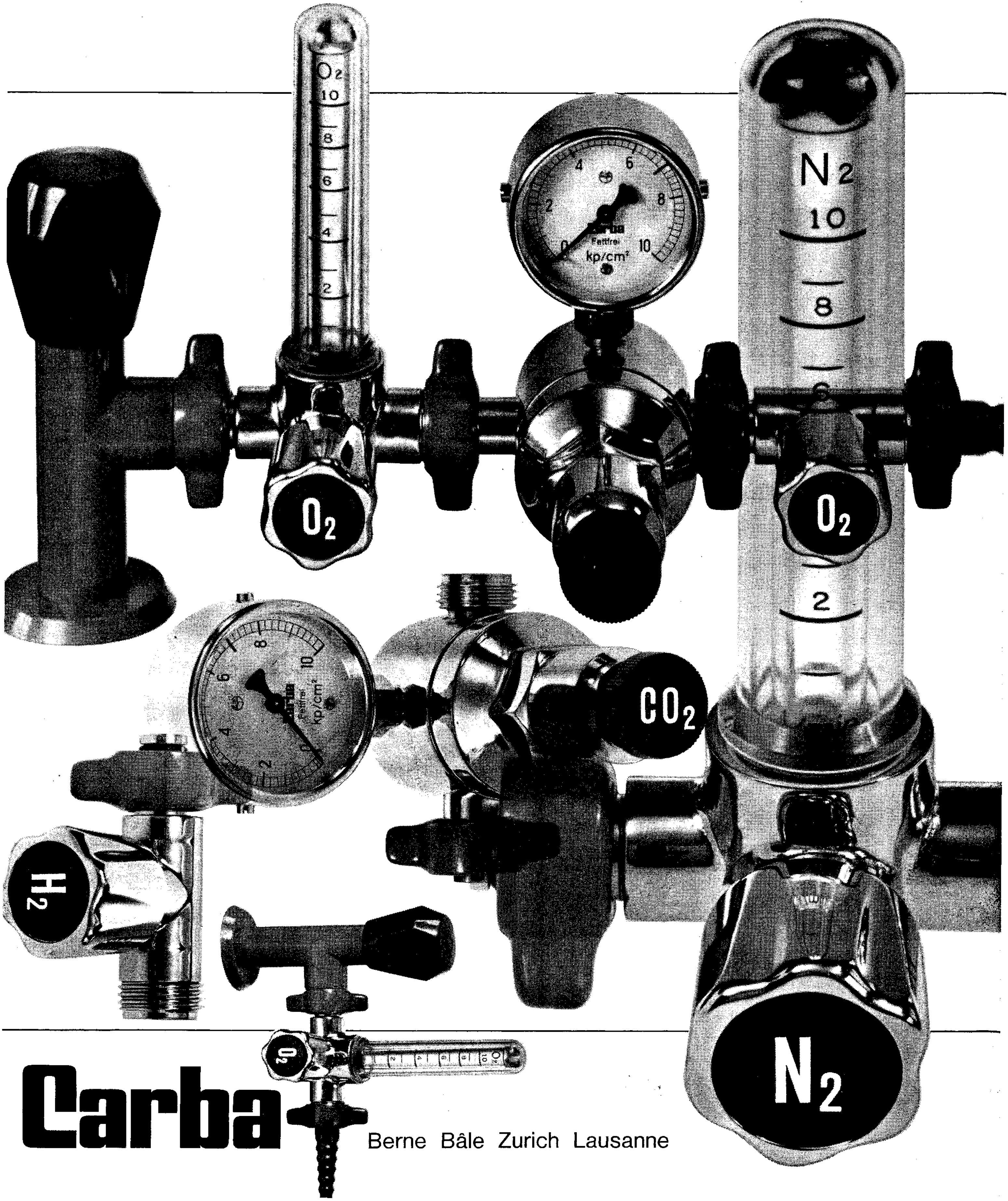

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