# CERN COURIER

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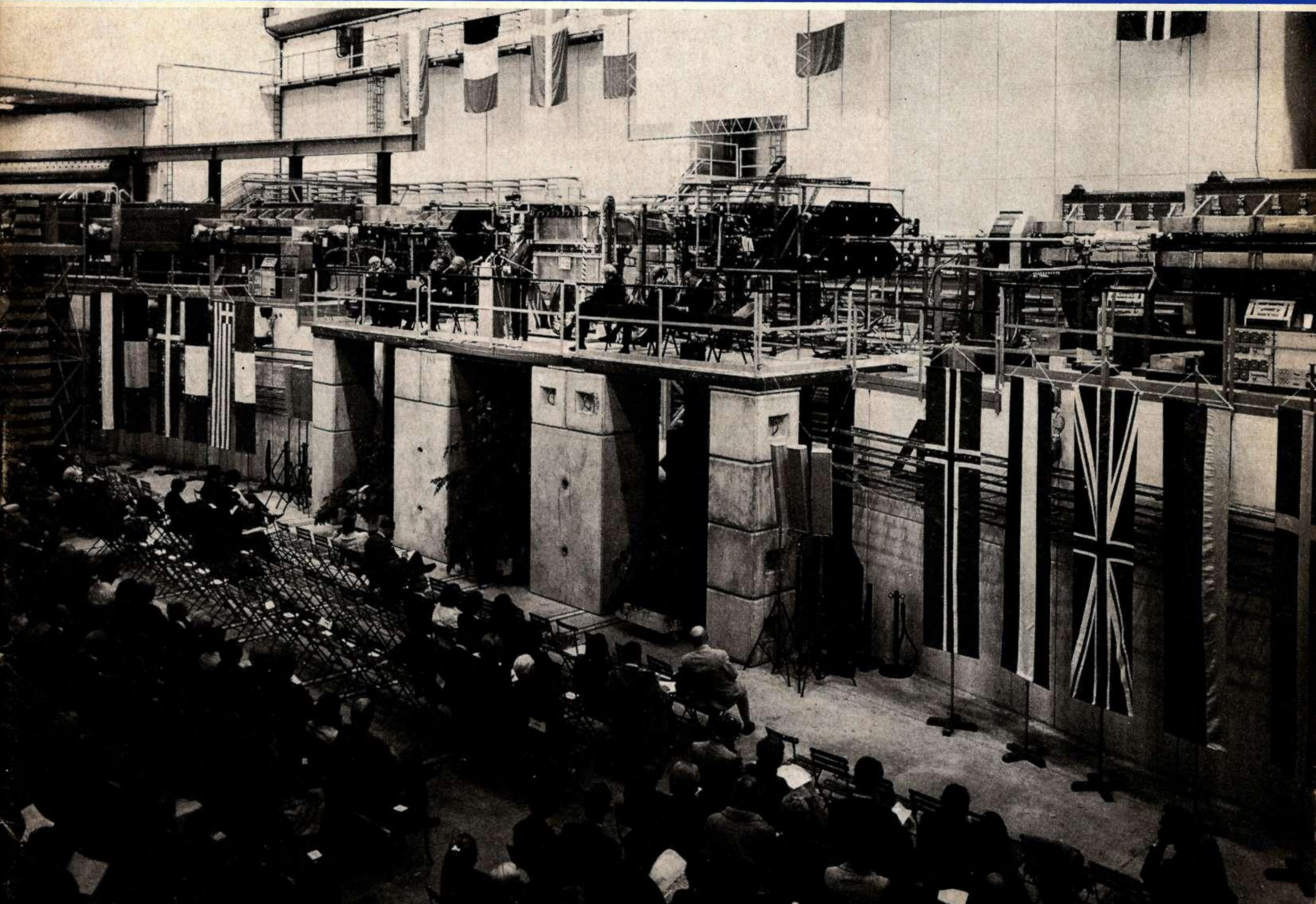
European Organization for Nuclear Research



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 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.

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*Cover photograph : The scene in Hall I4 at the inauguration ceremony of the Intersecting Storage Rings. In the Hall were about a thousand guests — representatives of the CERN Member States, eminent scientists, local dignitaries, visitors from other high energy physics Laboratories, and CERN staff. On the rostrum, established alongside the rings themselves, were Professor Eduardo Amaldi (President of the CERN Council), His Excellency M. Marcel Anthonioz (French Minister for Tourism), Professor Victor Weisskopf (former Director General of CERN), Professor Willibald Jentschke (Director General of CERN Laboratory I), Professor Werner Heisenberg (Nobel Prize Winner), Ambassador René Keller (Head of the Division of International Organizations of the Swiss Département Politique Fédéral), Ambassador François de Rose (French Ambassador to the North Atlantic Council) and Professor Kjell Johnsen (Director of the ISR Construction Department). (CERN 308.10.71)*

# CERN Accelerator Conference

The Eighth International Conference on High Energy Accelerators sponsored by the International Union of Pure and Applied Physics (IUPAP) was held at CERN from 20 to 24 September. It attracted about 200 specialists in this field from many research centres, mainly in Europe, USA and USSR, in addition to people from CERN itself.

In this article, after some general comments, we will cover several of the more interesting topics in some detail. This report is not intended to be a completely balanced reflection of the information presented at the Conference since it will concentrate particularly on covering information which has not found its way into CERN COURIER in recent months.

As usual, we begin by underlining two subjects of predominant interest. Four years ago, at the Cambridge Conference, people were obsessed by space charge effects and boosters. At Yerevan, two years later, interest had swung to electron ring accelerators and superconductivity. At CERN, electron ring accelerators had moved down a peg but superconductivity was still there, though narrowed to superconducting accelerator rings — superconducting r.f. cavities being no longer at the forefront. The other general topic to have moved up is that of storage rings.

Above everything else, storage rings held the stage at the CERN Conference. Particularly in the wake of the success of the ISR, and with electron-positron machines at Frascati, Orsay and Novosibirsk supporting fruitful experimental programmes, there are some major new proposals from Brookhaven and Stanford for storage ring construction, in addition to the projects already underway at Cambridge, DESY, Novosibirsk, Orsay and Stanford. Also, when talking of the options beyond the several hundred GeV stage at the new USA and European proton synchrotrons, the possibility of superconducting storage rings is much more prominent.

Another general comment about the Conference is that this has been the year of the right. If we exaggeratedly divide accelerator builders into right and left, or, if you prefer it, into conservative and radical camps, then at the two previous meetings the radicals had been able to provoke their counterparts by holding up the promise of better and cheaper goods in breaking away from conventional techniques and attitudes. Both in synchrotron construction and superconducting cavity construction this promise has not yet been realized whereas the conservatives have further solid success under their belts. They did not neglect therefore, in the course of the Conference to drop a few grains of salt into radical wounds.

On the organizational side there were several changes from the usual practice in this series of Conferences. It had become obvious that such a weight of material was being presented that quality was being hopelessly submerged by quantity. The Organizing Committee decided to hive off almost entirely those areas which are covered by more specialized Conferences — for example there are specialized Conferences on cyclotrons, on linear accelerators and on magnet technology — which relieved the programme considerably.

The second move was to initiate panel sessions organized well in advance where a few experts on a particular topic were assembled round a table. Sometimes this resulted in stimulating discussions; sometimes it did not — perhaps because of too much prearranged talking and not enough spontaneity. However there is no doubt that this scheme was much better than listening to dozens of ten minute papers and future Conferences will almost certainly develop these ideas further rather than revert to former practice.

## *The big machines*

Under this heading we can group Serpukhov, Batavia and CERN but we will restrict ourselves here mainly to the latest news from Batavia.

News on the 76 GeV proton synchrotron at Serpukhov appeared in the August issue and next month there will be an article on the experimental programme at the machine. An item of interest at the Conference was that a booster project to increase the machine intensity is under serious study. They are concentrating on increased intensity of the accelerated beam rather than increased repetition rate because of power supply problems coupled with the desire to retain very long flat tops.

The new accelerator to be built at CERN Laboratory II might be called the 200/300/400/500/1000 GeV machine in view of all the options which are open. It is much simpler to refer to it as the SPS (standing for Super Proton Synchrotron). Since the authorization of construction in February the time has been absorbed by building up the Laboratory staff and by such things as negotiations on access to the site, the provision of electricity and cooling water, etc... and on freezing some vital parameters such as the precise tunnel configuration. However more obvious action will soon be apparent and the contract for carving out the machine tunnel will be placed at the end of November. We hope to return to CERN Laboratory II affairs in the December issue.

We have discretly withheld information from Batavia for several months because they have been wrestling with some unpleasant problems in the final stages of construction and commissioning of the 200 / 500 GeV

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machine at the National Accelerator Laboratory. After sustaining a quite incredible pace in design and construction right through to successful operation of the fast cycling 8 GeV booster synchrotron, a pace which the Batavia people would be the first to admit was helped by a fair share of luck, luck deserted them in the ultimate stage of bringing the main ring into action.

The booster reached full energy on 21 May and the linac-booster injection system for the main ring is providing good quality stable beams with up to 75 % operating efficiency. The booster accelerated intensity is $2 \times 10^{11}$ protons per pulse using only single turn injection from the linac. Four turn injection is planned and (since the booster, operating at 15 Hz, feeds 13 pulses to the main ring on one cycle) this should put the booster intensity at something like a factor of five below what is necessary for $5 \times 10^{13}$ protons per pulse at full energy from the main ring. To summarize — the linac is in fine shape and the booster is in sufficiently good shape that it will probably be fairly straightforward to work up to design figures.

The problems have come particularly in the magnets of the main ring. Prior to their installation the magnets were tested for voltage holding to 2.5 kV and their magnetic properties measured. While they waited to be powered in the machine tunnel they fell foul of the Chicago climate. Hot humid air entering the cold machine tunnel soaked the magnets with water. It then emerged that there are cracks in the coil insulation which when penetrated by the water meant that the insulation could no longer hold off the necessary voltages and it has not been possible to run the magnets up much above injection voltage. Magnets have been progressively removed, dried out and vacuum impregnated (about 200 had been so treated by the time of the Conference).

Commissioning of the main ring has been carried out for the most part by running the magnets d.c. at a level corresponding to 7 GeV injection. Beam has been observed circulating for up to 1 s but the beam intensity fell steadily during this time. The origin of the intensity decrease is probably obstacles in the ring vacuum chamber — a large number have already been located and removed. To get some experience with the r.f. system, the magnetic field has been ramped slightly and beam was captured by the r.f. and accelerated over something like 100 turns. Higher ramps are now being tried but attempts to go for full energy await the all clear on the magnets. The rescheduled full energy date of 1 July 1971 has obviously fallen by the wayside. Whether the project can be completed well within the original date of 1 July 1972 depends on how tractable the magnet problems prove to be.

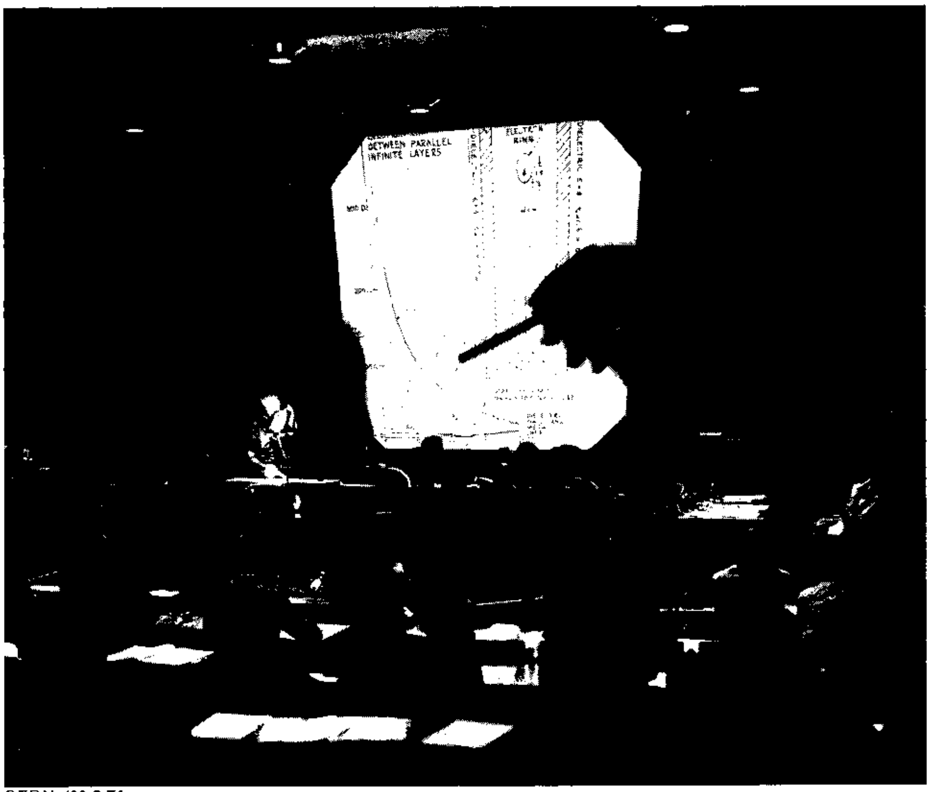
*Superconductivity*

The present flurry of activity in developing pulsed superconducting magnets and in designing accelerator systems in which they would be incorporated was covered rather thoroughly in the May issue (page 123). Since then a major event has been the successful operation (reported last month) of a synchrotron-like pulsed dipole magnet, known as AC3, at the Rutherford Laboratory. They are now developing two more advanced prototypes — AC4, a dipole 40 cm long, 9 cm diameter aperture (of which about 6 cm should be 'good field region') to give 4.5 T using 5 kA cable with filled epoxy and cooling channels; AC5 a 1 to 2 m long refined version of AC4.

The conviction that superconducting synchrotrons are feasible looks even deeper entrenched. They are almost always spoken of now in the context of extending the capability of an existing machine — for example taking the SPS to higher energies. As recorded previously, this particular proposition is being attacked by a consortium of three European Laboratories (Karlsruhe, Rutherford and Saclay) known as GESSS, Group for European Superconducting Synchrotron Studies.

Their studies have concentrated on a replacement of the conventional SPS magnets by superconducting

*Conference scenes..*



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magnets or on adding a superconducting ring on top of the conventional ring in the same tunnel. The first alternative would probably gain from injection at 28 GeV (rather than 10 GeV proposed for the conventional ring) to avoid passing through transition energy (and thus avoid the cost of aperture which transition would require) in the superconducting ring, but even at this injection energy there could be problems due to residual fields in the superconductor. Anything below 50 GeV may be uncomfortable.

The second alternative clears these problems by injecting at say 200 GeV from the conventional to the superconducting ring but replaces them by those of moving very high energy beams about efficiently in a restricted space. (Ejection from the superconducting ring in both cases is another problem of manoeuvre in restricted space. 'High beta insertions' where the beam is specially blown up — as opposed to low beta insertions in storage rings where the beam is specially squeezed — so as to be more efficiently picked off by a septum magnet, are a possible solution under investigation.)

Both alternatives suffer from the interference to the SPS physics programme which their construction would require. If a superconducting extension of the SPS were authorized, it might prove more economical, in terms of minimizing the effect on the physics programme and of liberating the machine design from constraints imposed by too close an integration with an existing system, to carve out a new tunnel a few metres away (tunnel cost being a comparatively small fraction of the total project cost).

However, despite the conviction the superconducting synchrotrons are feasible, costs are very difficult to pin down. It is certainly possible to do comparative sums showing, for example, how magnet and refrigeration costs are likely to vary with such things as aperture, location of iron, etc... but the unit around which the comparative figures emerge is not clear. It is not yet sure that the cost of construction/operation per GeV will be lower than using conventional techniques (though there are other advantages on the superconducting side regardless of equivalent cost). Some tentative figures were presented at the Conference but they are not solid enough yet to be bandied about (they might be termed GESSS work !).

There are good signs however in that industry is pricking up its ears more about the possibilities. Siemens are to launch a development programme on superconducting synchrotron magnets (aided by a government grant over three years). Also two commercial firms are fastening onto the possibilities of vanadium-gallium to replace niobium-titanium as the superconductor. $V_3Ga$ has the properties which make NbTi such an acceptable material for winding into coils and in addition its critical temperature is 15 K as opposed to 9 K and critical current is much higher. $V_3Ga$ would ease the severe conditions on temperature control which will exist for NbTi where fluctuations of a fraction of a degree Kelvin could send the superconductor 'normal'. However the metallurgical problems of producing $V_3Ga$ in usable quantity are not easy to solve. They are under attack particularly at Brookhaven.

It is sobering thought that two years ago the degree of enthusiasm now shown for superconducting pulsed magnets was rampant for superconducting r.f. cavities. Since Yerevan superconducting r.f. cavity work has run into considerable trouble.

Two years ago excellent results had been obtained at the Stanford High Energy Physics Laboratory (HEPL) in tests on small niobium cavities. Qs in the region of $10^{11}$ and field gradients of 27 MeV/m were achieved which were comfortably in excess of the $10^{10}$ and 13 MeV/m required for a 2 GeV superconducting linac on which construction had started at HEPL. These results increased the interest in superconducting linacs at Illinois (as part of a 600 MeV microtron), Karlsruhe and Stanford, SLAC. However, now that full-scale niobium cavities have been manufactured Qs in the $10^8$ range and field gradients around 3 MeV/m are the usual figures.

The trouble almost certainly lies in the quality of the niobium surfaces when manufactured on a large-scale and it should eventually be possible to clear it, but how is not yet known.

Meanwhile large-scale superconducting cavities made of lead have come much nearer their theoretical potential (see the report of the Rutherford work in the May issue page 136). How-

*Benefiting from the splendid Californian climate the electron-positron storage ring SPEAR takes shape in the open air near the output end of the 20 GeV electron linear accelerator at Stanford. First tests with the completed ring are scheduled to take place early summer next year.*

*(Photo SLAC)*

ever, the potential of lead is much lower than the potential of niobium and the applications of superconducting lead cavities do not seem as exciting as those of niobium.

From being on the crest of a wave, this field of accelerator technology now finds itself facing some nitty-gritty work before it can be confidently absorbed into large-scale projects. A significant sign of this is the decision of Stanford SLAC to take the pressure off their superconducting work (which was aimed at demonstrating the feasibility of a 100 GeV conversion of the 20 GeV electron linear accelerator — see vol. 10 page 284).

SLAC instead are leaning on the recirculation scheme known as SLOOP. The potential of this scheme is compounded of, firstly, a straightforward replacement of 20 MW klystrons by 30 MW versions which are now available, lifting the peak energy to 25 GeV, and secondly, the construction of two magnet loops each end of the machine and a flight tube along the length of the machine so that electrons can be bent back and stored at high energy and then fired again through the accelerator.

A loop radius of 95 m has been used in studying the idea. Electrons of energy 25 GeV being bent through such a radius would loose about 0.5 GeV energy each time (via synchrotron radiation) and this would need to be made up by r.f. cavities. To keep such losses down it is intended to store the accelerated electrons at 17.5 GeV. With the machine repetition rate of 360 pulses per second the electrons will take 112 turns through the loops before being sent again through the accelerator to gain another 25 GeV reaching a total energy of 42.5 GeV.

Two other possibilities would be open with SLOOP — to increase the duty cycle of the machine by pealing off part of the stored beam, and to collide very high energy electrons by sending them opposite ways through a loop. This system seems the most economical way of pushing the peak energy at SLAC much higher. The cost estimate is about $14 million and the predicted construction time 2 to 2.5 years.

## *Storage rings*

A major talk on storage rings was, of course, on the CERN ISR which had been completed and brought into action since the Yerevan Conference. However (following the articles in the last issue and with the inauguration ceremony reported in this issue) readers are likely to have reached saturation point on ISR information. We will turn to electron-positron storage rings.

Two projects are under way in the USA — the bypass scheme at the Cambridge Electron Accelerator and SPEAR at Stanford SLAC. The bypass was described in vol. 8 page 289 — it essentially involves the use of the electron synchrotron to accelerate and store both electron and positron beams. When intense enough beams have been built up, a magnet loop or bypass can be switched in so that the beams are deviated to orbit through the bypass where they are specially doctored to give healthy luminosities. The current status of the project is that single beams of up to 50 mA peak (12 mA average) have been successfully switched through the bypass and stored at energies up to 2.5 GeV.

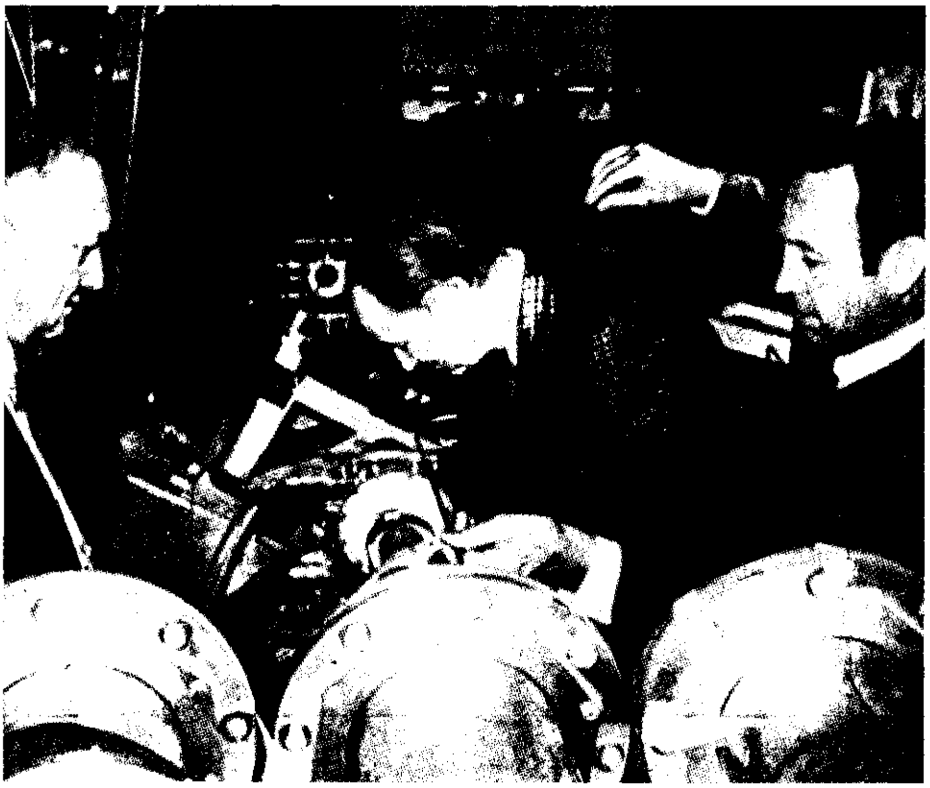
However some sticky problems have slowed the progress towards making the facility available for experiments. The peak positron current accumulated has been 25 mA (7.5 mA average) but the usual filling rate is about 0.1 mA per second compared with the hoped for 6 mA/s. Non-linear resonances are making it necessary to limit positron amplitudes in the synchrotron. The injected positrons are taken to 2 GeV rather than 3 GeV, which reduces the damping, before they are brought down again to injection energy to receive the next positron burst. Fortunately, the beam lifetime in this cycling mode is 300 s rather than the expected 16 s.

Beam-beam interactions have also proved troublesome. The beams have to be kept physically apart using electrostatic fields to avoid unacceptably low lifetimes during the filling process. The stored electron current can be taken to 8 mA average before it adversely affects the injected positron beam lifetime. Also electron beams in excess of 70 mA can cause the weaker positron beam life-time to fall to about 15 s. Problems in the bypass have made it necessary to install large bore quadrupoles and a rebuilding of part of the bypass is planned.

The first luminosity measurements were carried out this year with 2 GeV

The Director of the Lawrence Berkeley Laboratory, E. McMillan dips his head carefully into the beam of nitrogen ions accelerated by the Bevatron. Heavy ions passing through the retina of the eye seem convincingly pinned down as the origin of the light flashes seen by astronauts on Apollo flights (see story in last issue).

(Photo LBL)



beams in each ring. Values up to $10^{27}$ $cm^{-2}s^{-1}$ were recorded, in good agreement with prediction for the currents and dimensions of the circulating beams. When luminosities in the $10^{28}$ range can be reliably achieved the experimental programme will start.

SPEAR has been considerably modified from the initial scheme described in vol. 9, page 271. It began as a two asymmetric ring scheme, was trimmed to one ring, and now finds itself under construction with symmetry restored. The go-ahead was given in August 1970 and it is hoped to inject the first beams in April next year and to complete the project within a budget of $ 5 million.

The 'ring' consists of two magnet semi-circles 31.5 m radius separated by 12 m straights of which 5 m in each are free for the installation of experimental equipment to study electron-positron collisions. The machine lattice allows a variety of operating conditions to be established. The bending magnets are of solid, rather than laminated, iron and have aluminium coils. They are assembled in modules on girders which also carry quadrupoles and sextupoles. Their field corresponding to a 2 GeV beam is about 0.5 T. They are capable to climbing to higher fields (equivalent to 4.5 GeV) but the initially installed r. f. power of 160 kW will limit the peak energy to 2.5 GeV (compensating for synchrotron radiation).

Electrons and positrons will be injected at an energy of 1.5 GeV from the Stanford linac (filling times of a few minutes are expected). They feed into a vacuum system made from extruded aluminium tubing which, in the bending magnet fields, is pumped by distributed sputter ion pumps, made at Stanford, operating at about 600 litres per second. It is hoped to store 200 mA in each beam with a lifetime in excess of an hour and to achieve a luminosity of $0.5 \times 10^{32}$ $cm^{-2}s^{-1}$ at 2 GeV. Moving to the one ring scheme has sacrified luminosity at low energies but the results from operating electron-positron storage rings seem to put the emphasis on experiments at higher energies. Proposals for experiments are now being invited.

The two operating electron-positron storage rings in Europe, ACO and ADONE and the two under construction, DORIS and DCI, are mentioned in the report on the Daresbury Study Weekend later in this issue. DCI at Orsay is the only one not covered previously in CERN COURIER ; it is a trimmed down version of the four beam space charge compensation scheme first put forward under the name of COPPELIA (see vol. 9, page 382). Authorization was given for construction from March 1971 with some imposed limitations - for example that it has to be accommodated within the existing end-station building at the Orsay electron linac. A budget of 40 million French francs is likely, spread over four years — the storage rings are expected to be in operation in 1974.

There are two rings separated vertically by 1.7 m and the beams cross vertically. An intersection region has 6 m available for the installation of experimental equipment and the total length of the long straight sections is 17.5 m. The magnet bending radius is 3.8 m.

Electrons and positrons will be injected from the Orsay linac at an energy of 1 GeV and enough r.f. power will be installed in DCI to achieve a peak energy of 1.8 GeV. The luminosity is expected to reach $10^{32}$ $cm^{-2}s^{-1}$ at 1.5 GeV.

The news from Novosibirsk is that the building for the 25 GeV proton-antiproton storage ring VAPP 4 is complete and half the magnets are installed. It is intended to have the full ring by the end of next year and to use it initially with electron-positron beams while waiting for proton and antiproton injection systems and for the electron cooling system for the antiproton beam to be built up.

Two very adventurous new storage ring projects are being mooted in the USA. One is the 200 GeV proton-proton scheme at Brookhaven using superconducting magnets (described in the August issue). The other is an electron-positron-proton scheme worked on particularly at Berkeley and Stanford. The idea is to have two intersecting rings — one for protons (maximum energy 72 GeV), one for electrons and positrons (maximum energy 15 GeV) — of gross radius 260 m. Peak centre of mass energies are then 65 GeV for electron-proton and 30 GeV for electron-positron.

The scheme has the rings intersecting in four places in the horizontal plane at an angle of 10 mrad. It is planned to have one bunch in each beam (giving a 30 mA circulating current) and to reach luminosities of $10^{32}cm^{-2}s^{-1}$. The protons would be provided by a linac and a 1 GeV booster and the major problem would probably be to compress the accelerated beam into one bunch so as to achieve the required proton densities — this would require some clever gymnastics in a complicated r.f. system. The electrons and positrons could, for example, come from the existing Stanford linac and the major problem in handling these beams at high energy is likely to be the large quantity of r.f. power (as much as 2.7 MW) required to compensate for the energy lost by synchrotron radiation.

A wide range of interesting physics experiments can already be foreseen for this imaginative project.

### *Electron ring accelerators*

After the splendid success of the first green-fingered years with ERAs, a great deal of painstaking work has proved necessary to master the idea of using a ring of electrons to carry protons or heavy positive ions to high energies. The 'state of the art' was reported in the February issue of this year (page 49) and there is not very much to add.

At the Conference all four laboratories with fairly extensive development programmes on ERAs reported their work. Dubna have had the greatest degree of success with the acceleration of alpha particles held by the electron rings. By activation techniques (producing radioactive gallium on a copper target) the energy of the alphas was estimated at around 30 MeV with about $10^9$ alphas accelerated in each electron ring.

A new injector (to give 3.5 MeV and 2000 A with 20 ns bursts at 50 to 100 Hz) is being built. It will feed a new compressor and next year it is hoped to try acceleration of the electron rings in superconducting r.f. cavities (no details of progress with the development of such cavities were available).

Berkeley brought their new electron linear induction injector into action in the spring and are now able to inject into a compressor at 4.2 MeV. However the research has not concentrated on using the full potential of their system (where rings of $6 \times 10^{12}$ electrons have been achieved which could be sufficient for many purposes) but on trying to get a thorough understanding of the physics involved in forming intense rings of electrons.

They have studied phenomena such as neutralization of the ring by positive charges liberated in the residual gas, the resistive wall instability and the negative mass instability which is proving the most intractable of all. It occurs early in the compression cycle (in the first few hundred turns) and results in longitudinal bunching of the electrons around the ring. When these phenomena are well understood and mastered the work will turn to acceleration of loaded rings. A new compressor (Compressor V) is almost ready to be brought into service.

At Munich (MPI Garching) instability studies are also under way. They had difficulty achieving high electron densities in the compressed ring and for a long time $10^{10}$ was the usual figure but a peak of $2.2 \times 10^{12}$ has now been measured. Resonances are now crossed later in a longer compression cycle when the ring is smaller in radius. It is hoped that a laser initiated electron beam will result in an injected beam with much lower momentum spread.

Karlsruhe achieved compressed rings just before the Conference. The rings were shrunk from 20 cm to 3 cm radius and held $10^{10}$ electrons. More work is needed to sort out hardware problems and to have a better compression cycle before beginning the research programme on ring formation. Meanwhile development of the ion injector for loading the rings is continuing.

A new question mark on the ERA scene stems from some calculations on possible coupling between electron motions in a compressed ring and the motions of the trapped ions in the ring. Three years ago such calculations suggested no problem but more thorough work seems to indicate that coupling could seriously reduce the holding power of the rings which would limit how hard the rings could be pulled, when accelerating them, so as not to drag the ions and electrons apart. It would be nice to be at the stage when some experimental measurements could be put alongside the calculations for comparison.

### *Heavy ion acceleration*

In a mixed bag of topics on the last day of the Conference, two papers (concerning work at Princeton and at Berkeley) were given on the acceleration of heavy ions in proton synchrotrons. What the presentations lacked in length, they compensated for in enthusiasm. Their work on nitrogen ions was described last month (page 251) and there is no additional information to report here. It seems worthwhile, however, to pick out this topic. Both the PPA and the Bevatron in their first tests were able to supply beams reliably enough and of sufficiently good quality for some experiments. Obviously the intensities are still very low but there are straightforward manoeuvres to increase intensities by a factor of 100 or so towards the $10^8$ ions per second level. An interesting new programme of physics at big accelerators is opening up.

### *Financial restraints*

The Conference concluded with a talk on the financial environment within which accelerator building and high energy physics has to be done. The present worrying situation in the USA was described in the August issue, page 226, and in Europe there are also large areas of belt-tightening as the new CERN accelerator goes ahead.

It is not the business of accelerator designers to limit their imaginations by being dominated by finance all the time and it was right at an Accelerator Conference to talk finance at the end rather than to introduce it at the beginning. There is a later stage, when the high energy physics community as a whole has to make its choice of accelerator facilities and to adjust them realistically to the financial environment.

At present, it seems right to restrain our appetites. There may be more meals coming along later but for the moment we appear to have reached the cheese board and need to be carefully selective. It was a pity therefore to hear several remarks on financial matters which did not flatter our sponsors and which one did not expect to hear again from the accelerator community. Our appetites of the mid-60s cannot be fully met but we can still do a very great deal with the excellent facilities that we have and will have.

# CERN News

## Hydrogen streamer chambers

The EMSA group (Electromagnetism Studies and Applications) of the Track Chambers Division have already shown that it is feasible to develop hydrogen streamer chambers which would combine the functions of a target and of a detector which can be triggered (see vol. 10, page 229). The use of hydrogen in a streamer chamber requires that twice the usual electric field be applied for a time three or four times shorter than for the usual helium-neon mixture. This development work has been satisfactorily completed with the application of new techniques to give voltage pulses (reproducible to better than 1 %) with a very fast rise time (less than 2 ns), short duration (5 to 6 ns) and high amplitude (500 kV).

The pulses are produced using the following three elements : a generator supplying a positive d.c. voltage, a triggered spark gap and a Blümlein line for shaping the pulse. The generator is a Sames 600 kV set, of a type widely used at CERN in electrostatic separators and which has high stability (up to $10^{-6}$). The spark gap is fired with 100 % reliability using a 300 kV trigger voltage applied via an extremely fine tungsten pin (0.1 mm for 100 to 200 kV negative striking voltage). This does not affect the d.c. voltage holding in any way. The pulse is shaped by a tricoaxial line (Blümlein line) the originality of which lies in its solid insulator (impregnated araldite) and in the method of metalization (spraying copper on the araldite).

With this device, a pulse with a maximum height of 500 kV can be applied to the chamber with a total delay time of 400 ns (the time between the passage of the particle and the application of the high voltage pulse).

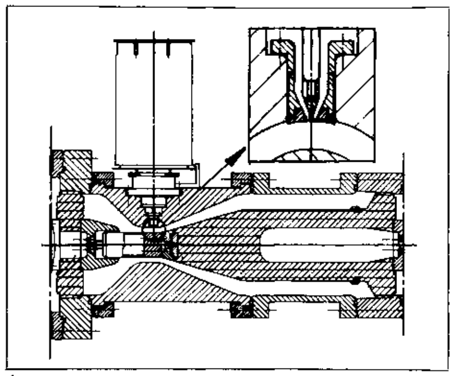
To obtain shorter streamers in hydrogen it is necessary to apply shorter pulses. For this purpose, three Blümlein lines, corresponding to 16 ns, 9 ns and 6 ns pulses, have been built all based on the above principle ; the photograph illustrates results they have given.

The internal volume of the chamber with which these tests have been carried out is $21 \times 26 \times 9$ cm$^3$. The interelectrode walls are made of impregnated araldite, providing a good vacuum seal, and the chamber can be readily dismantled. Besides hydrogen, other gases and mixtures have been used, including — helium-neon (25 % He - 75 % Ne), which was used for calibrations after any major modification to the equipment ; pure helium ; hydrogen with an admixture of methane in proportions ranging from 5 to 90 %, of $SF_6$ (up to 100 p.p.m.) and of neon (up to 20 %) ; pure methane, in which streamers appear more clearly than in helium-neon but which requires fields about two and a half times higher.

These tests indicate that a new variety of detector — the hydrogen streamer chamber — could be added to the physicist's arsenal.

*1. Diagram of one of the Blümlein lines with the detail of its spark gap picked out to show the tungsten pin 0.1 mm in diameter to which is applied a trigger voltage from a Marx generator.*

*2. Photographs taken parallel and perpendicular to the electric field, showing streamers recorded in different gases. 1. Hydrogen (voltage gradient 33 kV/cm ; pressure 200 torr ; pulse 6 ns base with 1.6 ns rise time). 2. Helium (voltage gradient 27 kV/cm ; pressure 350 torr ; pulse as for hydrogen). 3. Methane (voltage gradient 35 kV/cm ; pressure 190 torr ; pulse 9 ns base with 2.5 ns rise time). 4. Helium-neon mixture (voltage gradient 20 kV/cm ; pressure 660 torr ; pulse 16 ns base with 4.1 ns rise time).*



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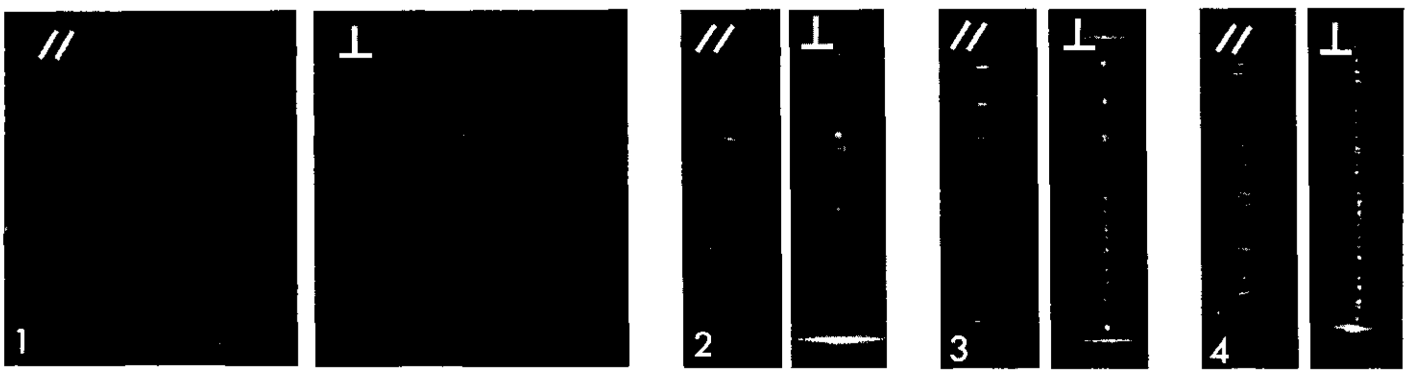
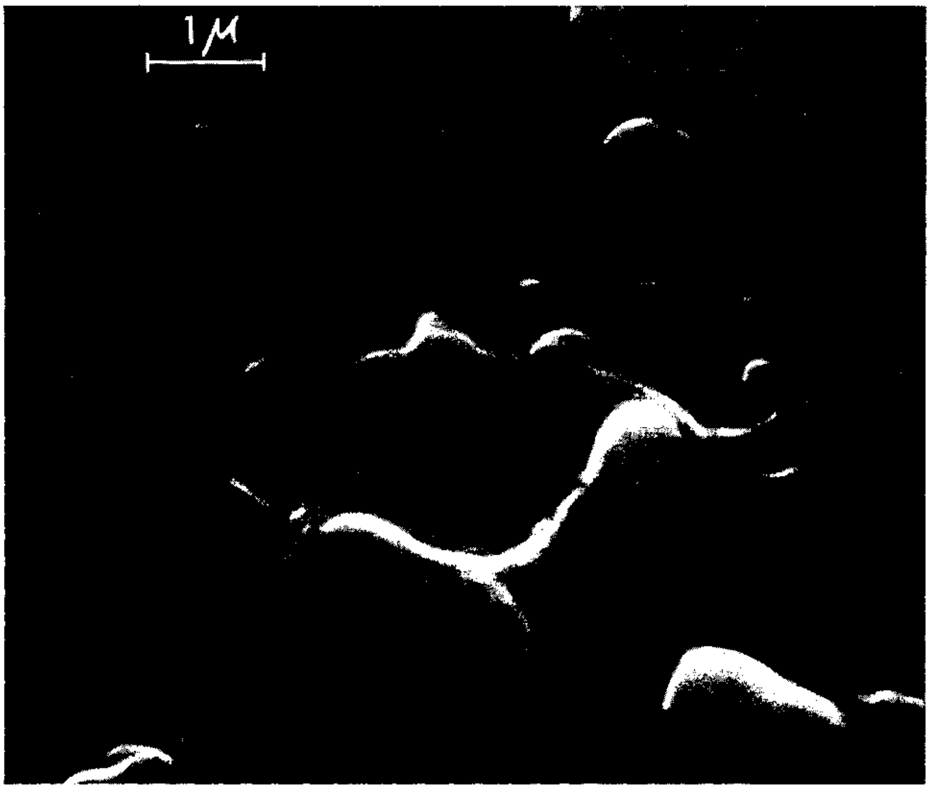



2.

*Photograph taken in a scanning electron microscope showing the surface of a pure titanium cathode subjected to breakdown at very high voltage (600 kV) in ultrahigh vacuum. Microparticles can be seen torn away from the anode by the electrostatic forces and leaving craters on the cathode. Most of the microparticles which lead to the production of the spark are less than a micron in diameter. A spark can originate on the lips of the craters and at the rough areas produced by the impact.*




## High voltage in vacuum

The study of high voltage in ultrahigh vacuum, begun at CERN in 1964, has just drawn to a close with an experiment to detect microparticles using a laser beam (see vol. 9, page 208) and with a detailed analysis of the time delay to breakdown in ultrahigh vacuum between titanium electrodes (maximum voltage per pulse 600 kV).

This work has shown that microparticles are a main agent in producing sparks. By measuring time delays, it has been possible to identify at least three breakdown mechanisms and to define the various combinations of voltage and interelectrode gap where microparticle-initiated breakdown predominates. The photograph shows some microparticles and their effect on the cathode surface.

This work (being published as a CERN report by F. Rohrbach) could have its effect in many practical applications both in physics laboratories and in industry — for example: streamer chambers (using low-pressure hydrogen, deuterium or helium); electromagnetic deflectors; X-ray flash tubes; applications involving high fields in ultra-high vacuum, etc.

*On a very modest scale, site work has begun for CERN Laboratory II. A trench is being dug between Laboratory I and the site of Laboratory II to lay some PVC pipes — one for water, another for an electric cable, two for telephone cables and a further two that could eventually form part of a system for the remote processing of data.*
*The water and electricity supplies are of limited capacity and are only a temporary measure. Eventually water will be drawn from Lac Léman and electricity from Génissiat, but construction work on the complex of offices and laboratories will begin soon and will need these services available.*

# Photon and lepton physics

*Report of a study week-end held on 1 to 3 October at the Daresbury Laboratory to discuss the progress and possible future of photon and lepton physics in Europe.*

The study week-end brought together a small number of people, most of whom are involved in research at electron accelerators in Europe, to review current experimental programmes in photon and lepton physics and to get some appreciation of the possible future of these branches of high energy physics. With the investment in the construction of the large new proton synchrotron at CERN, and in a situation of non-flourishing budgets, it is obvious that the major areas of interest in these branches of research have to be looked at carefully to judge which are the best research facilities to sustain or develop. The proton carries more weight than the electron and the electron community are understandably concerned that the interest in their research be given a fair hearing before decisions are taken regarding any curtailment of branches of high energy physics in Europe.

## *Electron machines*

This certainly does not mean to say that photon and lepton physics is currently badly served. On the contrary there were reports from the extensive research programmes at the Daresbury 5 GeV electron synchrotron, NINA, (by E. Gabathuler), at the DESY 7.5 GeV electron synchrotron (E. Lohrmann) and (on a more restricted University scale) at the 500 MeV and 2.5 GeV Bonn electron synchrotrons (G. Knop), which are all in a very healthy state.

NINA has an accelerated beam intensity of about $6 \times 10^{12}$ electrons/s. There are four photon beams and two ejected electron beams. Two tagging facilities are now available covering a 1.5 GeV range in 30 MeV bites and a 2 GeV range in 7 to 10 MeV bites. DESY has an accelerated beam intensity of a few times $10^{12}$ electrons/s which should be increased readily by a factor of three when a new 400 MeV injector comes routinely into operation in November, following a machine shutdown. The addition of a flat top in the magnet cycle will also increase the duty cycle by about a factor of three. The larger machine at Bonn has an accelerated beam intensity of $2 \times 10^{12}$ electrons/s. It feeds five photon beams and an ejected electron beam. Possible improvements include the addition of a second ejected beam feeding a new experimental area.

Experimental programmes can be divided into photoproduction experiments (using bremsstrahlung and tagged photon beams) and electroproduction experiments (using electron beams) and there are a few experiments using hadrons (kaons). The experiments are covering the resonance region (up to around 3 GeV) and the high energy region up to energies of around 6 GeV. Physicists are studying resonance production and structure via real and virtual photons in a long series of experiments which could continue for many years yet before they yield a full analysis. Electroproduction studies are probing the structure of the nucleon and here again several years of research can be seen applying coincidence techniques to inelastic processes. Other topics open to extended study are the photoproduction of vector mesons at high energies, total cross-sections, structure of the photon itself, interactions with complex nuclei and the relatively unexplored area of associated production.

Experimental techniques seem to be moving towards the increasing use of polarized targets and polarized beams (Bonn and DESY are studying polarized electron sources) to gain the extra information they can yield. Experiments are likely to gather still higher statistics possibly taking advantage of the higher data collection rates of multiwire proportional chambers and are likely to study higher momentum transfers. Tagged photon beams are already proving their usefulness, in providing photons of well-defined energy.

Other interesting programmes of research are benefiting from the energy radiated by the orbiting electrons in a synchrotron. DESY has had a synchrotron radiation facility in action for some time and is intending to add another at the synchrotron itself and to build one at the storage rings currently under construction. Daresbury has a synchrotron radiation facility nearing completion. The availability of intense sources of radiation extending from the X-ray to the infrared region attracts a variety of other disciplines into electron Laboratories. Research can cover such topics as the structure of organic compounds, the optical properties of solids, X-ray crystallography, properties of metal films, etc...

Two electron-positron storage rings are in operation in Europe (the 1.5 GeV ADONE at Frascati and the 540 MeV ACO at Orsay). M. Conversi discussed the important information they are providing concerning problems related to vector mesons, tests of quantum electrodynamics and on hadron production where multi-body events have been unexpectedly prominent. Two further colliding beam facilities are being built (DORIS designed for 3 GeV beams at DESY and DCI for 1.8 GeV beams at Orsay). Detection techniques are likely to be more concerned in the future with particle identification (distinguishing pions from kaons, identifying neutrals) and with establishing detectors with $4\pi$ geometry around a collision region (large magnet projects are being prepared for ADONE and DORIS).

There was also some discussion about the possibility of using electron beams in the CERN Intersecting Storage Rings (a possibility stirred up perhaps by the Berkeley/Stanford

*The DESY Laboratory site where the most extensive facilities for lepton physics in Europe are being built up. Top centre of the photograph can be seen the wheel shape of the 7.5 GeV electron synchrotron. Lower down to the left is the long thin building housing the new 400 MeV linear injector and to the right of that can be distinguished the oval shape where the 3 GeV electron-positron storage rings are under construction. This aerial photograph dates from almost a year ago and the storage rings buildings are now much further advanced.*

*(Photo DESY)*

ideas on electron-proton collisions mentioned above in the report of the Accelerator Conference). Electrons of energy around 5 GeV could be retained in a ISR magnet ring and a 1 A circulating current would require around 1 MW of continuous power to sustain it at these energies.

## *QED and neutrinos*

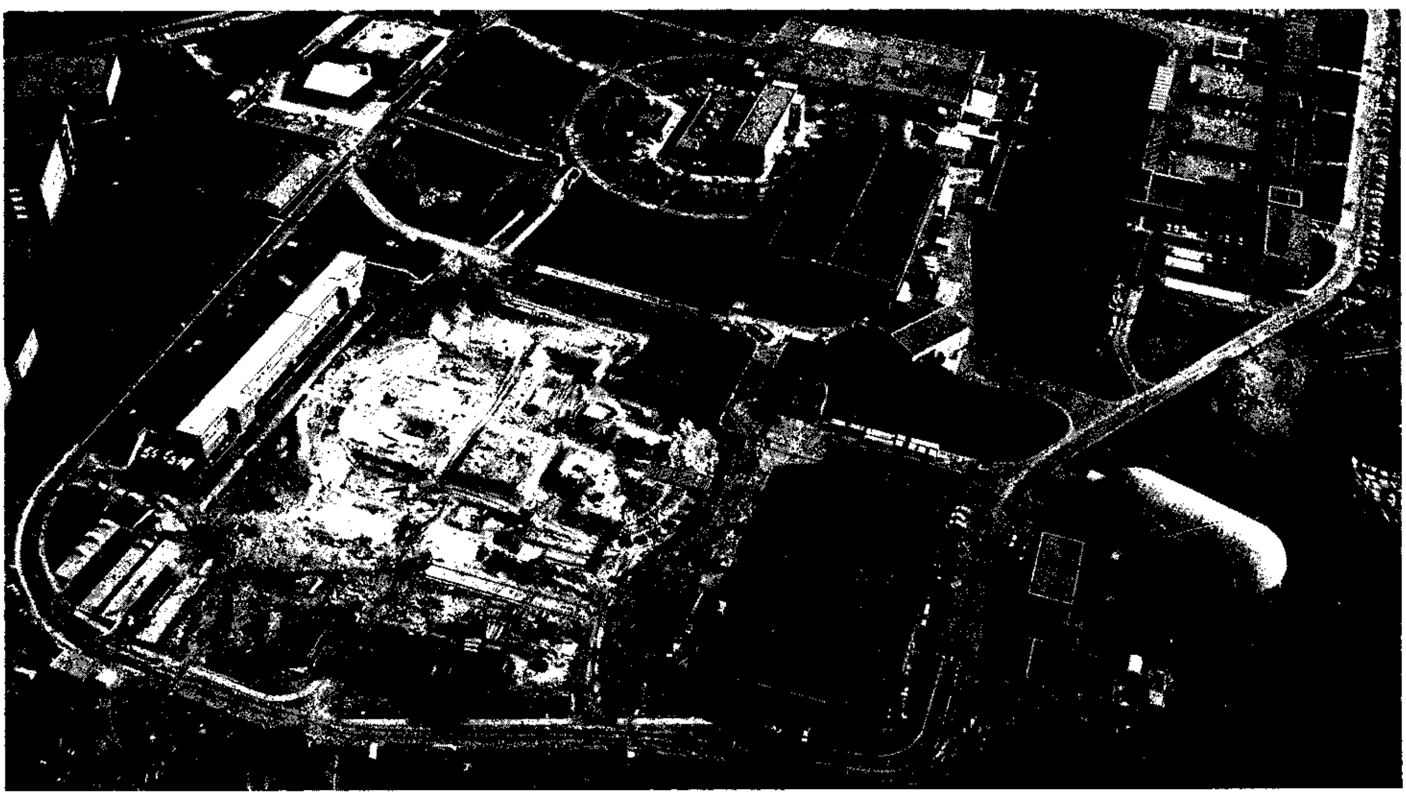
The discussions broadened to take in research at other than electron machines and there were thorough surveys of experimental tests of quantum electrodynamics (by E. Picasso) and on the neutrino physics programme at CERN Laboratory I (D.C. Cundy).

QED resists all attempts to undermine it. Experimental measurements of the hyperfine structure (also in muonium), on positronium, of the Lamb shift (where an extremely difficult experiment on muonic atoms is now underway at the CERN synchrocyclotron), on the g-2 of the electron and muon (where a new measurement, pushing the accuracy a factor of twenty further, is to be carried out at CERN), all are in agreement with each other and with the latest theoretical calculations. There is scope for further tests at higher energies where searches for the Dirac monopole and measurements of deep inelastic electron and muon scattering and measurements of wide-angle muon bremsstrahlung will feed further detail into our knowledge of QED.

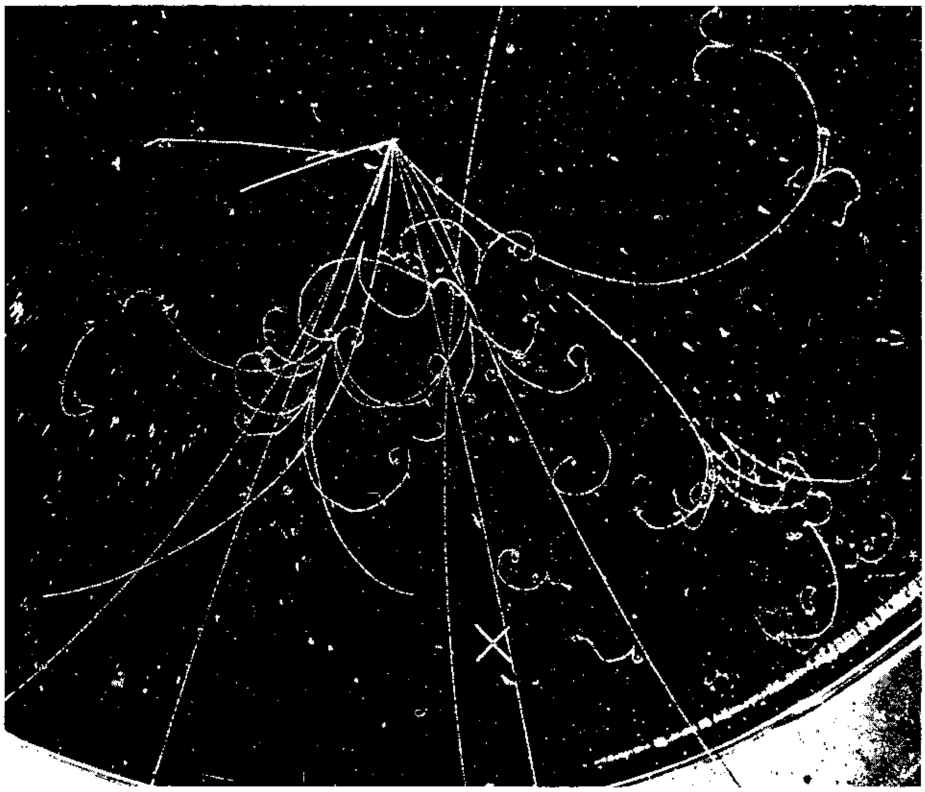
The neutrino programme at CERN Laboratory I is concentrating on the use of the heavy liquid bubble chamber, Gargamelle, which is scheduled to take half a million neutrino pictures (hoping to collect over 18 000 events) and half a million anti-neutrino pictures (2000 events) in freon during its 1971-72 runs. It has been decided not to use the 3.7 m hydrogen chamber, BEBC, for neutrino physics until higher energy beams from Laboratory II become available.

The Gargamelle experiment will give a factor of ten increase in neutrino event statistics over previous experiments. This will make it possible to put better limits on the possible existence of neutral current processes, on heavy leptons and on whether the coupling constant for the diagonal process $\nu_e + e \rightarrow e + \nu_e$ is anomalously large for high energy neutrinos. A conclusive test on whether the lepton number conservation obeys an additive or multiplicative law will be carried out by looking if electron neutrinos from $\mu^+$ decay give electrons or positrons.

However the main aim of the experiment is to study the behaviour of deep inelastic neutrino scattering. Existing neutrino data, obtained at CERN, shows evidence that neutrino interactions may follow the same scaling behaviour as is exhibited by



*An indication of the complications which lie in store at higher energies : in this bubble chamber photograph an event sequence has been initiated by a 10 GeV neutrino in freon. Such events are very difficult to measure due to the charged pions interacting in the liquid to give neutral pions which result in large electron showers.*



electron scattering. For a deeper understanding of this behaviour it is very important to measure the neutrino and anti-neutrino cross-sections as a function of energy. The measurement of inelastic neutrino events is no mean task, as can be appreciated from the photograph.

At CERN the detailed study of neutrino induced baryonic transitions such as $\nu + n \rightarrow \mu^- + p$ and $\nu + p \rightarrow N^{*++} + \mu^-$ must wait until protons are available from CERN Laboratory II and a special high intensity, but low energy, neutrino beam is constructed for BEBC.

The problem of studying neutrino interactions at energies above 15 GeV in bubble chambers poses many problems. It is most probable that BEBC and Gargamelle will then need to be aided by other detectors.

## *Proton machines*

As proton synchrotrons are moving to higher energies they will probably serve photon and lepton physics more fully than in the past. A first sign of this is the experimental programme at Serpukhov where an electron beam with energy extending to 35 GeV is set up yielding a flux of $10^5$ electrons per pulse. A Moscow, Serpukhov, Yerevan collaboration is scheduled to begin, before the end of this year, a measurement of the photon-proton total cross-section using tagged photons at energies over 20 GeV. Also there are neutrino plans and there will be a muon beam. A Serpukhov team are preparing an experiment, to start by the end of 1972, on deep inelastic muon scattering over the energy range from 30 to 40 GeV. Muon experiments are also planned for the heavy liquid bubble chamber, SKAT.

The plans for photon and lepton physics at Batavia were described by A.L. Read. There will be a neutrino beam which can be adjusted to two operating conditions (a wide spectrum beam from a focusing horn or a di-chromatic beam, quadrupole focused, with two narrow energy bands associated with pion and with kaon decay) ; a muon beam of a few $10^6$ per second (where 'muon spoilers' will attempt to disperse the 'halo' of muons which always surround a muon beam — since high energy muons which are not focused by magnets tend to sail through magnet steel and coils and thus stay near the beam) ; an electron/tagged photon beam with a few $10^8$ electrons per pulse at 300 GeV produced from a 500 GeV beam (version one of the photon beam, is likely to be a neutral beam which has been passed through a length of deuterium to reduce the hadronic content; version two is likely to be a several stage affair involving conversion of the photons to electrons).

Among the many experiments approved for the NAL programme there are searches for Dirac monopoles, intermediate bosons, heavy leptons and the Lee-Wick particle; neutrino experiments (two counter experiments as well as the 15 foot bubble chamber experiments) and muon deep inelastic scattering studies. The electron/photon beam will be used for a photon-proton total cross-section measurement and there are proposals for a study of photon induced reactions and of inelastic electron scattering.

The preliminary thinking about the experimental programme using beams of several hundred GeV from CERN Laboratory II was given by J.V. Allaby. Most thought has gone into the use of the West Experimental Area alongside the ISR which will probably be fed with beams earlier than the new North Experimental Area to be built in Laboratory II. Because of its length and its distance from the accelerator the West Area has to be considered the lower energy area where beams of over 200 GeV could be troublesome to handle.

For photon and lepton physics one beam is obvious — a neutrino beam to BEBC. This could have its target underground and have the neutrino parents pointed at BEBC so that a long distance through the earth could serve to filter out particles other than neutrinos, or it could have its target above ground inside the West Hall and be optimized for a lower energy range of neutrinos (produced from, say, 70 to 100 GeV protons) and higher intensity using steel shielding. The North Area is the place for very high energy work and it is probably there that muon beams will be built since there will be more beam length available which is a necessity for efficient muon beams at high energy. However an electron/photon beam is feasible for the West Hall.

A new idea to tackle the problem of sifting out high energy electrons from other charged particles has recently been put forward by F.J.M. Farley, E. Picasso and L. Bracci with contributions also from D. Newton. A momentum-selected beam of electrons plus other particles is sent through a region of high magnetic fields arranged in alternating sequence (for example + — — +) causing all the particles to swerve from side to side as they travel through. (Their trajectories suggested the ski-flavoured name of 'chicane' for such a device). Electrons will lose energy since they emit synchrotron radiation as they follow a curved path and thus a conventional spectrometer can subsequently separate them from the other particles. For example, to filter out 100 GeV electrons, a magnetic field of 10 T (superconducting magnets) over 4 m would give about a 5% energy loss. From $10^{12}$ interacting protons per pulse, about $5 \times 10^7$ electrons at 100 GeV might be realized from such a system.

It was pointed out that the intensities from the high energy proton machines which have been mentioned above are not comparable with those to which we have become accustomed at electron machines. However there is no competition between developing new electron machines and developing lepton facilities at proton machines. There are no proposals on the table for electron machines to yield 100 GeV energies and the only choice is between $10^7$ electrons at 100 GeV and no electrons at 100 GeV. The competition really lies in promoting a lepton physics programme at the big machines against the many hadronic demands.

*Possible future machines*

The future of electron accelerators was discussed by M.C. Crowley-Milling. The major proposal in Europe comes from Daresbury where the idea of feeding a 15 to 20 GeV synchrotron from NINA was promoted several years ago (see vol. 9 page 44). A more detailed design study of this proposal will be published shortly and they have also considered electron synchrotrons of energy as high as 40 GeV. It is obvious however that, since the cost of the new CERN machine is eating into the national high energy physics programme in the UK, there are not enough pounds sterling around to build such machines without a completely new initiative from the UK government.

A problem with electron machines compared with proton machines is that higher energies are harder to come by. The inclination of electrons to lose energy by synchrotron radiation (a loss increasing as $E^4$) involves crippling demands on r.f. power in synchrotrons. Linear electron machines can be even more expensive (calculations indicate that synchrotrons still come out the best buy through to energies approaching 40 GeV) and have duty cycle limitations. A way around the energy problem in linear machines is the recirculating scheme now being mooted at the Stanford Linear Accelerator Centre (see the report on the CERN Accelerator Conference earlier in this issue) and there is also a scheme developed at DESY, known as the mesotron, which has a series of magnet loops linking the ends of two linacs for repetitive circulation of the electrons. The great white hope of superconducting r.f. cavities, which could greatly affect the present cost estimates for higher energy machines, still seems a long way from realizing its potential.

If the need for further facilities for photon and lepton physics in Europe can be clearly demonstrated so that they become promoted by the high energy physics community at large, a centre organized on the European scale might be the most likely way that they will see the light of day.

# Around the Laboratories

*Giancarlo Wick (left) receiving the 1971 International Physics Prize from Gaspare Oddo, Mayor of Erice. The Prize was awarded with the citation : 'His contributions to quantum field theory and scattering theory are both basic, and extensive; they have become foundations of these two vast and fruitful areas of research. The Wick theorem and the Wick product are common vocabulary in today's literature, not only in high energy physics but in solid state physics and many body problems as well. His very recent work on a finite theory of quantum electrodynamics is again of fundamental importance'.*

## LOS ALAMOS
## 211 MeV

A month ahead of schedule the LAMPF team accelerated protons to an energy of 211 MeV on 27 August (LAMPF thus becoming the highest energy proton linac in the world). The 100 MeV stage was reached in June but up to that point the linear accelerator was treading old ground for only the four Alvarez type tanks were in operation. The sigh of relief was this time more profound because the first cavity sections were in use. The side-coupled cavity (see vol. 8 page 132) is a new concept developed at Los Alamos.

The next big step is planned for July of next year when the protons will be taken all the way along the machine to a peak energy of 800 MeV. The experimentalists are waiting eagerly for access to LAMPF beams. More than 700 scientists from 175 institutions are members of the Users Group which will hold its third annual meeting on 8 November.

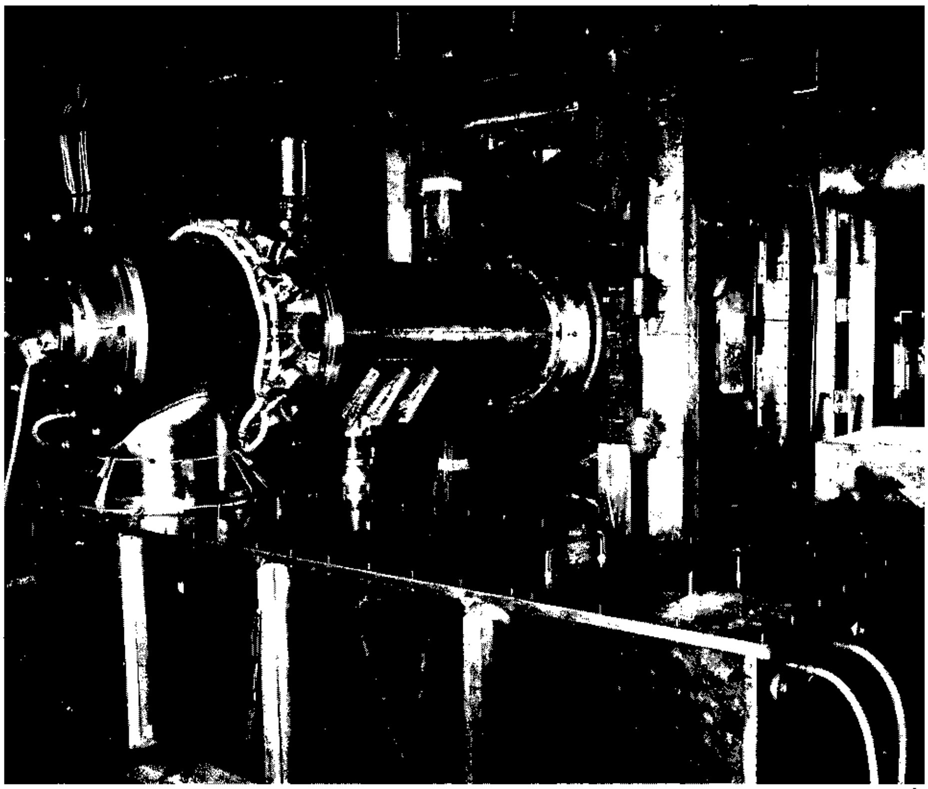
## DESY
## Streamer chamber

It is some time since we last reported on experiments using streamer chambers. This certainly does not mean that the technique has fallen by the wayside. Following the pioneering work of the Russian group under the late G.E. Chikovani, the Stanford Linear Accelerator Centre has led the way with a 2 m chamber followed by DESY and joined lately by Berkeley (where a UCLA chamber, which will become an LBL facility, is in operation to study the decay of the $X^{\circ}$ into two charged pions and a gamma looking for C violating effects) and by Argonne (where a chamber built by a University of Illinois team, which will become an ANL facility, is almost ready for an experiment).

To recall the technique briefly — A very short high voltage pulse is applied between plane electrodes. In the intervening volume electrons left in the wake of a charged particle will initiate a series of sparks. However the pulse is kept so short that these sparks are not allowed to develop and are thus photographed as streamers only a few millimetres long distributed along the path of the particle. Usually the gas used between the electrodes is a helium-neon mixture surrounding a small hydrogen target. The CERN work to develop a streamer chamber using only hydrogen is described earlier in this issue.

A new stage has been reached in the work at DESY. Earlier developments were covered in vol. 8, p. 190 and vol. 9, p. 144, describing a double-gap chamber operated within the magnet of the 84 cm hydrogen bubble chamber. At the beginning of this year, a new magnet for the streamer chamber was received. It is similar to the bubble chamber magnet, providing a volume of $110 \times 60 \times 55$ cm$^3$ and a maximum field strength of 1.9 T. For this magnet, a new streamer chamber system has been built and it was operated successfully this summer.

The sensitive volume of the chamber is $100 \times 60 \times (2 \times 24)$ cm$^3$, filled with a helium-neon gas mixture. Again, it is a double-gap chamber with the high voltage applied to the middle electrode. The high voltage pulse is supplied by a ten-stage Marx generator which has 80 kV per stage and thus provides a pulse of 800 kV, at a repetition rate of 5 pulses per second. For pulse forming, a coaxial Blumlein system is used giving a rise time of 3 ns and a pulse length (FWHM) of 10 ns. A new technique for automatic control of the memory time has proved successful.



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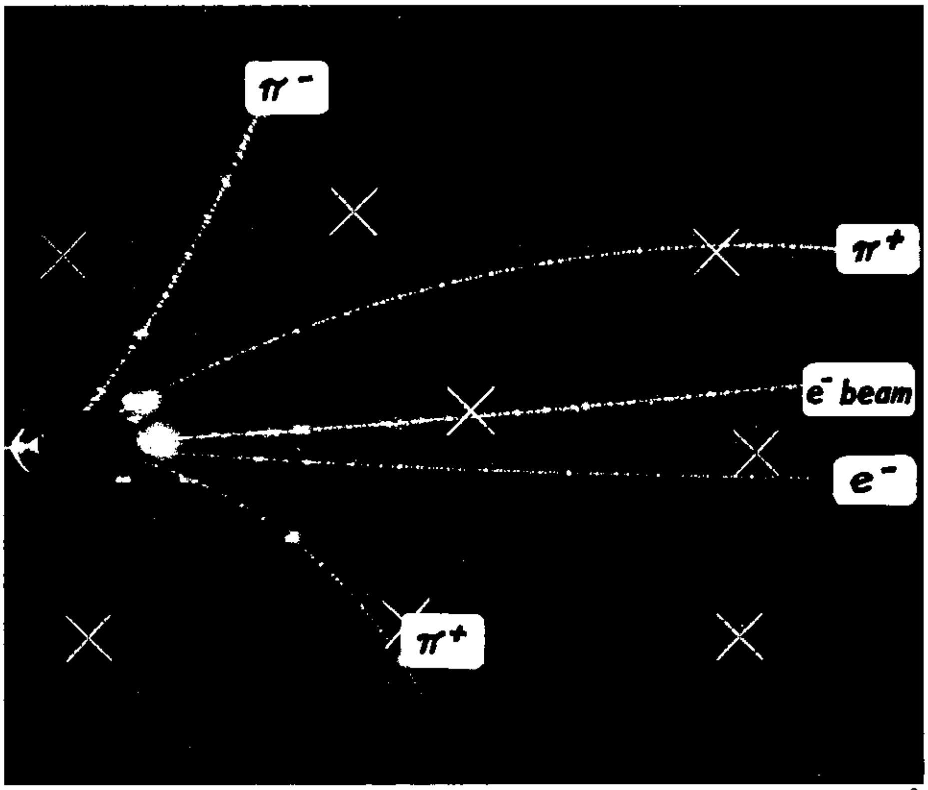


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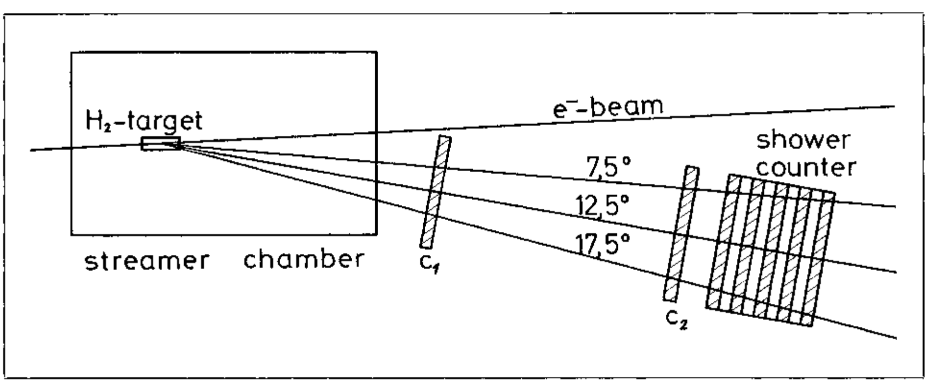


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A liquid hydrogen target is placed within the high voltage field of the sensitive volume. It has a length of 10 cm in the direction of the beam and a width of 1 cm. For thermal isolation it is surrounded by an evacuated container made of plexiglas. Liquification of the hydrogen is achieved with a refrigerator based on the Joule-Thomson effect, placed at the back of the chamber and working within the magnetic field.

In July the first pictures were taken in a study of the electroproduction of hadrons, (i. e. the reaction $e + p \rightarrow e' +$ hadrons in the transition region from no scaling to scaling detecting all hadron final states). The chamber is triggered by the scattered electron which is tagged in a hodoscope of shower and scintillation counters. The kinematical region which will be explored comprises momentum transfers between 0.3 and 1.3 $(GeV)^2$ and hadron masses up to 3 GeV. The intensity of the electron beam is limited to approximately $10^6$ electrons per second by the number of knock-on electrons and with this flux about 1000 events per day are expected.

The experiment on electroproduction of hadrons will continue when the synchrotron comes into operation again after the present shut-down, which is scheduled to last until November.

*1. The newly built streamer chamber at DESY. In the foreground is the ten-stage Marx generator and Blumlein pulse forming system. The chamber is 1 m long, 60 cm high with two inter-electrode gaps of 24 cm. (Photo DESY)*

*2. An example of the quality of photograph being obtained in the DESY streamer chamber. This multi-pion event (taken with an incoming beam of $2 \times 10^5$ electrons/s and a memory time of 2μs) was recorded during a test run prior to the start of an experiment on the electroproduction of hadrons.*

*3. The layout of the counter hodoscope which will be used to trigger the optical system of the streamer chamber when an event of interest has taken place.*

# Inauguration 16 October 1971

*Extracts from the speeches given on the occasion of the formal inauguration of the Intersecting Storage Rings. The ceremony was held in Hall I 4 in the presence of about 1000 visitors and CERN staff. The principal speakers were Professor Victor Weisskopf and Ambassador François de Rose. Professor Werner Heisenberg inaugurated the ISR.*

## Professor W. K. Jentschke

*The Director General of CERN Laboratory I opened the ceremony with a few words of welcome...*

'It gives me great pleasure to welcome to our Laboratory the many distinguished visitors who have honoured us today with their presence at this ceremony of inauguration of the intersecting storage rings.

Professor Heisenberg, Ambassador de Rose and Professor Weisskopf are so well known to almost all of you that they need no introduction. We are happy to see also so many of our good friends from amongst the French and Swiss authorities, who by their generous collaboration made easier our task of building this new instrument. We are honoured by the presence of many eminent scientists, representatives of national Laboratories, people who have worked closely with us in the conception and realization of the project and the formulation of a scientific programme which has already started on the machine.

None of what we see here today would have been possible without the support of Europe's industries, who succeeded within the time limits in making what we wanted. Amongst our guests are representatives of the firms which contributed to the construction of the ISR. And finally we have the staff of the ISR Department, for whom no praise is too high, and the many other people who also played their part in the project. I am proud to find myself at the head of such a group of people.'

## Professor K. Johnsen

*The Director of the ISR Construction Department presented the project...*

'Today is a great day for all of us who have taken part in the construction of the ISR. It is therefore natural to look back and let our minds dwell on the milestones we have past, and on the difficulties and pleasures we have had.

The real start of the history of colliding beam devices was in 1956 when the research group of the Mid-western Universities Research Association in the USA with Professor D.W. Kerst as its leader, put forward the idea of particle stacking in circular accelerators. Of course, people who worked with particle accelerators had dreamt earlier about the high energies one could obtain if one could only make particles collide with each other. This could, however, only be dreams with the particle densities available in accelerator beams at that time. The invention of particle stacking changed this drastically, and many laboratories began studying colliding beam devices during the latter part of the fifties. At CERN such work was carried out under the guidance of the late Professor A. Schoch.

The next important step forward was the coming into operation of the two large proton accelerators at CERN and Brookhaven in 1959/60, which not only produced higher energies than previous accelerators, but also higher beam densities than people had dared to hope. After this, simple evaluations demonstrated that storage rings added to the CERN proton synchrotron could become a research tool of great potential and we decided to concentrate considerable effort on practical design studies. At the same time we started European-wide — even partly world-wide — discussions about the physics interest in such instruments.

These discussions were very difficult because, with the knowledge then available, there were very good reasons why people developed very divergent views. In particular both the project itself and the possible physics programme had many uncertainties that the detailed discussions could only partly clear up. Nevertheless, our Director-General, Professor Weisskopf, presented to the CERN Council the proposal to construct Intersecting Storage Rings based on a detailed design study issued in 1964. It looked to me as if the political bodies became attracted by the novel features of the project, by the uniqueness of such a device in the world and even by some of the daring aspects of storage rings. Our Member State governments authorized CERN to go ahead from 1 January 1966.

What had largely been a paper study suddenly became a reality. Much money was involved, much difficult work lay ahead. I shall never forget my feelings when in large rubber boots, I first inspected this site, so generously put at our disposal by the French government, after bulldozers in large numbers had gone to work.

I could accept responsibility for the construction because I had around me a very good nucleus of a design and construction team with Dr. K. Zilverschoon as my closest collaborator. We had a powerful Parameter Committee of very knowledgeable accelerator physicists and engineers, and could go ahead at once, building up the staff needed, building up further knowledge, diving into the detailed design and approaching European industry with our problems.

A few special words are merited concerning our relations with industry. The novelty of our project meant that it was unfamiliar to industry in most of its aspects. On the other hand, the specialized know-how that industry had in relevant fields, was extremely important to us, in particular since we quite often found it necessary to work at the limit of what present day techniques can give. Therefore, we had to create the right kind of relation and mutual confidence. It was our studies that crystallized out requirements, tolerances, etc., that had to be imposed. But there was no point in putting down impossible requirements, and here our close contact with the industries concerned put in the right kind of corrective. In some cases we had to give in to the hard facts presented by them, in other cases we could convince them that things they thought impossible were in fact possible. Altogether, we placed contracts for about 250 million Swiss francs for this project, and we have come out of this with excellent relations with our suppliers. The goods are here, and in general of the quality needed for such a difficult project.

Of course, everything did not happen according to the original planning. Sometimes things were late, or other difficulties were encountered. In such circumstances flexibility is required by everybody concerned. The staff of the ISR Department, showed the highest degree of team spirit, which became particularly visible during the final stages of the installation when many critical situations arose. Also the whole CERN Laboratory was behind us with continuous help during the whole construction period.

The first beam tests started by the end of October last year, a little ahead of schedule... the day for trying a circulating beam was 29 October, and what a day it became. I remember walking around the machine in the afternoon. Everything was there, clean and tidy but I could not believe that there would not be a hidden fault somewhere among those thousands and thousands of components. But it did work, and incredibly so. In a control room packed with people, anxiety radiating from their faces, we saw the first beam go straight in, we had lifetime tests and we stacked to considerable beam currents. It is on such occasions that it is nice to be in charge, not only because of the impression of being part of a success, but also because of the fantastic feeling of sharing what happens with a large number of other human beings who have been collaborators and whose faces show that they feel exactly as you — excited and pleased. During the whole construction period Professor Gregory had been our Director General but his term of office was coming to an end. We felt that it would be nice to give him at least one beam before he left, and we were very pleased that we succeeded, and that he could personally share the excitement with us.

It remained to produce the other beam so that we could collide protons. This had to wait until January, and we were able to share these exciting events with the new Director General, Professor Jentschke. On 27 January we registered the first ever observation of proton-proton interactions in colliding beams. What was being seen was equivalent to what a conventional accelerator could produce if it had an energy of at least 500 GeV. Such phenomena had never been produced before in a controlled fashion and on later occasions we went considerably higher. The joy was not less than during the night of the first beam tests. We could announce to the whole physics community and to the CERN Council that we had achieved what we had promised — a colliding beam device for protons.

It was only a month later that we were ready to receive the first experimental teams. The construction period was declared over on 1 March, some four months earlier than originally planned and the costs were within the foreseen budget of 330 million Swiss francs with a small margin.

This does not mean that we can sit

*The two invited speakers at the inauguration, Ambassador de Rose (left) and Professor Weisskopf. They were photographed while taking a look at the ISR prior to the ceremony.*

down and relax — we find ourselves busier than ever... but that is another story.

May I finish with a few words to the President of the CERN Council, Professor Amaldi, who represents the authorities behind this Organization for which we are priviledged to work. I should like to express our appreciation for the confidence that we were given during the construction period. It has been an experience that will always be a pleasure to think back on. Our most sincere wish is that this instrument will now be given the opportunity to show its worth as a research tool. With the support we have had in the past, we look with confidence to the future.'

## Professor V. F. Weisskopf

*Former Director General of CERN...*

'We are celebrating the end of a great mission. I was fortunate enough to be present when the idea was born and when the decision was taken to embark upon this tremendous project. The main originators of the idea were Professors Donald Kerst of Wisconsin and Gerard O'Neill of Princeton and Gösta Budker of Novosibirk ; the machine was designed and developed by CERN teams led by Professor Kjell Johnsen and Dr. Cees Zilverschoon. My only contribution to the project was to show some enthusiasm when I was Director General !

There were three personal reasons for this enthusiasm : firstly, a deep belief in the fundamental importance of our growing insights into the basic structure of matter ; secondly, a deep conviction that the physicists of Europe can, and should, be not only on a par with other scientific communities but ahead at least in some aspects ; thirdly, a deep sentimental attachment to CERN, this unique social and political experiment which brings together people from many different nations in a life full of intellectual creativity — and which happens to be located at one of the most beautiful spots on our planet.

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In an advanced field of science such as high energy physics certain preconditions are necessary for the success of an idea and a project. One needs — intellectual strength of highest order ; inventiveness and originality in the choice of questions to be asked of Nature ; the application of the most advanced technical tools (even more, one must develop the available tools and invent new technology) ; most of all, courage and daring to go along untrodden paths and to use untried methods where there is always the possibility of failure. And one needs confidence that a task can be done in spite of the apparent difficulties — indeed, one must be attracted by those difficulties.

All these aspects were and are amply present in the ISR project. It is a new way of asking questions of Nature. It required, and it will require, new ideas, new instrumentation in order to read Nature's answers. Many people said in the past that it could not be done. It required the highest technological skill and innovations to a larger degree than the construction of previous accelerators ; to quote just one example, the ISR contains the largest ultra high vacuum ever produced in the world. It needed foresight and both conservatism and daring, to achieve a machine the like of which has never been built before. But it was achieved after all : it worked the first time it was turned on. After only three months of running, it has given us most interesting and unexpected physical results. As Professor I.I. Rabi said, 'The ISR does not ask questions to Nature ; it grabs Nature by its throat and forces her to speak !'

There are more reasons why one should be enthusiastic about the storage rings. It brings different kinds of physicists into close co-operation. CERN as a whole has brought together scientists from France, Germany, Italy, Britain, Scandinavia and many other countries to work at the same task. The ISR is bringing into closer touch two types of physicists — the experimental physicists and the machine builders, who have been too much separated in the past. The machine physicists have built accelerators, bubble chambers and other useful devices and the experimental physicists have then taken them over and 'used' them. At the storage rings the situation is different. Every experiment represents a changed and improved storage ring. One cannot 'use' the ISR without being deeply involved in its running. Therefore, the work at the ISR re-establishes the unity of instruments and experiments which is so important for a healthy development of our science.

These were some of the reasons for my enthusiasm. But there were people who thought that it would be too much of a risk ; they said that only very few experiments could be done at such a machine. They said, 'The Americans did not build it, so it cannot be a good machine'. It was often difficult during the planning phase to keep up one's enthusiasm. I surely would have lost my own if there had not been other people who helped keep the idea alive. Fortunately, there were quite a number and a list of them would be too long, but I would like to mention three by name. One is Eduardo Amaldi and another is François Perrin, who have supported and defended the idea from the beginning. The third is Mervyn Hine without whose insistance, critical wisdom, push and energy we would never have arrived at a decision to go ahead. But those to whom we really owe this marvel of an instrument are the builders — the Bonaudi's, Resegotti's, de Raad's, Fischer's, Schnell's, Van der Meer's — who, under the leadership of Kjell Johnsen and Kees Zilverschoon have done great work. They could not have succeeded without the constant help of the teams of extremely skilled engineers, mechanics and workers who were able to translate the ideas into practice. I cannot give all their names here but would like to mention Mr. Horisberger and the late Mr. Stierlin. In the name of Europe and of the physics community of the whole world we thank you all.

I wish to add a word or two of warning. We scientists in our small community in Europe are well aware of the value of fundamental science and of the value of this unique social and international experiment that is CERN. However, I fear that the public at large remains more or less unaware of this. It is the duty of CERN and of the European scientists to remedy this, a duty as important as research itself.

We live at a time when there are strong trends away from science, rationalism and the promotion of objective and rational research. CERN should be a mainstay against these dangerous trends but I do not think that we are or, at least, not as much as we could be. We must make much better use of CERN's dual role as a unique scientific and political institution. We must bring out the romantic quality of fundamental research and the romantic quality of international cooperation.

Perhaps we are a little spoilt by the success of CERN and by the fact that we have, after all, persuaded Governments to continue and to increase their financial support. This success will not last if CERN does not become a source of pride for a much greater proportion of the population, an emblem of the new spirit that prevails or should prevail in Europe. But it is not only financial support that is in jeopardy, it is the new Euopean culture — the new role that Europe should play in the culture of the future, as a link between the old and the new, between East and West, between the glories of yesterday and the great potential of tomorrow. To fulfil this role, Europe needs the spirit and scope of CERN on a much greater scale and in much greater evidence.

We can now be confident with regard to CERN's future, not only because of the success of the ISR, but mainly because the construction of the new 300 GeV accelerator is finally under way. This fact alone assures that Europe and CERN will ride on the crest of the wave in high energy physics.

When I talk about ISR, I am sincerely and frankly biased. I love this baby of ours and I believe that it represents the wave of the future. I am also sure that the new method of clashing beams — the ISR way — will be taken up again and again, on larger scales, in connection with the 300 GeV accelerator here at CERN, in Batavia, in Brookhaven, in Serpukhov, in Novosibirsk and at many other places. In Germany there is already a sister ring for clashing electron beams under construction.

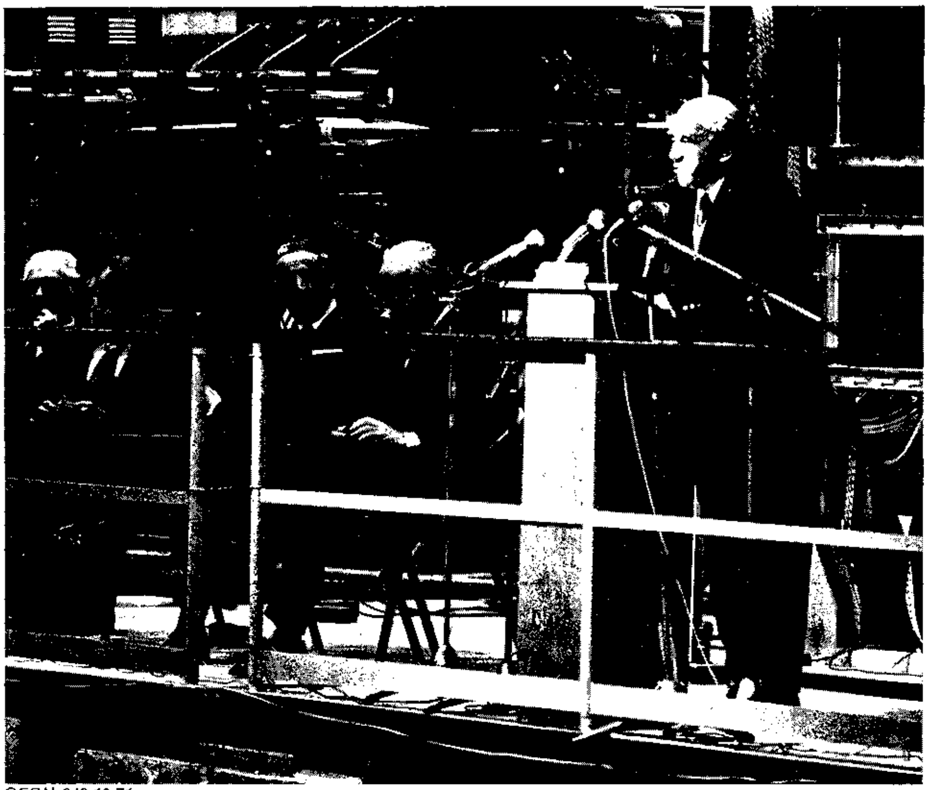
Let me end with a variation of a famous remark of Ernest Rutherford : 'Here at CERN we not only ride the crest of the wave, we made the wave.'

## Ambassador F. de Rose

*French Ambassador to the North Atlantic Council and former President of the CERN Council...*

'In my association with CERN, there are three dates which stand out vividly in my mind. The first was twenty years

*Professor Werner Heisenberg speaking at the ceremony when he inaugurated the ISR. To his left are Professor Jentschke, His Excellency M. Anthonioz, Professor Weisskopf and Professor Amaldi.*



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ago, when the countries of Europe agreed to examine the possibility of setting up an international institute for research.

The second was eleven years ago, when I was President of the CERN Council. We inaugurated the Proton Synchrotron, the most powerful accelerator then in operation in the world which brilliantly fulfilled the objective laid down by our governments — to provide European physicists with a research tool that would enable them to play a part in scientific progress comparable to that of their predecessors.

The third is this inauguration ceremony. In view of my association with CERN, and the fact that I am the only non-scientist to be speaking, I feel justified in recalling the reasons for CERN's exemplary success. After all, progress was not achieved by simply avoiding the difficulties that were encountered.

There was the difficulty of breaking fresh ground — an agreement had to be formulated on the basis of which thirteen countries could cooperate, in a field that, until then, had mainly been the concern of a few inspired men. There were the difficulties in convincing politicians, who did not have that priceless asset — a precedent to which they could refer. In scientific circles too, many people were seriously concerned that the adoption of an international programme might prove detrimental to the national programmes. There were difficulties in investing large sums of money in fundamental research, the profitability of which could hardly be assessed on the basis of economic terms. There were difficulties for governments in reconciling so many competing requests when any choice implied a bitter sacrifice.

Finally there were the new problems of the expansion of the site for the machine we are inaugurating to-day. For the first time in history, a large laboratory is straddling the border between two countries. One has only to think of all the different types of problem that have been solved — of sovereignty, jurisdiction... — to realize how true it is that there is a mystique of CERN. I hope that these solutions will make the next stage easier — that of building the super-accelerator, wich will be situated almost entirely in France.

I would like to express my thanks to all those who bore a responsibility in the making of CERN's future. There has been enthusiastic support for the idea that particles produced in Switzerland would be accelerated across the border at the speed of light and made to collide in France. This idea was most favourably received by General de Gaulle and his Government, and in Switzerland by the Federal and Geneva authorities. Also by Parliament and, in particular, by the then President of the Commission for Foreign Affairs, Mr. Maurice Schumann, who has maintained his keen support for the idea as Minister for Scientific Research and to-day as Minister for Foreign Affairs.

I am sure that the Mayor of Divonne, Minister M. Anthonioz, gave indispensable aid in enabling the CERN site to be extended into the Pays de Gex. His presence here to-day, despite the burden of governmental responsibility for the development of tourism in France, is proof that the interests entrusted to him are being fully met by CERN's present and future achievements.

I would also like to pay tribute to the efforts of Senator R. Ruet, Conseiller General, of President J. Saint-Cyr and of Mr. G. Dupoizat, Prefect, of the Department of the Ain. The communes of St-Genis and Prevessin — whose Mayors, Mr. P. Blaison and Mr. G. Laverrière, are with us — took the

*The two Directors General of CERN during the construction of the ISR photographed before the ceremony. On the left is Professor Gregory, Director General from 1966 to 1970 who saw in the first stacked beam in October of last year. On the right is Professor Jentschke, Director General from the beginning of this year who saw in the first operation of both rings together and the first proton-proton collisions in January.*

first steps in welcoming to the very ground where we now stand the machine we are inaugurating. Their Communes are also receiving the Super Proton Synchrotron. This gigantic machine will, in fact, occupy no less than a third of the communes. In a few years' time, they will rank first among their 38 000 sister communes in area devoted to scientific research.

CERN is forging ahead of the goal set by its founders. This is true from the geographical standpoint — after being the first international laboratory, it is now the first international institution with a site spreading into two countries. It is also true from the standpoint of its objective. At the outset its aim was to provide European scientists with research facilities equal to those existing in the most powerful countries in the world. But these storage rings are unique in the whole world. Is it not in keeping with the vocation of our continent, which for long was the main centre of research activity, that we should place this machine at the disposal of scientists not only from our own countries but also from all countries in the world ? The saying that science knows no boundaries will probably never again be illustrated in such a striking manner.

The success of the enterprise and its future, depend on establishing permanent contact between Geneva and the national centres to ensure a true community of men, ideas and equipment. This two-way system of communication had to be constantly maintained and the interpenetration between the research done here and the academic work of the Universities had to be as complete and permanent as possible. CERN had to be the opposite of an ivory tower, where a few privileged persons enjoyed a wonderful adventure, but were isolated from the rest of their colleagues.


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This objective has been achieved since about two-thirds of those working in Europe on high energy physics research are collaborating with CERN; 80 % of the experiments here are carried out by visiting scientists and 20 % by the Organization's staff. With the storage rings this situation will be maintained — the first experiments were prepared by combined teams from no less than thirty-four Universities.

Another reason for success was the reliability of the expenditure forecasts, which as far as the Finance Ministries were concerned, built CERN's reputation as an Organization which, although its expenditure was considerable, revealed no hidden surprises. The machine we are inaugurating was completed slightly ahead of schedule and the initial cost was respected. One has only to remember that the task involved building an entirely new machine to realize that Professor Johnsen and his team achieved what elsewhere would be considered a masterly feat but at CERN is already a tradition.

With the ISR and the 300 GeV accelerator, our governments really looked far ahead since it is generally recognized that CERN will satisfy the needs of European research into the composition of matter up to the end of the 1970s and, with the improvement possibilities open to it, will continue to do so right up to the end of the century.

It is also an act of faith. In the present circumstances, this is of special importance as it reflects two trends of thought which question the attitude of society to scientific research. For some, the expenditure is out of proportion to our resources. Just as the major roles in space research fell to the two 'super-powers', so too, fundamental physics should be left to them. Europe would restrict its ambitions to the technological exploitation and to

*The key to the beam stopper which intervenes between the 28 GeV proton synchrotron and the Intersecting Storage Rings. It was this key, gold-plated for the occasion, which changed hands in the inauguration of the ISR. It now rests in state in a small box which has engraved on its lid a picture by the 19th century painter, Gustave Doré, which was designed to illustrate La Fontaine's fable 'The Two Goats'. The picture shows the goats in head on collision.*

the applications of fundamental discoveries made elsewhere.

This view, whilst tempting, clearly results from the failure to appreciate that Europe was the birth-place of modern science where human thought as we know it took shape. Our countries are not, however, the only ones involved in this adventure — scientific progress is not linked with a particular environment or culture. And to think that, at a time when this superior mode of communication between men of different cultures was acquiring a truly universal dimension contributing to the birth of a genuine world civilization, Europe would withdraw its participation ! It is an invitation to abandon intellectual — and therefore cultural, political and economic — development. Such a policy would also be one in which we had everything to lose. Technology develops only where fundamental research thrives.

Others — their number is perhaps greater and their out-look more idealistic — feel that it is science as the source of technology which should be challenged. We are no longer living at the time when science was enveloped in an aura of holiness and it was believed that scientific progress would guarantee the happiness of mankind. The applications of science may compromise even the continuation of life on this planet : already the ravages of pollution stemming from the uncontrolled development of technology are such that a number of people — particularly the younger generation — contest science itself and suspect it of containing an inherent threat to our natural environment, to freedom and even to human life itself. It is precisely because this fear is a real one, and may be justified, that the role of CERN, devoted to fundamental science and based on international cooperation, acquires a new dimension and even greater respect.

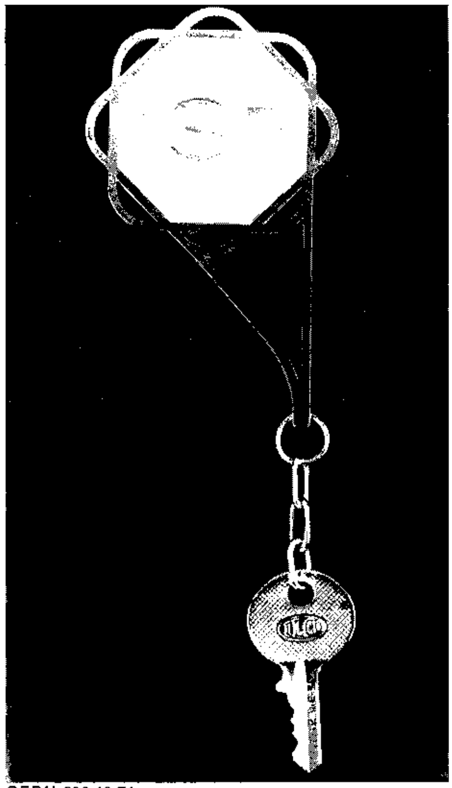
With the inauguration of the Intersecting Storage Rings and the construction of the Super Proton Synchrotron, physicists must be more than ever conscious that they have received special treatment in competition with so many other sciences and with other needs of public importance. Just as privilege entails responsibility, so this special treatment carries with it certain duties. Firstly, the duty to remain faithful to the scientific ambition and to the political ideal which gave birth to this Organization ; secondly, the duty to persevere along the path of its success.

It is in this way that CERN will continue to illustrate and perhaps define the role of science in the society of tomorrow — science that is neither religion nor counter-religion neither panacea nor evil spirit, but a fundamental part of culture and the most powerful means by which the destiny of mankind may be transformed. It is gratifying that the contribution of the nations of Europe in this task is the fruit of an exemplary international co-operation entrusted above all to our younger generation.'

## Professor W. Heisenberg

*Nobel laureat for physics ; delegate of the Federal Republic of Germany to the CERN Council from 1955 to 1964...*

'I congratulate CERN, its physicists, engineers and organizers, on the completion of the Intersecting Storage Rings. I consider this a very important achievement in the history of CERN, a step towards the exploration of a new part of elementary particle physics which could be seen but hardly explored in the cosmic radiation. The storage rings will give CERN a leading position in international high energy physics for many years to come.



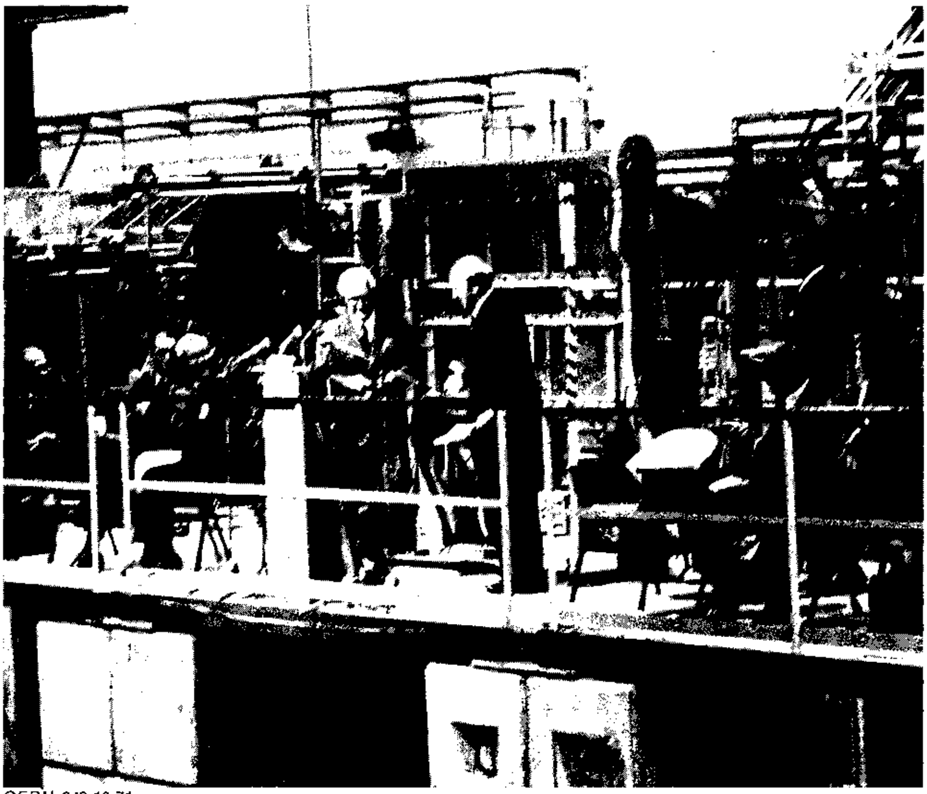
*CERN 396.10.71*

If the storage rings were a ship it would be appropriate to smash a bottle of wine or champagne on the bow of the vessel. But they are not a ship and it would be better to press a button, release a beam and thereby smash a number of elementary particles. But that could not be seen and would therefore not be very impressive. So we have decided on a less spectacular ceremony.

Here we have a key, a golden key which controls the transfer of protons from the Proton Synchrotron to the Intersecting Storage Rings. I have it here not only for our own protection but also in order to hand it to the President of the CERN Council, Professor Amaldi.

Let this key be a symbol of our hope that the Storage Rings will be the key to a thorough understanding of the world of elementary particles. As is the rule in physics, such a symbolic key should first be in the

*The moment of inauguration. Professor Heisenberg hands the key to Professor Amaldi, President of the CERN Council and representing the European h'gh energy physics community.*



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hands of the experimental physicists and only when they have done their work should it be handed back to the theoreticians. I give it to Professor Amaldi as an experimental physicist but in the hope that it will not be too long before your colleagues from the Storage Rings can symbolically hand it back to my colleagues, the theoreticians, with many good new results.'

## Professor E. Amaldi

*President of the CERN Council and representing the European high energy physics community...*

'In receiving this key, I would like to stress the outstanding contribution to the life of CERN of all those who have already spoken and who are here to celebrate the most recent and, at the same time, one of the most important, successes of the Organization : the commissioning of the Intersecting Storage Rings. I would like once more to express the gratitude of the Council to Professors Weisskopf and Gregory for their outstanding contribution, as Directors General, to the Intersecting Storage Rings project and to the present Director General of Laboratory I, Professor Jentschke, since it was under his direction that the machine first operated and provided its first scientific results. Also, for several years before his appointment, Professor Jentschke was Chairman of the Storage Rings Committee which established the scientific programme now being carried out at this machine.

The Council's warmest thanks go to those who took part in the design and construction of the storage rings. Above all, they go to Professor Johnsen, who competently and firmly, but also with typical Scandinavian composure and simplicity, brought this exceptional enterprise to a successful conclusion to the entire satisfaction of the Council, Finance Committee, Scientific Policy Committee and the community of physicists. I ask Professor Johnsen to convey our appreciation to all his staff. The value of their achievement lies not only in the uniqueness of the storage rings, which enable a new field of high energy physics to be explored, but also in the perfect operation of the machine which can therefore be used to maximum effect by the physicists.

I would like to associate myself with Ambassador de Rose in expressing the Council's gratitude to the local authorities, and primarily to the French authorities on whose ground the storage rings are situated. I also thank the governments of France and Switzerland, who collaborated, between themselves and with CERN, in solving a long list of completely new problems arising from the fact that CERN's Laboratories spread into both countries.

Finally, I would like to express on behalf of the Council, the Directors General, past and present, and all the research physicists both at CERN and in the national laboratories working in collaboration with our Organization, our profound gratitude to the governments of all the Member States. It was they who provided the Organization with the resources to build the ISR, which will enable European physicists to make a vital contribution to the development of high energy physics in the years to come, during which time another great CERN programme is taking shape — the construction of the 300 GeV accelerator.

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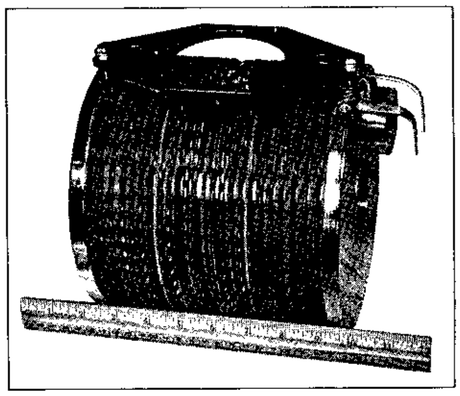

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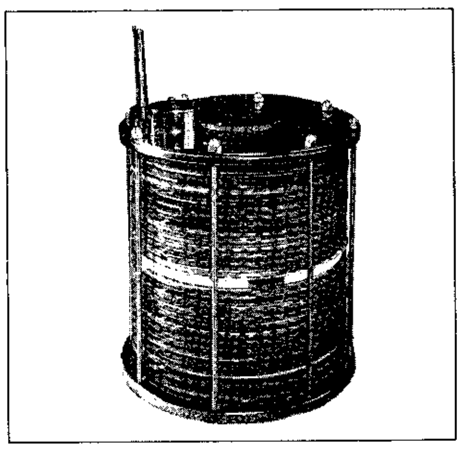

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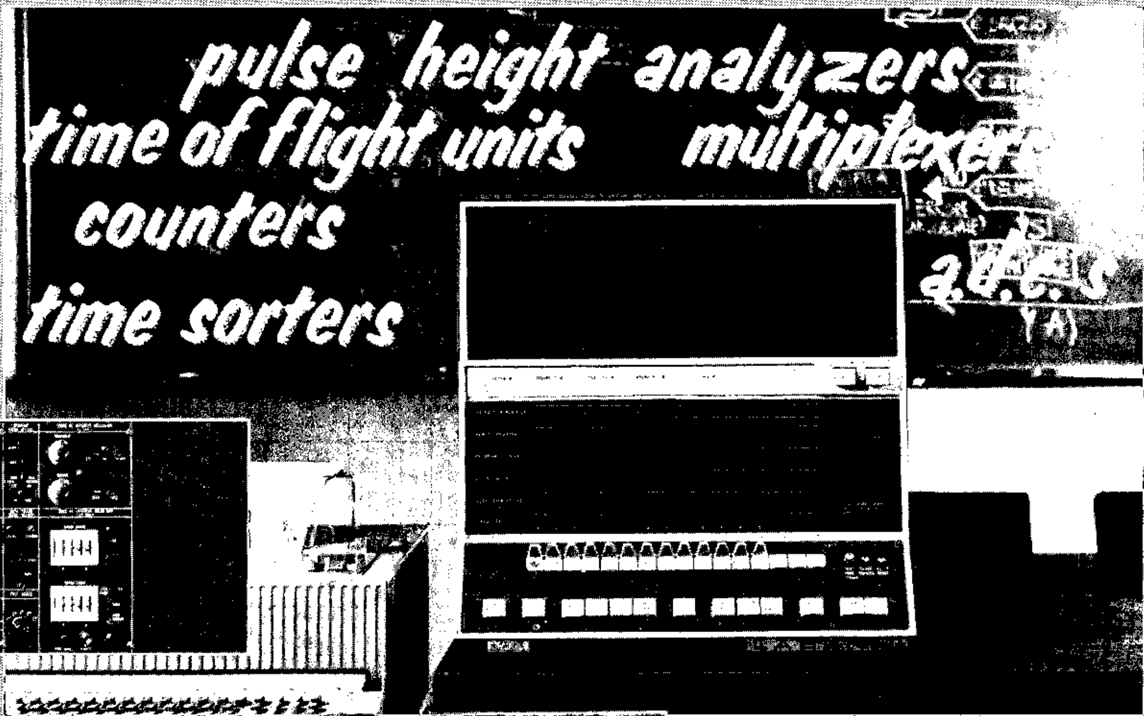


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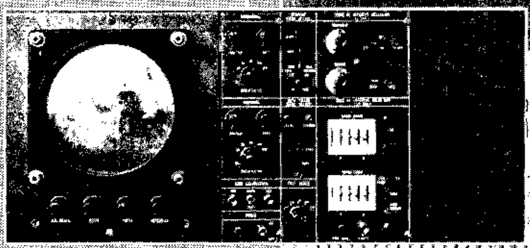

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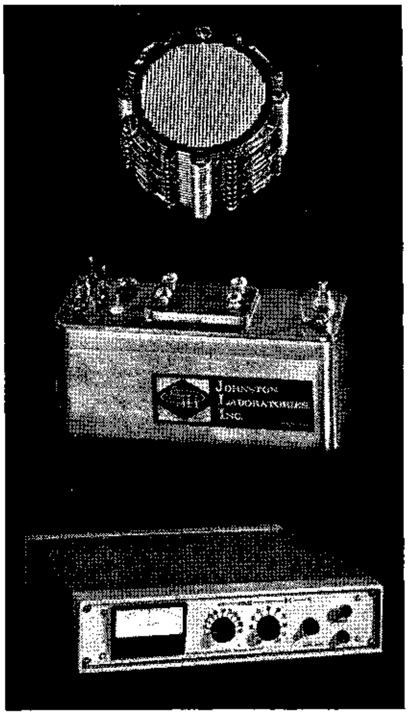

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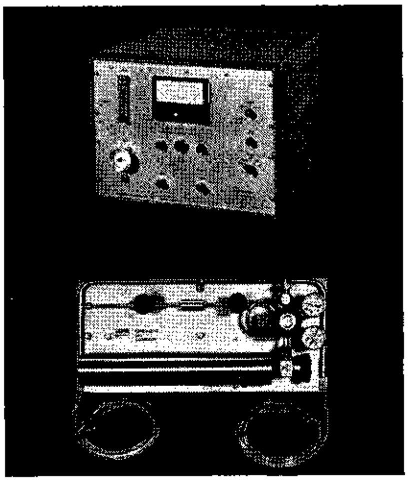

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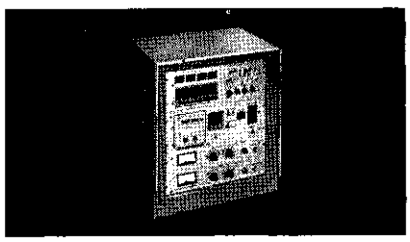
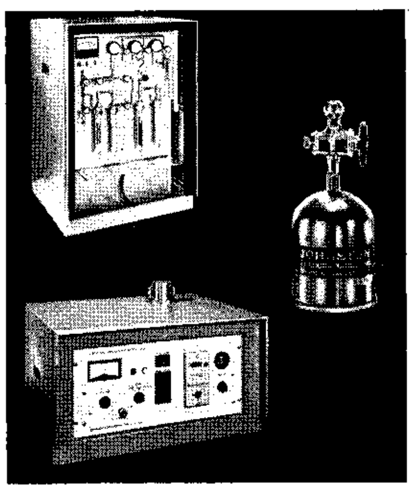
**Electronic Console (GEC-12).** For simultaneous, ultra low level analysis of carbon-14, tritium, radon, and beta radio gases. Absolute efficiency: 85%. Reproductibility: 0.1%. More sensitive than liquid scintillation. Use in tracer studies, radio-carbon dating, biochemistry, hydrology.



# Radon System

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



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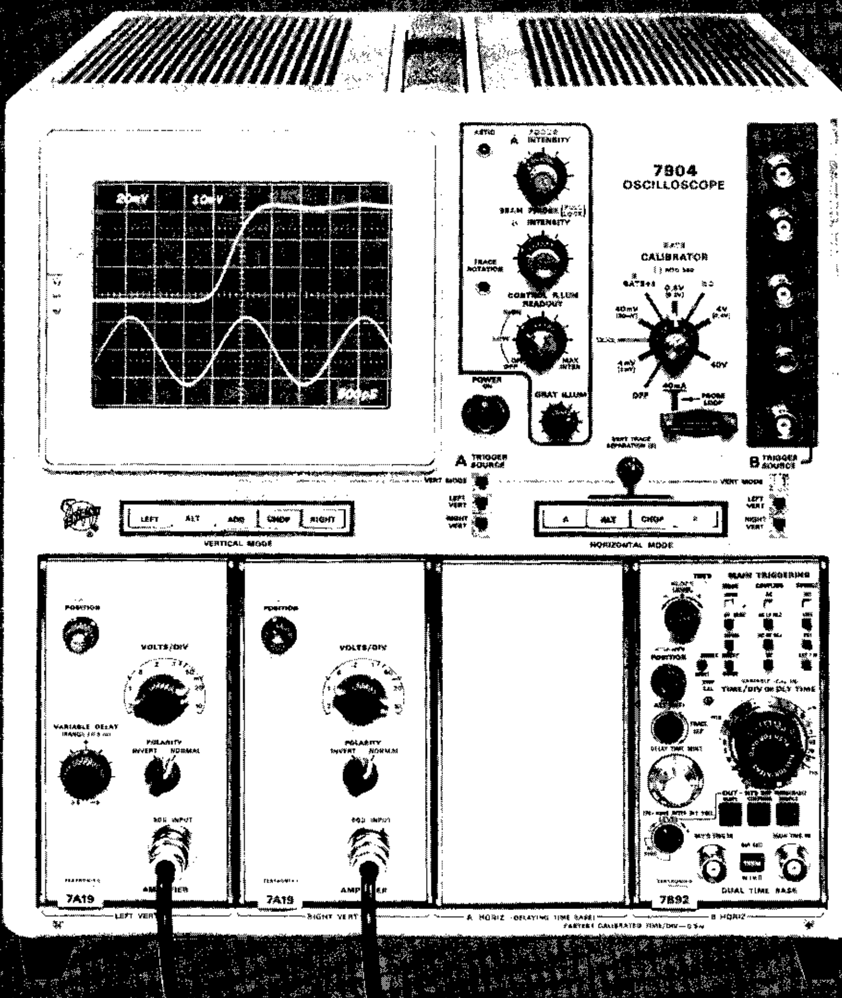
**Johnston Laboratories, Inc.**

**3 Industry Lane, Cockeysville, Maryland, USA 21030**

# 500-MHz

## with 1-Gigahertz Direct Access



The new Tektronix 7904 Oscilloscope is power packed. With 7A19 Amplifier plug-in it offers a phenomenal real-time bandwidth of 500 MHz at 10 mV/div. And the ultra-high CRT bandwidth makes possible direct access offering 1-GHz bandwidth at a deflection factor of 4 V/div.

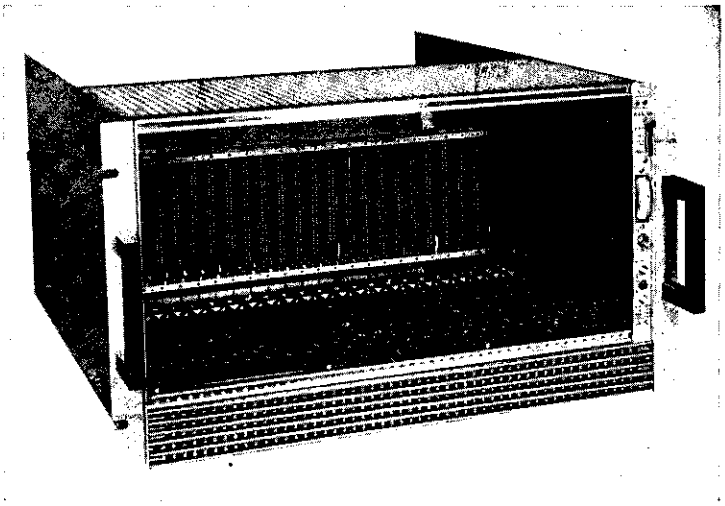
The new 7B92 Dual Time Base is in a class of its own. It has sweep rates to 0.5 ns/div, triggering to 600 MHz and a display mode that allows you to view the intensified delaying sweep and delayed sweep simultaneously.

**Instrument prices:**

| | | |
|---|---|---|
| 7904 | 1 GHz Mainframe | Fr. 13 610.— |
| 7904 | without Readout | Fr. 11 730.— |
| 7B92 | Dual Time-Base | Fr. 6 570.— |
| 7A19 | 500 MHz Amplifier | Fr. 2 350.— |
| 7A2IN | Direct Access Unit | Fr. 1 640.— |

**Tektronix International AG**
**6300 Zug Tel. 042 21 91 92**

# SAPHYMO-SRAT



## Le pionnier dans les alimentations Standard « CAMAC »

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C7 ALJ 13 D

**200 Watts disponibles**

| | |
|---|---|
| + 6 v | 25 A |
| — 6 v | 10 A |
| + 12 v | 3 A |
| — 12 v | 3 A |
| + 24 v | 3 A |
| — 24 v | 3 A |

**DIVISION ALIMENTATIONS**

**SAPHYMO-SRAT**

**SERVICES COMMERCIAUX**

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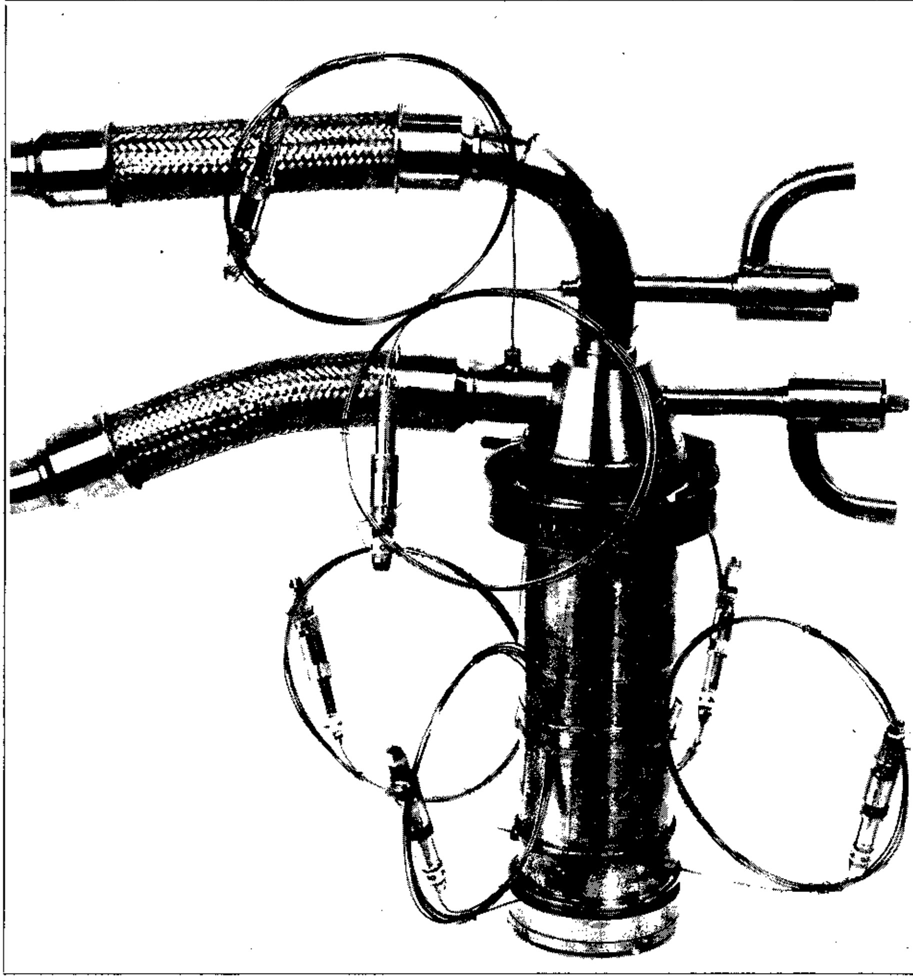
**Tél. 588.16.39, 588.45.39**

AUTRES FABRICATIONS

Blocs BSI
Blocs type CEA
Alimentations variables de laboratoire
Alimentations haute tension
Alimentation multi-sorties
Alimentations sur mesure



Cette cible à neutrons destinée au Bureau Central des Mesures nucléaires de GEEL (Euratom) est réalisée à partir d'un cœur en uranium allié à 10 % de Molybdène, gainé d'acier inoxydable mince. Elle est refroidie au mercure.
La réalisation de telles cibles fait appel, outre les techniques particulières liées à la mise en œuvre de l'uranium, à de grandes compétences en soudage fin, microsoudage et instrumentation.
A cette occasion, CERCA a mis au point des techniques fines de jonction étanche thermocouple-gaine par soudage direct de la gaine des thermocouples sur des raccords spéciaux.

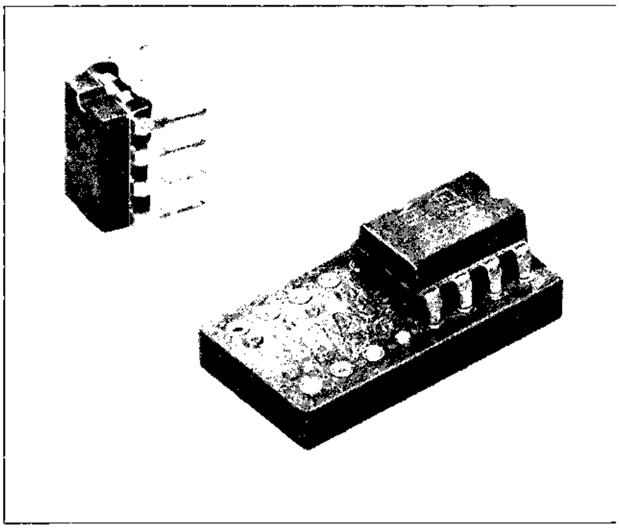
# CERCA

**Compagnie pour l'Etude et la Réalisation de Combustibles Atomiques**

**41, Avenue Montaigne PARIS 8e**
**Tél. : 359 - 46 - OO TELEX : CERCA PARIS 29 - 242**

## Circuits intégrés Signetics

# Amplificateurs opérationnels de première qualité en boîtier silicone MINI-DIP-Dual-in-Line à 8 pattes (désignation «v»)



| | | | |
|---|---|---|---|
| NE | 531 | V | High slew rate : 35 V / µs. typique pour des gains de 1 à 100 |
| NE | 533 | V | Micropower: consommation max. 100 µW sur Vs = ± 3V |
| N | 5709 | V | General Purpose: remplacement µA709 |
| N | 5741 | V | General Purpose: remplacement µA741 |
| N | 5748 | V | General Purpose: remplacement µA748 |
| N | 5556 | V | High Performance: remplacement MC 1556 |
| N | 5558 | V | High Performance: remplacement MC 1558 |

**D'autres amplificateurs opérationnels intéressants de Signetics sont aussi à disposition.**

## Qui achète des circuits intégrés, achète aussi des socles AUGAT

**Dewald Electronic**

**Dewald SA, Seestrasse 561, 8038 Zurich**
**Tél. : (01) 45 13 00**

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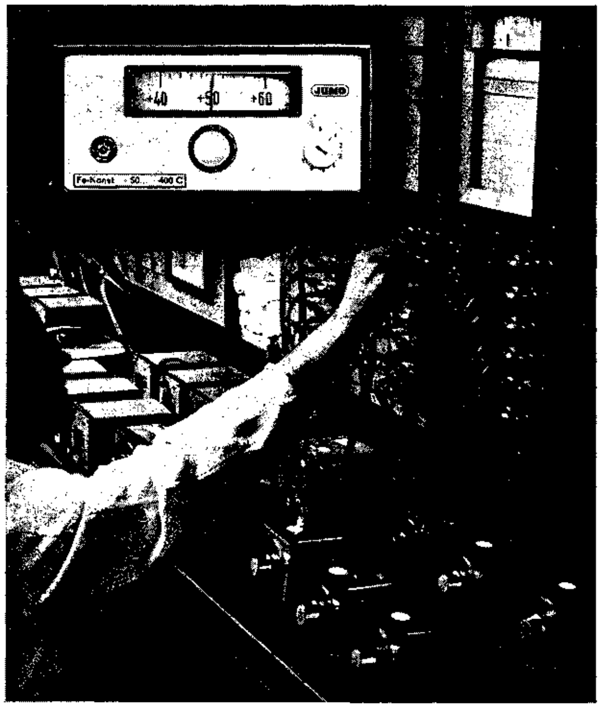
of plastics machinery, industrial furnaces and ovens, climatic test equipment, and drying installations using JUMO electronic controllers with proven long-term performance



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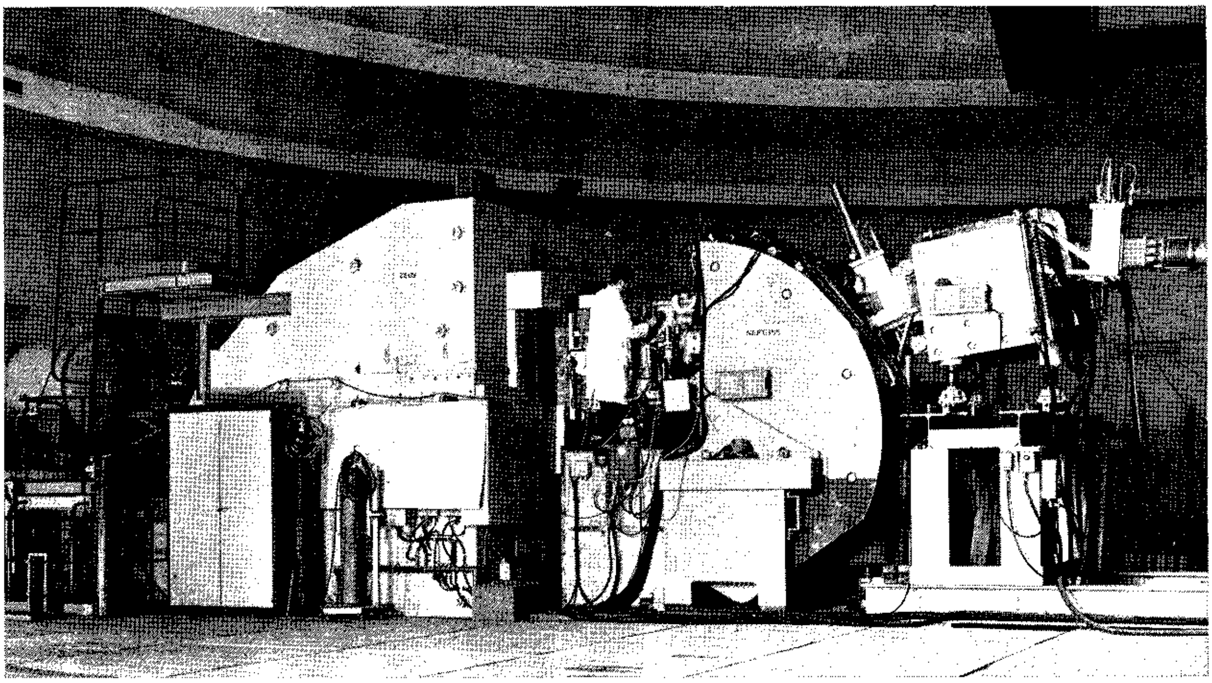
# Creusot-Loire nucléaire



Laboratoires de physique nucléaire
(équipements pour accélérateurs - analyseurs - spectromètres)

**Cern (Genève)**

- circuit magnétique du synchrocyclotron (2 500 tonnes)
- circuits magnétiques et corps de chambres à bulles: CBH 81 - CB 200 - GARGAMELLE
- circuits magnétiques des aimants OMEGA et SFM (en cours)
- enceinte magnétique de la chambre à bulles BEBC (en cours)

**en France**

- CEA (Saclay) - SATURNE: structures de la chambre à vide, éléments des dispositifs d'injection, équipements des salles d'expérience
- ENS (Orsay) - ACCELERATEUR LINEAIRE: spectromètres et déviations, circuits magnétiques de l'anneau de stockage
- LABORATOIRE JOLIOT-CURIE (Orsay): analyseur de particules du synchrocyclotron

Grâce à la complémentarité de ses filiales et participations le groupe Creusot-Loire peut assurer:
ingénierie - architecture industrielle - réalisation - entreprise générale

**CREUSOT-LOIRE**
**DEPARTEMENT NUCLEAIRE**
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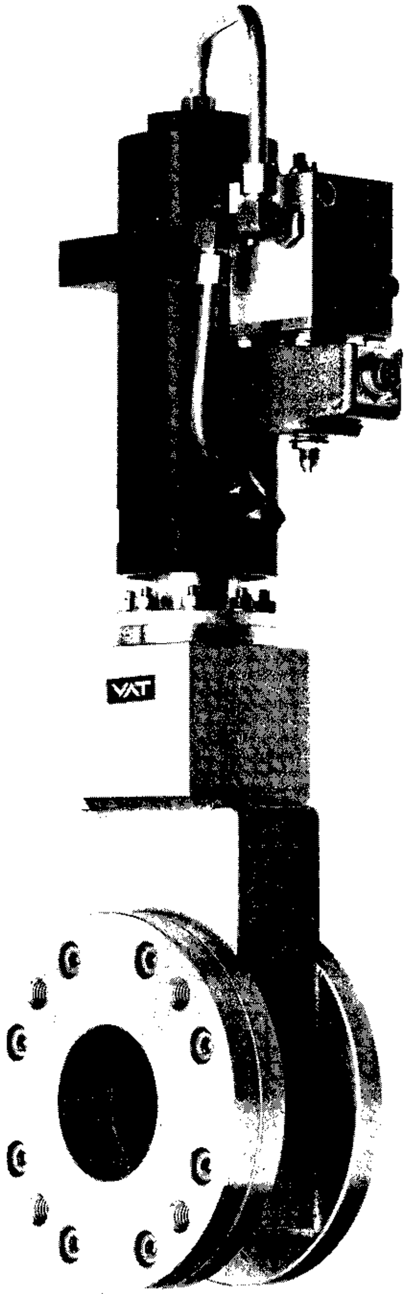


∅
16
25
40
65
100
150

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für Vakuum-Apparate-Technik
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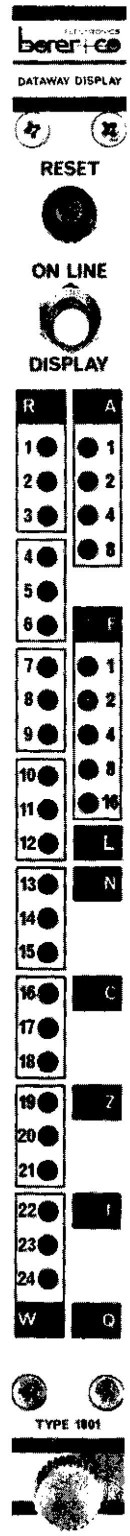
Tel. 085 / 7 15 85 Telex 74162




# CAMAC DATAWAY DISPLAY

## Type 1801

Shows latest
Dataway operation

On-Line Mode
for easy check
of systems

Display Mode
for fault finding

Write and Read
Memory

Bright diode display

Also available:

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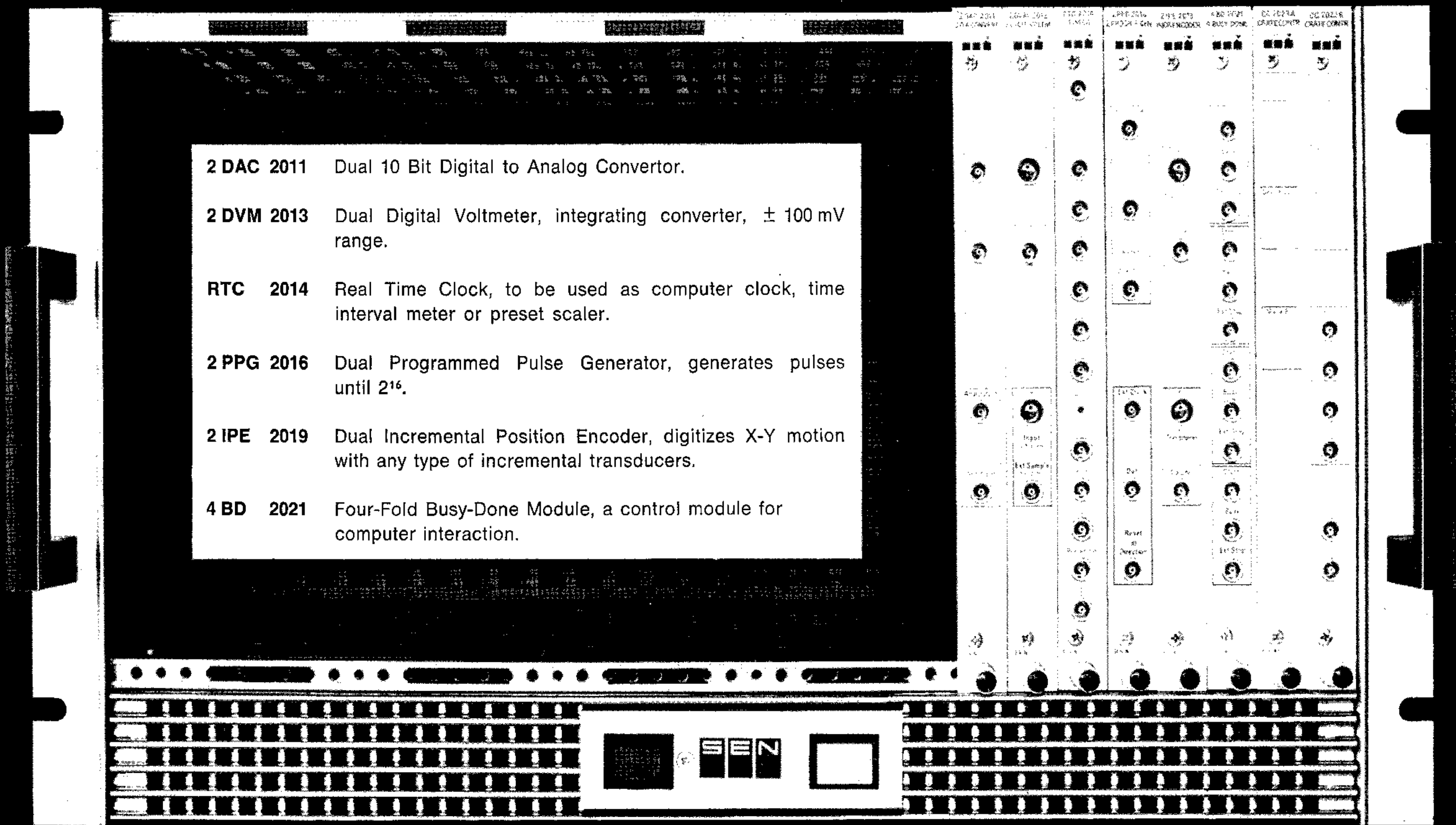
## ...and now the CONVERTERS and TIMER.

# SEN CAMAC



| | | |
|---|---|---|
| 2 DAC | 2011 | Dual 10 Bit Digital to Analog Convertor. |
| 2 DVM | 2013 | Dual Digital Voltmeter, integrating converter, ± 100 mV range. |
| RTC | 2014 | Real Time Clock, to be used as computer clock, time interval meter or preset scaler. |
| 2 PPG | 2016 | Dual Programmed Pulse Generator, generates pulses until $2^{16}$. |
| 2 IPE | 2019 | Dual Incremental Position Encoder, digitizes X-Y motion with any type of incremental transducers. |
| 4 BD | 2021 | Four-Fold Busy-Done Module, a control module for computer interaction. |

And next month?...


SEN ELECTRONIQUE

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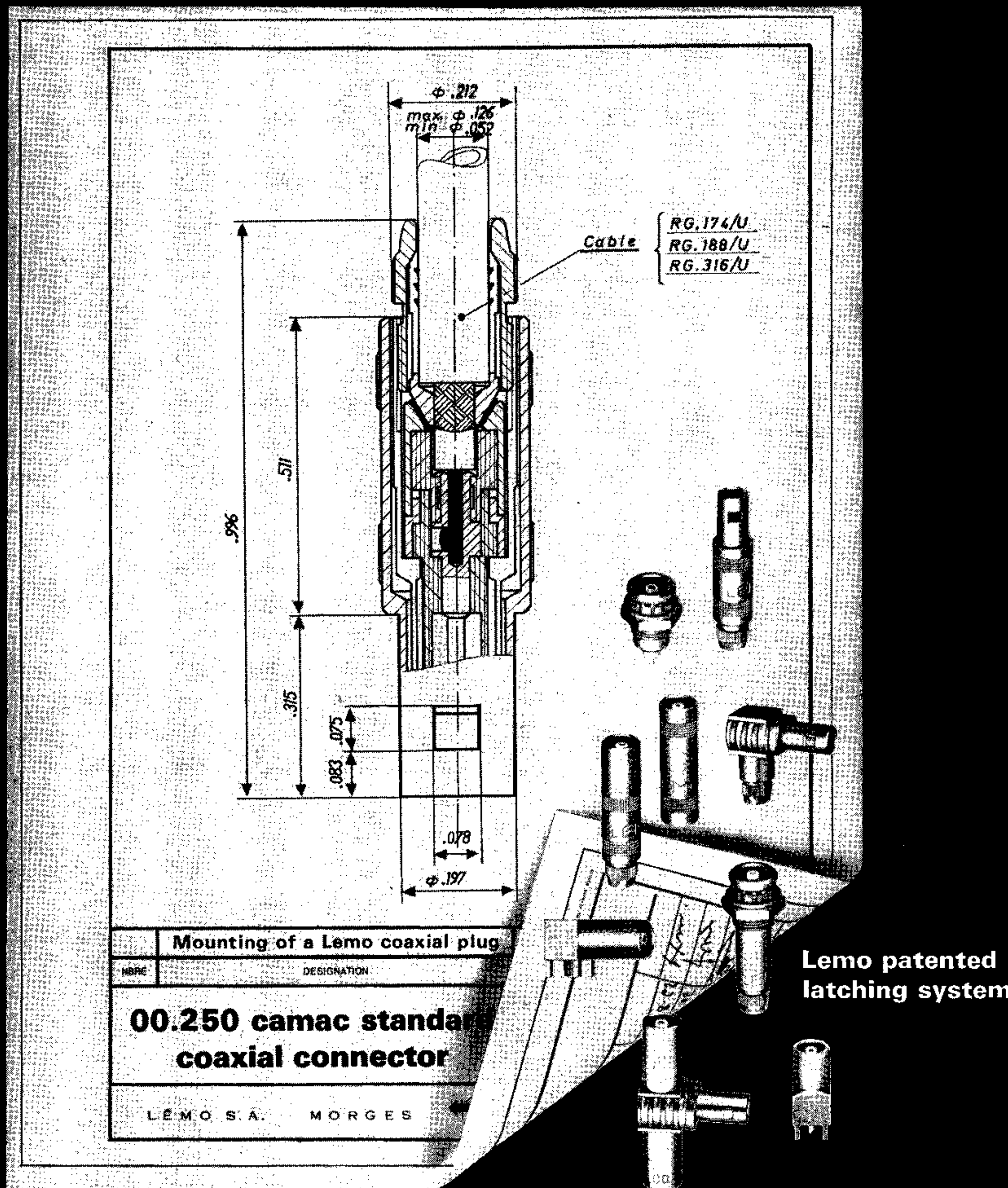
1211 GENEVA 13
SWITZERLAND
Tél. (022) 44 29 40

Denmark: JOHN FJERBAEK i/s, Ingenior, M. AF I. Hoeghsmindevej 23 - 2820 Gentofte/Copenhagen
France: SAIP, 38, rue Gabriel Crié - 92 - Malakoff
Germany, Benelux: HERFURTH GmbH, Beerenweg 6/8 - D 2000 Hamburg 50 (Altona)

Italy: ORTEC-Italia SRL - Via Monte Suello 19 - 20133 Milano
Sweden: POLYAMP AB - Toppvägen 20 - Jakobsberg
U. K.: NUCLEAR MEASUREMENTS Dalroad Industrial Estate, Dallow Road, Luton/Beds.
U.S.A.: ORTEC INC. - 100 Midland Road - Oak Ridge, Tenn. 37 830




## *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
Special arrangement : • 157

**LEMO S.A.**

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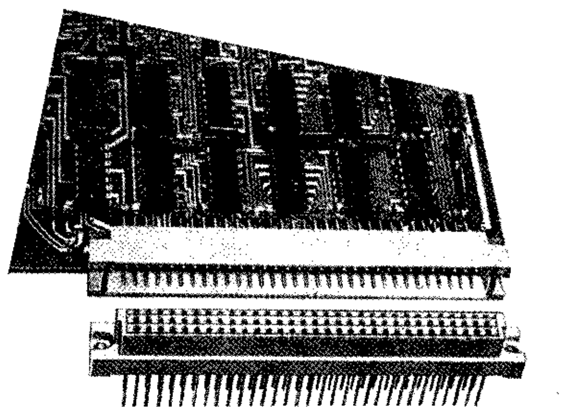
# PLUG-IN CONNECTORS FOR P/C BOARDS

« HIGH QUALITY »

Type STV 32, 64, 96 pins



| | |
|---|---|
| Temperature range: | — 65° ... + 125° C |
| Resistance against: | |
| Shock: | ... 50 g |
| Acceleration: | ... 100 g |
| Vibration : | ... 20 g between 10 and 2000 c/s |

- — Designed according to IEC and DIN standards
- — Tested in accordance with VG 95 324
- — VDE approved and QPL listed

## Application:

General high quality electronics purposes, military, aviation, marine and space-research equipment.
Suitable for single — double — and multilayer-prints.
Connection with mini or standard wrap-type wiring, or with soldering methods.
Terminals arranged in a two or three row pattern.

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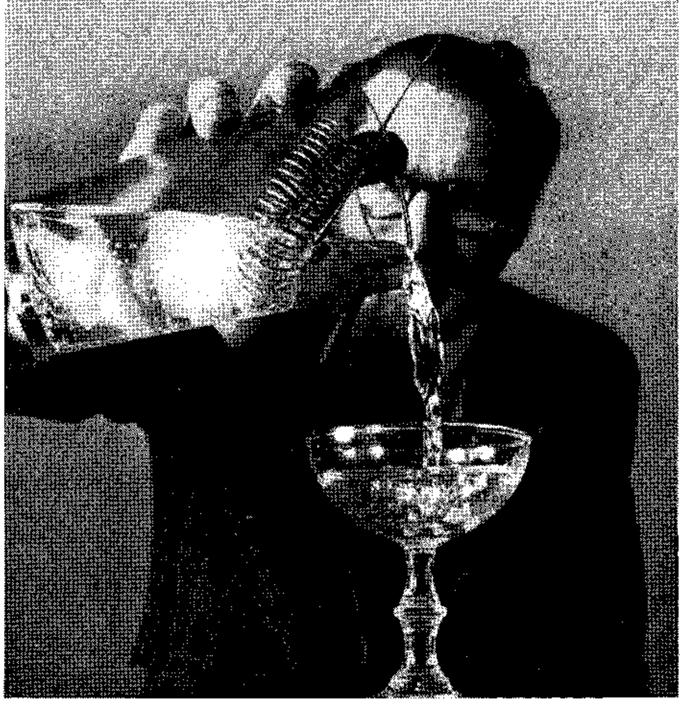
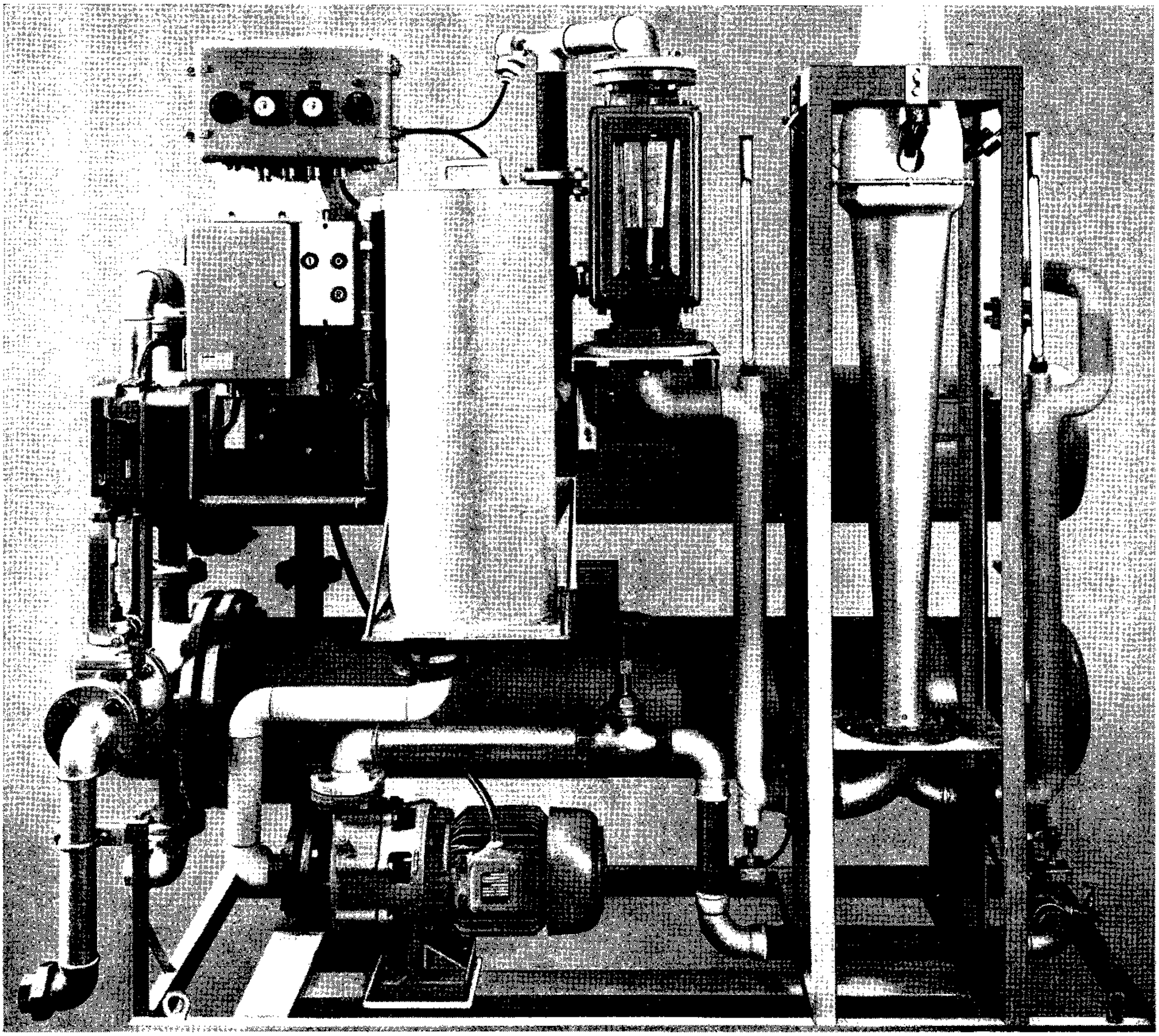


# Resistive loads

## For testing amplifiers, oscillators, transmitters up to 2000 kW



Dummy load 600 kW, 50 ohms

Brown Boveri resistive dummy loads are available in standard ratings of

**600 kW**
**1000 kW**
**2000 kW**

with impedances of 50, 120 and 150 ohms unbalanced and 300 ohms balanced*

These impedances remain practically constant over a very wide frequency range so that the standing wave ratio from 30 Hz to 30 MHz is below 1:1.1 and between 30 MHz and 250 MHz does not exceed 1:1.5

Whenever high-power dissipative resistance loads are required, specify

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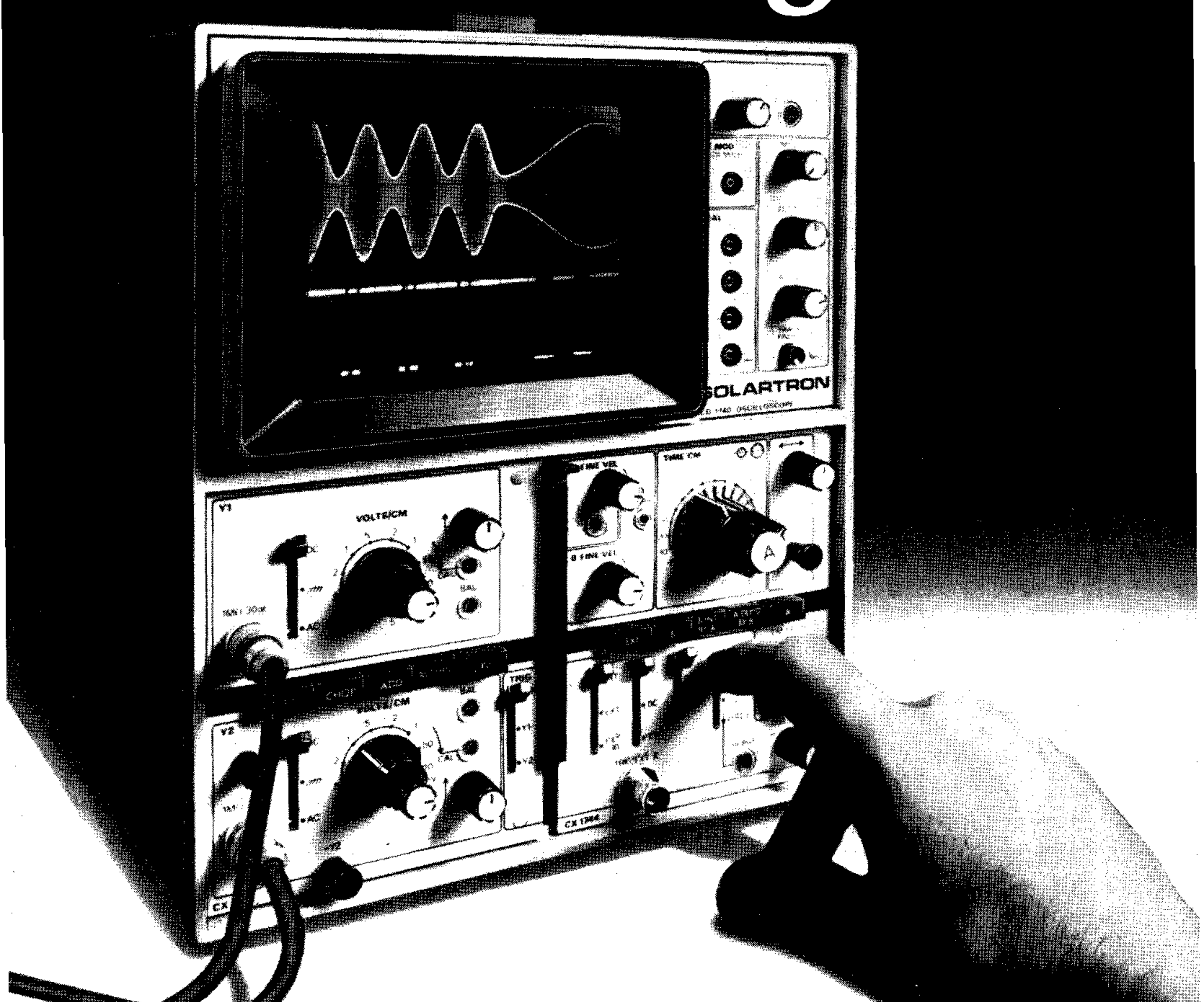
**Brown, Boveri & Company Ltd., 5401 Baden/Switzerland**

* Other impedances available on special order

E 152534-VI

# The touch of genius!




## You've never had a 50MHz 'scope handle this well–or perform better.

This is the one that handles like a dream, Solartron's outstanding new 50 MHz CD1740.

The push-buttons and lever switches are where you want them, when you want them, on a compact $8\frac{3}{4}''$ x $10\frac{1}{2}''$ front panel.

Take the trigger controls for example. With the five lever switches up, you have fully automatic triggering over the full bandwidth with a bright base line under 'no signal' conditions.

And you simply operate the appropriate clearly designated lever to select a special source, slope, level, single shot or coupling (which includes TV sync).

Further, there's a sure-fire trace finder button which brings a free-run brightened trace on screen – whatever the control settings.

But handling apart, the CD1740 packs *real* performance.

The timebase push-buttons give you 10 sweep modes including delayed and delayed gating with the capability of closely inspecting complex wave forms without jitter.

Two identical Y channels with fet inputs give low noise and drift, 600V protected, chopped or alternate, added or differential. And you get 5 mV/cm sensitivity on both X and Y when Y amplifier feeds the X unit.

Add to this an advanced internal graticule mesh tube – run at 12.5 kV – and you have a bright crisp 10 x 8 cm display of excellent geometry right up to the nanosecond speeds available from the timebase.

Just 'feel' the performance and you'll give it the thumbs up.

**Schlumberger**

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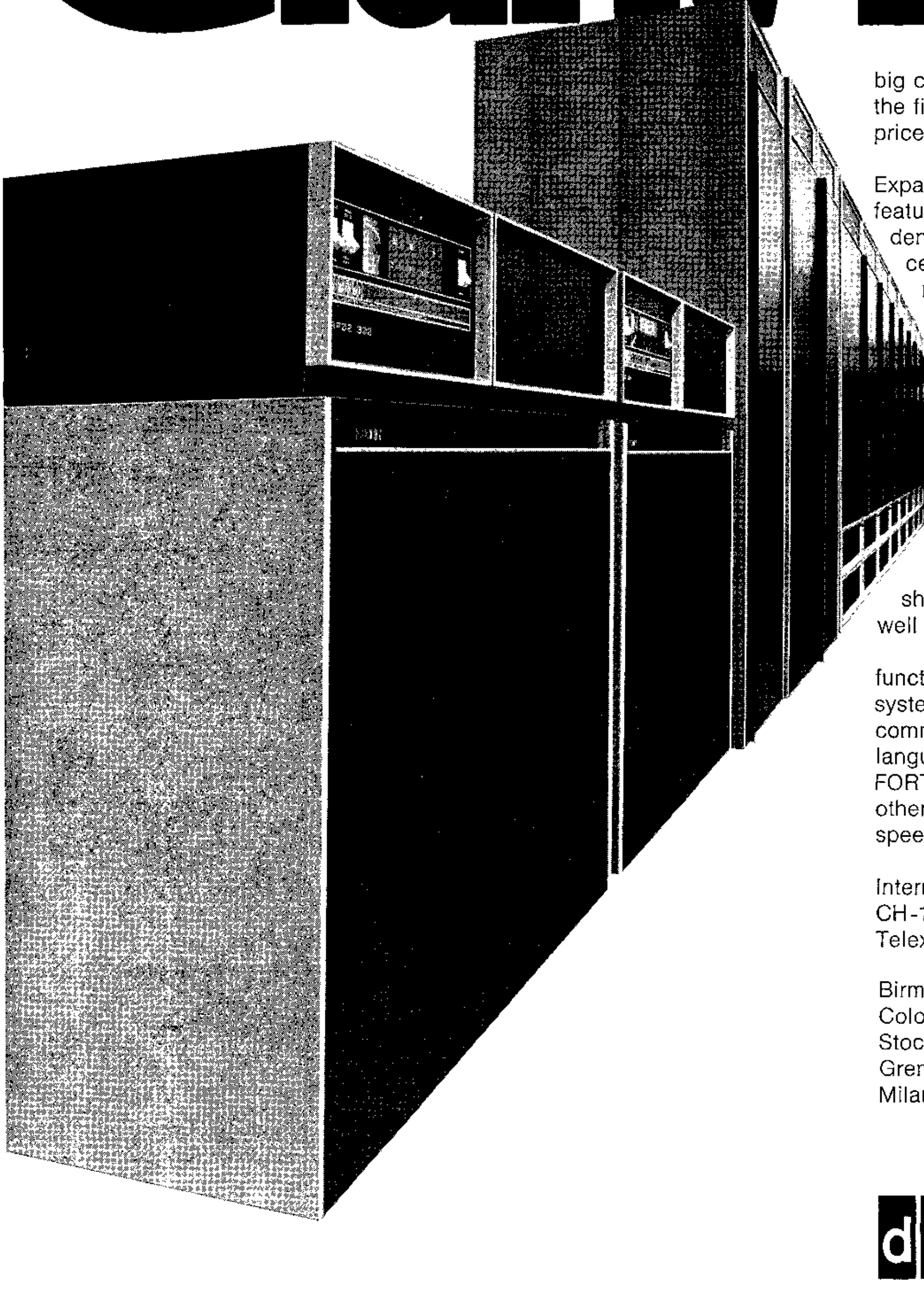
15, Jeu-de-l'Arc  tél. (022) 35 99 50

**8040 Zurich**
Badenerstr. 333  tél. (01) 52 88 80

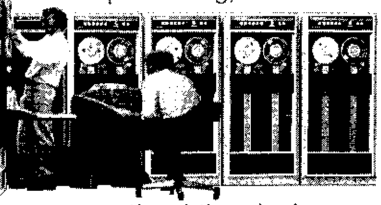
# The Giant Ten



Digital Equipment's new family of big computers, DECsystem-10. Each of the five systems (2nd shown) is a price/performance giant.

New faster, bigger processor. Expanded core memories. More COBOL features. New high performance dual density disk packs. Super multiprocessor systems. Improved card readers. New magtapes. And more.

DECsystem-10 runs four functions: batch processing, multi-access



conversational timesharing, remote job entry (batch and timesharing), and real-time equally well and simultaneously.

All five systems run all four functions using the same operating system with the same job control commands. All are serviced by the same language processors COBOL, ALGOL, FORTRAN, BASIC, MACRO, and many others. The only thing that changes is speed and capacity.

Digital Equipment Corporation International-Europe, 81, Route de l'Aire, CH-1211 Geneva 26. Tel. 022/42 79 50, Telex 22683.

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